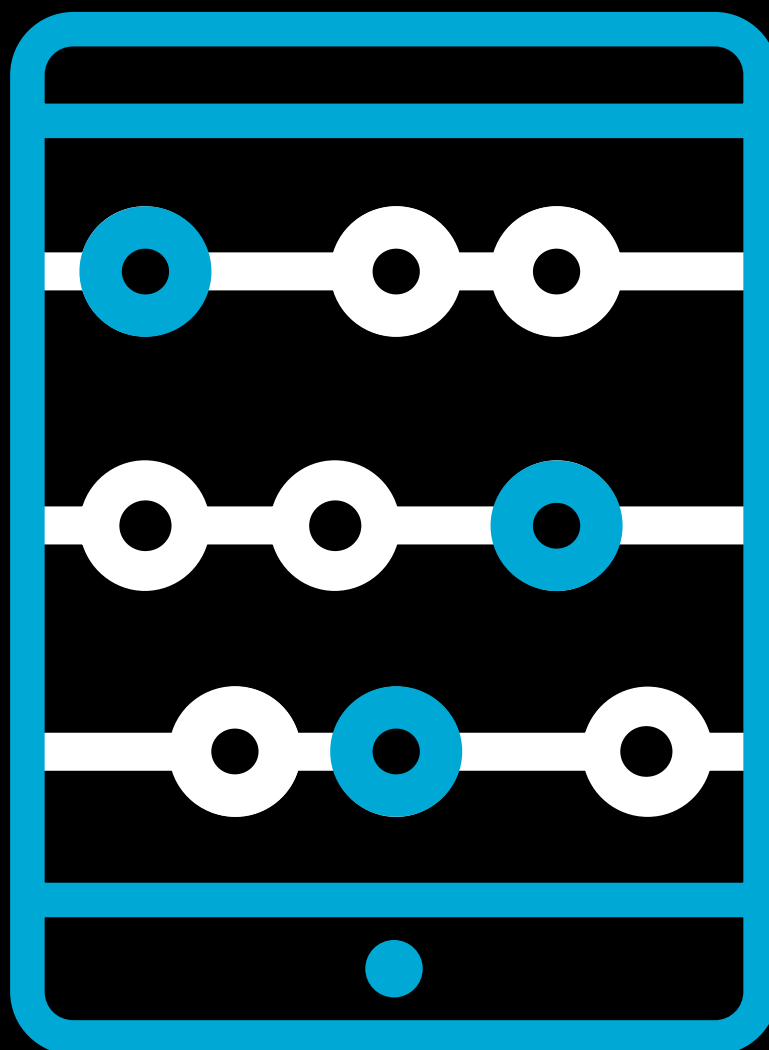
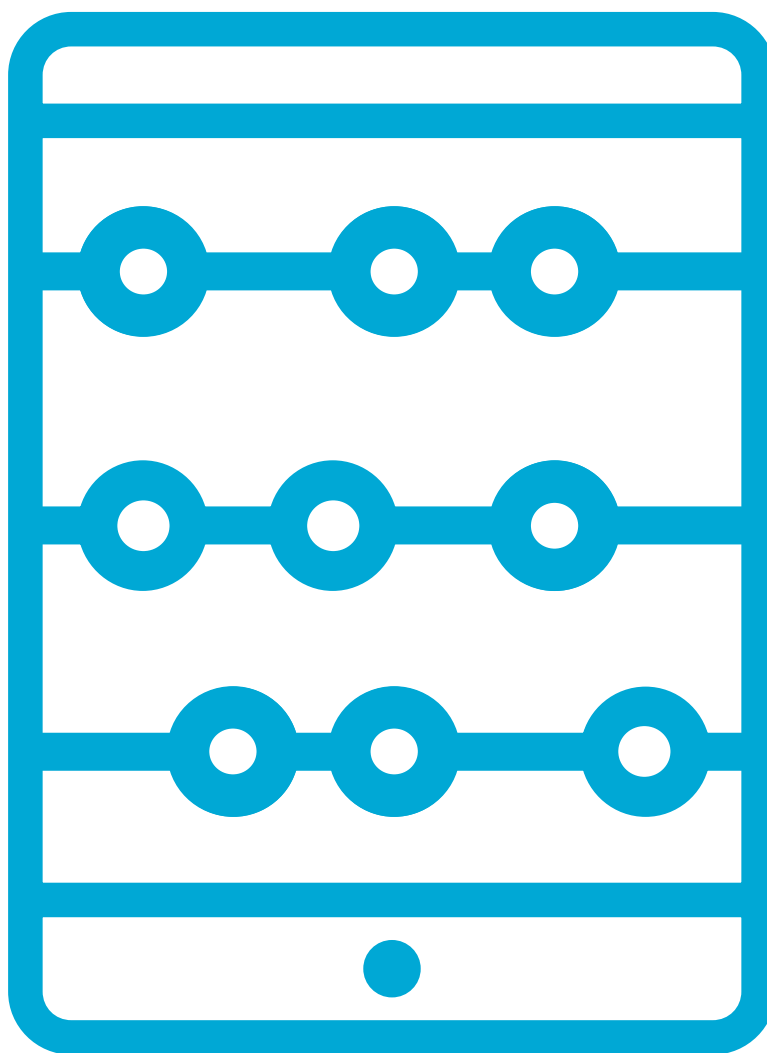






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1 INTRODUCTION

This Activity Report describes INESC TEC activity and main achievements in 2018. Specific indicators portraying the institution and its activity are presented and a selection of the tangible results obtained are described.

Section 2 offers a summarized presentation of INESC TEC profile, its vision, mission, organisational model, policy priorities and research and innovation goals. Section 3 presents the institution main activity indicators for 2018, namely those regarding Human Resources, Activity in Projects and Publications.

Research at INESC TEC is developed in 13 Research Centres, organised in four stable structures called 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 and their main achievements in 2018.

Section 5 presents the Scientific and Technological Activities developed along 2018 by the Research Centres, including also their objectives, main achievements and activity indicators.

Section 6 focuses on the TEC4 initiatives, platforms that articulate INESC TEC's activity towards economic and societal impacts, presenting the achievements in 2018 for the ongoing initiatives in the following domains: SEA, AGRO, ENERGY, INDUSTRY, HEALTH, and MEDIA.

Section 7 presents INESC TEC main research infrastructures supported under the Portuguese Roadmap of Research Infrastructures.

Section 8 introduces two “special” projects running at INESC TEC: the UT Austin Portugal Program and the Digital Competence National Initiative (INCoDe.2030), highlighting the contributions of the institute to public policies in education and science.

Finally, Section 9 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 Profile, vision and mission

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

The University of Porto, INESC, the Polytechnic Institute of Porto, the University of Minho and the University of Trás-os-Montes e Alto Douro are INESC TEC's associates (UM and UTAD since February 2019). Presently, INESC TEC's main sites are located in the cities of Porto, Braga and Vila Real. At the end of 2018, INESC TEC's 13 R&D Centres hosted 745 integrated researchers (339 PhDs), including staff researchers, researchers from Higher Education Institutions, grant holders and affiliated researchers. INESC TEC's team also includes trainees and technical and administrative support staff.

INESC TEC's vision is to be a relevant international player in Science and Technology in the domains of Computer Science, Industry and Innovation, Networked Intelligent Systems, and Power and Energy.

As an institution operating at the interface between the academic and business worlds, bringing academia, companies, public administration, and society closer together, through its "managed science" model, INESC TEC leverages the knowledge and results generated as part of its research, in technology transfer projects, seeking impact both through value creation and social relevance.

The dual mission of INESC TEC is to excel in research, seeking social relevance and international influence, and to foster pervasive intelligence, contributing to the competitiveness and internationalisation of Portuguese companies and institutions.

The merit of INESC TEC in the accomplishment of its dual mission has been formally acknowledged by the Foundation for Science and Technology, with the institute's recognition as Associate Laboratory, and the Portuguese Ministry of Economy, with its recognition as Technology Interface Centre.

2.2 Managed Science Model

2.2.1 Knowledge Value Chain

INESC TEC's management and operational model implements the concept of end-to-end knowledge value chain, driving knowledge from its generation in research activities to its valorisation through a mix of processes of technology transfer.

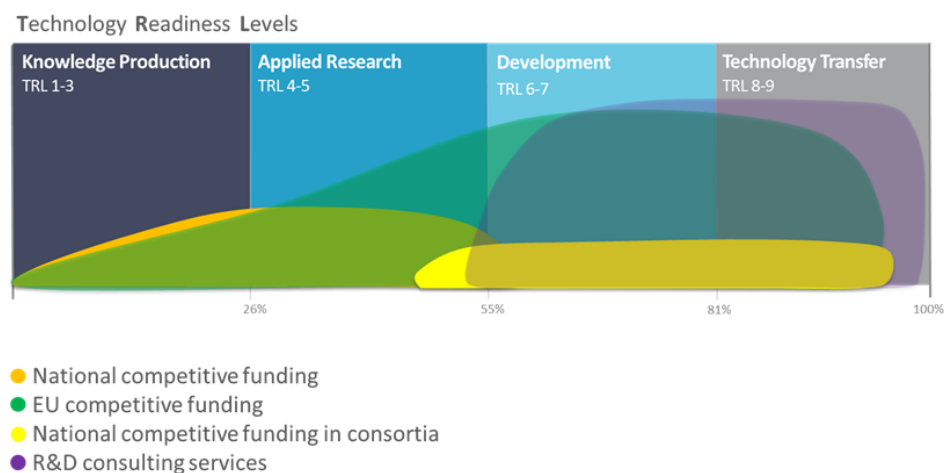


Figure 2.1 – End-to-end Knowledge Value Chain: an integrated two-way pipeline

The concept is illustrated in a very simplified manner in the figure above, which presents a view of the knowledge value chain as a seamless integration of four stages – knowledge production, applied

research, development, and technology transfer. Each is associated with a range of Technology Readiness Levels (TRLs) and major project and funding typologies. As with any model depicting a complex reality, the divisions between stages are fluid.

2.2.2 Clusters and TEC4s

Research at INESC TEC is undertaken by its 13 Research Centres, organised in four stable structures called Clusters: Networked Intelligent Systems (NIS), Power and Energy (PE), Industry and Innovation (II) and Computer Science (CS).

The interaction with the main market application areas is articulated by six initiatives called TEC4: TEC4SEA, TEC4HEALTH, TEC4AGRO-FOOD, TEC4MEDIA, TEC4ENERGY and TEC4INDUSTRY. The Figure 2.2 portrays these connected research and innovation structures.

Research

Clusters - Science push

Clusters of research centres build a multidisciplinary environment to optimize resources and maximise synergies



Innovation

TEC4 - Market pull

Strategy driven platforms addressing and impacting great societal challenges and market needs



Figure 2.2 – Putting pervasive intelligence to work

The Clusters bring together Centres in specific thematic domains, and are responsible for the research and development strategy and long-term planning in their domains. Each Cluster is coordinated by a Cluster leader and a Cluster Council. Performance indicators are consolidated at Cluster level to enable proper planning for the forthcoming periods. Each Centre is nevertheless responsible for its own planning, strategy and resources, and answers directly to the Board regarding its budget and performance indicators. The Clusters are followed closely by specific Members of the Board.

The TEC4 initiatives articulate INESC TEC's activity towards the market, defining market strategies and planning the interaction with the main market application areas. A TEC4 differs from a Cluster in the fact that it implements a market pull vision and does not have a rigid core of Research Centres. Instead, a TEC4 initiative structures and provides coherence to INESC TEC's activity towards specific markets, integrating and articulating the competencies of the relevant Centres and Clusters. A TEC4 is fundamentally driven by a market application domain perspective, where multidisciplinary interventions are usually necessary, instead of a science perspective. A TEC4 initiative establishes a network of external contacts and dialogue with industrial partners and brings back major challenges and the identification of opportunities to the multiple Centres. The TEC4s are flexible, evolving and adaptive to external conditions and internal response, seeking to avoid becoming rigid or permanent structures. While seeking impact of research in real world multidisciplinary environments, the TEC4 initiatives allow INESC TEC to address broad societal challenges.

2.3 Organisational structure

The figure below presents a simplified view of the institution's organisational structure. The high-level management of INESC TEC is undertaken by a Board of Directors, composed of nine members, and an Executive Board, composed of three members from the Board of Directors. The Boards act in coordination with the Council of R&D Centres, meeting every other week with the Centre Coordinators

and Service Managers. This ensures institution-wide coherence in vision and policy, and joint responsibility and commitment in both strategic and operational management decisions.

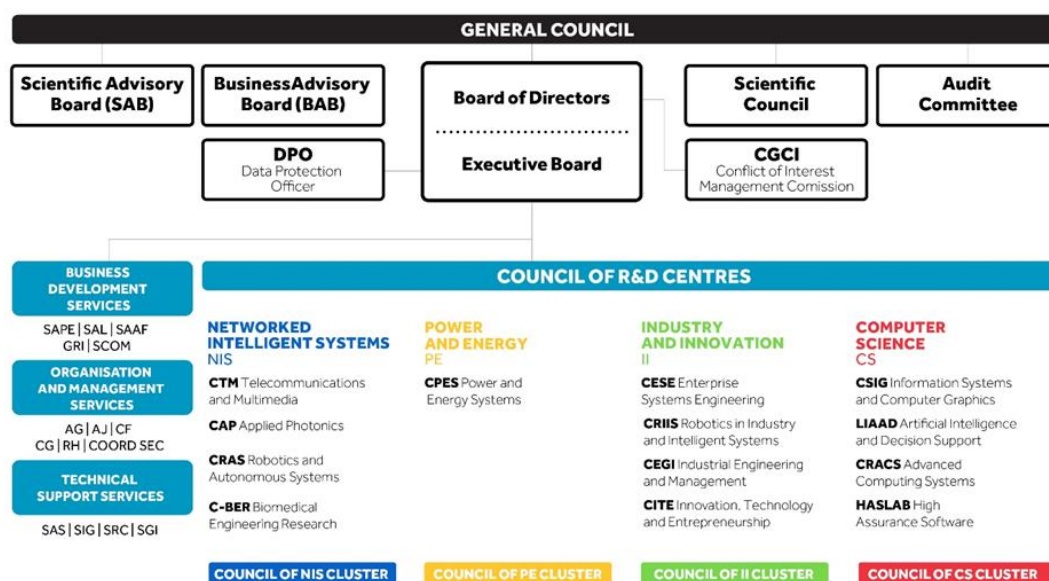


Figure 2.3 - INESC TEC Organisational Structure

The external Scientific Advisory Board audits the institute's scientific activity and provides guidance to the Board, the Clusters, and the Centres. Its composition reflects the diversity of areas and interests within INESC TEC. The Business Advisory Board performs a similar role in the areas of business development and industry relations, assessing the institute's performance and providing recommendations to the Board in those areas.

The Conflict of Interest Management Commission is appointed by the Board to implement the institute's Policy on Conflict of Interest. The Data Protection Officer leads the implementation across INESC TEC of the General Data Protection Regulation.

A streamlined and dynamic team of highly qualified technical and administrative personnel provides support to INESC TEC's activities. A comprehensive set of support services, presented in the table below, is organised to support the R&D Centres across the domains of Business Development, Organisation and Management, and Technical Support. Furthermore, each research Centre has its autonomous administrative support, also with highly qualified staff.

Table 2.1 - Support Services

Business Development	Organisation and Management	Technical Support
SAPE: Industry Partnership SAL: Technology Licencing Office SAAF: Funding Opportunities Office GRI: International Relations Office SCOM: Communication	AG: Management Support AJ: Legal Support CF: Finance and Accounting CG: Management Control RH: Human Resources COORD SEC: Secretarial Coordination	SAS: System Administration SIG: Management Information Systems SRC: Networks and Communications SGI: Infrastructure Management

2.4 Policy priorities

INESC TEC's mission is carried out along the following policy priorities:

- Excellence in research, talent development, and innovation;
- Full coverage of the knowledge value chain;

- Integration and multi-disciplinarity;
- Scale, density, and critical mass;
- International visibility and presence.

2.4.1 Excellence in research, talent development, and innovation

INESC TEC creates new knowledge and technology to improve products, processes, services and business models, contributing to the competitiveness of companies and institutions, and benefiting society. This knowledge is built upon a base of rigorous scientific research, and in a dynamic research environment that enables the institute to engage and foster the development of excellent researchers. The commitment to the reinforcement and internationalization of INESC TEC's research infrastructures is essential to ensure the competitiveness of this research environment. Initiatives such as the creation of a research data repository and the active participation in the Portuguese node of the Research Data Alliance, led by INESC TEC, contribute to strengthening the alignment with open science policies. The reinforcement of the international recognition of its researchers, through high impact publication profiles, international awards, or ACM and IEEE Fellowships, plays a major role in maximizing the impact of the institute's excellent research.

As part of its strategic partnerships with associated Departments, Schools, and Higher Education Institutions, INESC TEC seeks to continuously bring valuable contributions to their PhD and Masters Programmes. INESC TEC assists more than 20 PhD programmes, typically involving over 300 students, about 60 concluding their theses every year. Every year the institute's researchers supervise over 600 master's students. The strengthening of INESC TEC's involvement in PhD and Masters Programmes is essential to its ability to attract and involve young talent in conducting and disseminating excellent research while leveraging Higher Education Institutions intervention.

INESC TEC's focus on finding solutions to important problems, along with its culture of collaboration with industry, provides an ideal environment for innovators. On an international level, the build-up of its positioning as an interface organisation of excellence, is key to expanding the ability to partner with international organisations to provide them unique knowledge and relevant technology for innovation, generating and transferring socially relevant results. On a national level, the participation in initiatives such as CoLABs also contributes to this consolidation, while simultaneously allowing the strengthening of the collaboration with other national R&D organisations.

The reinforcement of its global dynamics of excellence is a permanent priority for the institution, whose expansion in recent years requires a renewed attention to some of its fundamentals, in particular to its human resources management, science management and advanced training models, as well as to research ethics and gender equity policies, areas for which diagnoses are being launched and reformulations will be proposed and implemented.

2.4.2 Full coverage of the knowledge value chain

The success of INESC TEC's managed science model relies on the ability to easily enable flows from upstream to downstream along the knowledge value chain, and feedbacks in the reverse direction. In fact, the interaction and collaboration with industry is also essential for the identification of new research lines, and the valorisation of research results, through processes such as technology licensing, collaborative development, advanced consulting, training, and spin-off launching, is key to the economic sustainability of the institute.

In order to excel in this dynamics, INESC TEC is increasingly challenged to ensure that individual researchers focus where they feel more comfortable to perform at their best, while at the same time Centres develop the broad spectrum of activities and the critical mass that allows knowledge to flow not only within each Centre, but also between Centres, so that INESC TEC as a whole is able to fully accomplish its dual mission.

2.4.3 Integration and multidisciplinary

INESC TEC pays constant attention to its integration dynamics, as the institution and its context evolve, and its resources are accordingly renewed, strengthened and recombined. The Clusters and the TEC4 initiatives are key instruments to support INESC TEC's policy for achieving institutional cohesion and maximising synergies, differentiation and impact. Overall, this policy seeks to strengthen the ties among Centres, by deepening cross-fertilization, originating new science by fusion of knowledge and skills, and conducting multidisciplinary research and innovation by truly multidisciplinary teams.

The institute strives to foster this meeting of different scientific disciplines, a key enabler of its impact in practice through science-based innovation. The implementation of initiatives that encourage and support the interaction among Centres is key to enable the integration of the institute's diversity of deep scientific knowledge into multidisciplinary solutions that transcend traditional technological divides. The Clusters and the TEC4 initiatives play a key infrastructural role towards this purpose, as well as other instruments, such as the recently launched Internal Seed Projects, which support inter-Centre research, junior researcher development, and proof-of-concept activities.

2.4.4 Scale, density, and critical mass

INESC TEC's ambitious vision and mission require a level of scale and density that can only be made possible through its multi-institutional base model. The resource endowment collaboratively brought to INESC TEC by its associates and privileged partners is continuously leveraged by the institute to sustain a level of growth and densification in the areas of knowledge that are critical for its activity, which is not only unique in the country, but also increasingly relevant in the international arena. One of the institute's key priorities for the future is a consistent effort to focus its activities and attract leading researchers to further reinforce its critical mass.

2.4.5 International visibility and presence

Excellence in science and technology nowadays requires collaboration and strong partnerships with leading international research institutions and companies. INESC TEC's international projects and activities are crucial to securing the status of international player, ensuring the institution's effective participation and recognition in the international arena. INESC TEC permanently directs significant efforts to its international activities, so that they continue to play a major role in the institution.

In this context, the first and foremost undertaking is the consolidation of the massive presence in European research and innovation, including the strengthening of collaborations with international companies. INESC TEC's active participation in the Raw Materials, Manufacturing and Digital KICs (Knowledge and Innovation Communities) has a highly relevant role in this domain. A second step is the strengthening of a base of operations outside Portugal, to increase the capacity to access projects, secure funding, and attract human resources at an international level. The operation in Brazil, with the creation of INESC P&D Brasil and its recognition by the Brazilian Science and Technology agencies as a Brazilian ICT (Institution of Science and Technology) must be understood under this perspective. The India Office also aims to develop relevant bridges with important companies and public actors and support the attraction of students and post-docs. The continued involvement in the Portuguese Government's International Partnerships with MIT, CMU and UT Austin, and in particular the hosting at INESC TEC of the national leadership of the UT Austin Portugal Program, will play a key role in the development of collaborations with the United States. Other initiatives, such as the AIR Centre or the CENTRA network of excellence, foster the collaboration with partners from an even broader spectrum of geographies.

2.5 Research and innovation goals

The institution's scientific objectives defined for 2018-2022 are aligned with its vision and mission, and in particular with the commitment to **fostering pervasive intelligence**. This is enabled by the structures and processes put in place at INESC TEC to promote and facilitate multidisciplinary cooperation, which allow linking sensors, communications, hardware and software systems, data, knowledge, models, decision and action.

INESC TECs high-level scientific objectives, defined at Cluster level, are summarised below with each Cluster's vision and research priorities (more details can be found in the Clusters and Centres sections):

- **NETWORKED INTELLIGENT SYSTEMS** - For the next five years, the Cluster envisions smaller, smarter, long endurance, collaborative intelligent/autonomous systems, as well as the convergence of deep learning and communications, and the ubiquity of computer vision. The Cluster will continue to work towards futuristic scenarios in which collections of cooperative autonomous systems, communications enabled, and carrying advanced sensors, will collect information in extreme environments such as the deep sea or the human body, and process it with artificial intelligence tools. For the medium term, four main research lines will be active: (1) sensing, (2) communications, (3) computer vision, and (4) autonomous systems.
- **POWER AND ENERGY** - The Cluster's vision is aligned with the EU policies for digitalization, energy efficiency and increase in Renewable Energy Sources (RES), and includes as main challenges the transformation of the energy sector through synergies between advanced mathematical modelling and digital technologies, the full decarbonization of the power system with novel solutions, and the bridging of the gap between research results and industry business cases with a multidisciplinary approach. The Cluster has defined the following main research lines: (1) towards 100% RES integration and massive integration of power electronics-based interfaces; (2) large-scale modelling and optimization of energy systems; (3) data-driven methodologies for energy systems; (4) asset management and predictive maintenance; (5) cybersecurity and Internet of Things (IoT) for critical infrastructures (electricity generation, transmission and distribution).
- **INDUSTRY AND INNOVATION** - The Cluster envisions fully integrated supply networks across different industries (e.g., manufacturing and process industries). This vision materializes in a powerful production link that embeds Industry 4.0 concepts and logistics flows that are capable of using sensor information to replan daily activities. Customer-centricity and production optimisation in real time, as well as the decentralization of decisions, will only be possible with highly flexible, reallocable, adaptable and intelligent automation, control and robotics. The use of collaborative robots (mobile and manipulators), smart sensor networks, industrial vertical IoT-based information architectures, and human-robot collaboration and interface, will play an important role. Resource efficiency, the implementation of the circular economy, as well as an optimal balance and integration between humans and machines will also be key requirements. The Cluster defines the following strategic research lines: (1) responsive, sustainable and resilient operations, including aspects from factory design to collaborative robotics and automation; (2) decision support in a digitised industry; (3) operational and strategic architectures for a data-driven industry; (4) technology adoption, management and policy for an inclusive industry; (5) mobility for the circular economy.
- **COMPUTER SCIENCE**: Computing is becoming ubiquitous, decentralized and mobile, reaching all devices, appliances and living beings, in real time, producing enormous amounts of data, which can produce a wealth of information if properly mined, while at the same time challenging individual privacy and society's fundamentals. More intelligent and autonomous systems will change the way we live and work. New interfaces will enable more immersive and inclusive interactions among humans and machines, blurring real and virtual environments. In line with this vision, the Cluster will focus on the following research lines: (1) big data and machine learning; (2) privacy-preserving computing; and (3) virtual environments, including intelligent multi-sensorial immersive virtual environments, augmented and virtual reality.

These scientific objectives are complemented by knowledge valorisation and technology transfer targets, structured by INESC TEC in the form of the TEC4 initiatives. Six initiatives are organised to address innovation challenges in different market domains:

- **TEC4SEA** - Bringing the digital world to a sustainable sea economy;
- **TEC4MEDIA** – Digital media technologies to improve the content value chain and user experience;
- **TEC4AGRO-FOOD** – Co-shaping the digital (r)evolution in agro-food and forestry;
- **TEC4INDUSTRY** – Collaborative value chains for an innovative, human-centred and sustainable industry;



- TEC4ENERGY – Decarbonization and digitalization of the energy sector;
- TEC4HEALTH – User-centred ICTs to improve health care and personal wellbeing.

3 RESULTS ACHIEVED IN 2018

This section presents a short summary of the results INESC TEC achieved during 2018, including the main indicators for human resources, activity in projects and scientific publications. The remaining sections of the document include detailed information for each Cluster and R&D Centre, the TEC4 multidisciplinary initiatives, research infrastructures, special projects, and Support Services.

3.1 Strategic priorities and objectives for 2018

The strategic priorities and objectives defined for 2018, presented and discussed with the General Council, were the following:

i) Scientific excellence

The consolidation of scientific excellence in INESC TEC's research domains, aiming at national and international recognition, is a permanent strategic priority for the institution. INESC TEC's Clusters are the structures responsible for defining and monitoring the implementation of its long-term scientific strategy.

The ongoing integrated R&D projects, focusing on important emerging scientific developments, aimed at renewing skills and developing critical masses, complementing the more upstream research supported by FCT projects and strategic funding from FCT. These projects have been an institutional investment to achieve scientific leadership in strategic areas and enable new European projects and research contracts with industry in the future.

The renewal of INESC TEC's position as an outstanding research unit, in the scope of FCT's evaluation process, was also one of the major scientific priorities.

ii) Technology transfer and valorisation

Knowledge valorisation and technology transfer are key priorities for INESC TEC to achieve its goals of impact, social relevance and economic sustainability.

The realization of INESC TEC's virtuous funding model, with a balance between different types of funding sources, at a global level but also ideally in each Cluster and R&D Centre, whenever possible, was the result of an increased effort in promoting European projects, contract research, and advanced consulting and training for companies and other organisations.

The TEC4 initiatives and the Business Advisory Board have been instrumental for this objective, namely by assisting in addressing industry needs through multidisciplinary perspectives and approaches.

The significant ongoing effort in Intellectual Property protection, pre-incubation activities and spinoff creation, which increased in 2018, completes the efforts to strengthen knowledge valorisation and technology transfer.

iii) Relationship with academic institutions

The collaboration with Higher Education Institutions is a foundational priority for INESC TEC.

The institution has contributed actively to the recent debate about the relation of the University of Porto (U.Porto) with its institutes. These contributions have already been instrumental in the preparation of the specific collaboration protocols with FEUP and FCUP.

Considering the dimension and diversity of the U.Porto universe and the fact that INESC TEC integrates faculty from different schools, the rich experience from the development of the collaboration protocols with U.Porto will potentially be useful in reviewing the protocols with the Polytechnic Institute of Porto (IPP), the University of Trás-os-Montes and Alto Douro (UTAD), and the University of Minho (UM), as well as the Polytechnic Institute of Bragança (IPBragança), the Universidade Aberta and other academic institutions, meeting the strategic guidelines of those institutions.

iv) International activity

The reinforcement of international activity has been crucial for the growth experienced in the last few years. The orientations of the Business Advisory Board have also been decisive in defining the international positioning of INESC TEC.

The increase in European programmes participation, the consolidation of the activity in Brazil and the opening up to new horizons, namely Asia, remained priority areas in 2018.

v) Contribution to public policy on R&D

Along the years, INESC TEC has been committed to the success of national public policies, more recently by maintaining its role as a key player in the partnership programs in Science and Technology between FCT and US Universities (first coordinating the UTEN initiative, then the CMU Portugal Program, and since 2018 the UT Austin Portugal Program), and being actively involved in the launch of new Collaborative Laboratories (CoLAB).

vi) Governance model and internal organisation

As part of the evolution of the institution's governance model, the deployment of the Conflict of Interests Management Policy was an important priority in 2018, together with the efforts towards the approval of INESC TEC's Intellectual Property Regulation.

The continuous need to improve the efficiency of internal processes has been addressed with enhanced automation and IT support, not only to increase resource efficiency, but also to achieve higher flexibility and quicker response, as well as to support the measurement of performance indicators for different aspects and levels of the institute. These indicators aim to support strategic decision making and operational management in all its activities, namely by contributing to continuous improvement, as well as the overall maintenance of the institution's economic and financial stability.

3.2 Highlights in 2018

Following the outlined strategy, INESC TEC was able to meet and, in some cases, exceed its goals for 2018. The following are some of INESC TEC's main achievements during 2018:

1. The successful launch of new projects and activities supported an overall increase in activity of about 6%, consolidating the growth observed in previous years of 14% in 2014, 26% in 2015, 6% in 2016 and 16% in 2017. This outcome is evidence of the institution's resilience and ability to compensate the often-strong oscillations in individual types of funding sources caused by the cyclic nature of national and international financing programs.
2. The FCT R&D Units evaluation process was a major focus for the activity during 2018. The institution mobilized itself in order to guarantee that the evaluation panel had an appropriate grasp of INESC TEC's activities and its impact in society. The result of the evaluation is expected for 2019.
3. INESC TEC has been reinforcing its international presence and activity, maintaining its research partnerships within the MIT Portugal and CMU Portugal Programs, and starting the hosting of the coordination of the UT Austin Program.
4. In addition, the institution has strengthened its position as a member of several international consortia and associations, such as AirCentre, ASTP-Proton, CENTRA, EEN, EERA, EFFRA, IBM Q Network, and KIC EIT Raw Materials. In 2018, INESC TEC was also one of the partners of the European consortium that was chosen for the creation of the KIC EIT Manufacturing, and one of the promoters of the initiative to create a Portuguese Hub of the KIC EIT Digital.
5. INESC TEC organized in 2018 the meeting of the European Commission's RISE Group in Portugal, as part of its Tour d'Europe.
6. Internationally, the Brazil Office has worked industriously to keep up with the increase of projects with INESC P&D Brazil. The new office for international relations has followed the activity in Brazil

and continued its promotion work to attract high quality researchers and foster projects with Indian institutions.

7. In the area of Intellectual Property protection, it is worth highlighting the remarkable results achieved in 2018, due not only to the efforts of INESC TEC's researchers, but also to the impetus provided by SAL (Technology Licensing Office). During 2018, 12 patents were submitted and 6 patents granted, in Europe, Japan, Korea and US.
8. In 2018, INESC TEC formally moved to take an equity position in its spin-off MITMYNID (launched in 2015, as a result of the WIDERMOS Project developed by the Centre for Information Systems and Computer Graphics), dedicated to developing software and services in transport and logistics. INESC TEC was also involved as a partner and with an equity position in the launching of the spin-off UBIRIDER, which develops mobile and web apps combining traditional and modern ways of transportation.
9. The organic growth of the different R&D Centres, organised in the above-mentioned clusters, consolidated the hosting environment for 745 integrated researchers. The Core research team includes 339 researchers with a Ph.D. degree, 155 of which are academic staff.
10. In terms of human resources, the most noticeable aspect, in 2018, is the increase of 31 persons in R&D employees (46 with respect to 2016), as a result of the implementation of the Government's policies for scientific employment.
11. At an internal level, the Conflict of Interests Management Policy was fully implemented in 2018, placing INESC TEC at the national forefront on this topic. Like other European organisations, the compliance with the European General Data Protection Regulation was also one of INESC TEC's main concerns in 2018.
12. INESC TEC actively participated in the national Collaborative Laboratories (CoLABs) initiative, created to meet the challenge of enhancing the density of knowledge-based activities in Portugal by fostering the collaboration between scientific and technological institutions and the social and economic fabric. INESC TEC led the creation of the CoLAB FORESTWISE, the Collaborative Laboratory for Integrated Forest and Fire Management, and actively participated in the consolidation of the CoLABs Vines&Wines and B2E (Blue Economy).
13. The institution was also active in the launch of the Digital Innovation Hub for Customer-Driven Manufacturing @ Norte - iMAN Norte Hub, aiming to foster the digital transformation of manufacturing companies of the Northern Region of Portugal (Norte) and to nurture the respective innovation ecosystem.
14. Still at a scientific level, 2018 was marked by the launch of the first call of Internal Seed Projects. This internal science instrument aimed at supporting projects in three categories: inter-centre research, junior researcher development, and commercialization proof-of-concept. The call solicited projects of a high-risk/high-reward nature, explicitly showing promise and a strategy for significant future expansion. The results of the first call were released in early 2019.
15. Considerable effort has been put in the increase of institutional visibility and recognition, by communicating the social and economic impacts of INESC TEC's research. In the annual event, INESC TEC Autumn Forum, more than 200 attendants gathered to discuss the theme "The companies that create the digital. The companies that are recreated by the digital". Besides the active participation in multiple events, such as Hannover Messe and Ciência 2018, INESC TEC researchers have participated in the organisation of 87 international conferences and in 280 Program Committees of international events.
16. The scientific achievements are detailed later, in the sections on Clusters and Centres, but the following deserve highlight:
 - Development of transversal deep information learning based on supervised learning and multiple instance learning framework for image quality and abnormality detection in medical images. This generic methodology has been applied with success to different image data, published in top-

ranked journals, received a conference best paper award and achieved top-10 performance on histology, retinal segmentation and skin and eye surgery topics, in international competitions.

- Development of a novel switched antenna array and MAC protocol running over standard IEEE 802.11 wireless cards for long-range, broadband ship-to-shore communications in alternative to Satellite communications, with the successful demonstration at the Lisbon Naval Base together with the Portuguese Navy.
- Demonstration of compositional mapping in complex mineral using LIBS technology with the test case of lithium from Portuguese mines exploration, based upon novel LIBS signal processing schemes and calibration transfer protocols (2 EP submitted).
- PISCES team was selected as one of nine finalists of the Shell Ocean Discovery XPrize international competition. The PISCES team approach is based on the combination of different marine robotic platforms to devise an effective and efficient solution for the exploration of the seabed. These platforms must be operated together and incorporate acoustic navigation and a mapping system.
- Development of data-driven energy optimization strategies for a wastewater pumping station by using a combination of reinforcement learning and machine learning.
- Extension of dynamic simulation platforms previously developed under a scope of “inverter-dominated islanded power systems” to a simulation platform for 100% power electronic power systems, involving advanced modelling concept for grid forming inverters and its performance during fault conditions.
- Development of a multi-temporal approach for the energy scheduling and voltage/var control problem
- In the context of energy conversion, a new modulation for the power converter designed as High-Frequency Link Matrix Converter (HFLMC) was developed. The proposed space vector modulation is able to control the power factor in the power grid interface as well as voltage and current at load. An international patent application was submitted in order to protect the intellectual property of this work. The patent was already given in the United States and the regional processes in Europe and Japan are ongoing.
- In the topic of organisational evaluation, the Theory of Performance Frontiers from operations management was tested, opening the possibility of evaluating firms’ Corporate Social Responsibility using quantitative methods and a proof of concept of an intelligent dashboard that identifies operational inefficiencies in advanced health care management and healthcare logistics showed promising results.
- Preparation, implementation and successful validation of several contract-based research projects supported by the developed reference framework based on 4.0 industry concepts and technologies, winning new clients of significant strategic importance for future research activity (e.g. GALP Energia and Grupo Amorim).
- A collaborative mobile manipulator that it is capable of autonomously navigate to the inside of a vehicle, where it performs several non-ergonomic fastening operations, and sharing both its working space and task with a human operator was developed in the context of the ColRobot H2020 project.
- 3rd edition of the Business Ignition Programme, a state-of-the-art programme to build and test alternative business models for the exploitation of technologies developed in academia, created in the scope of an ERDF co-funded project, led by U.Porto Inovação, CIIMAR and INESC TEC. Twelve technologies were submitted and evaluated in that edition of the programme.
- Publication of “Indifferentiable Authenticated Encryption”, where the theoretical foundations for analysing and constructing strong forms of encryption schemes were launched, and of “Delta State Replicated Data Types”, that establishes the foundations for efficient synchronization of state in global systems, and that has already led to several industrial implementations.

- Leveraging the work done in the HYRAX project, a new CMU Portugal Program project called Angerona is now addressing the challenges put forward by IoT security and privacy.
- Conclusion of the Google DNI funded project Algorithmic Science News (ASN), and start of the project Stop PropagHate, another Google DNI funded project.
- Arquivo.pt prize awarded to the web portal “Conta-me histórias”, which, given a topical query, has the capability of going through the Portuguese web archive and produce a proto-narrative in the form of a chronological sequence of relevant statements extracted from the news.

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 2016. The number of researchers with PhDs is also shown (339 at the end of 2018).

Table 3.1 - Evolution of INESC TEC Human Resources

Type of Human Resources			2016	2017	2018	Δ 2017-18	
Integrated HR	Core Research Team	Employees	56	71	102	31	44%
		Academic Staff	200	203	155	-48	-24%
		Grant Holders and Trainees	400	449	418	-31	-7%
		Total Core Researchers	656	723	675	-48	-7%
		Total Core PhD	283	312	259	-53	-17%
	Affiliated Researchers		59	64	70	6	9%
	Management, Administrative and Technical	Employees	59	69	80	11	16%
		Academic Staff	8	8	9	1	13%
		Grant Holders and Trainees	25	23	14	-9	-39%
		Total Manag, Admin & Tech	92	100	103	3	3%
	Total Integrated HR		807	887	848	-39	-4%
	Total Integrated PhD		347	381	339	-42	-11%
Curricular Trainees		36	26	15	-11	-42%	
External Research Collaborators		102	113	203	90	80%	
External Administrative and Technical Staff		8	10	12	2	20%	
External Students		71	104	121	17	16%	
Total		1024	1140	1199	59	5%	

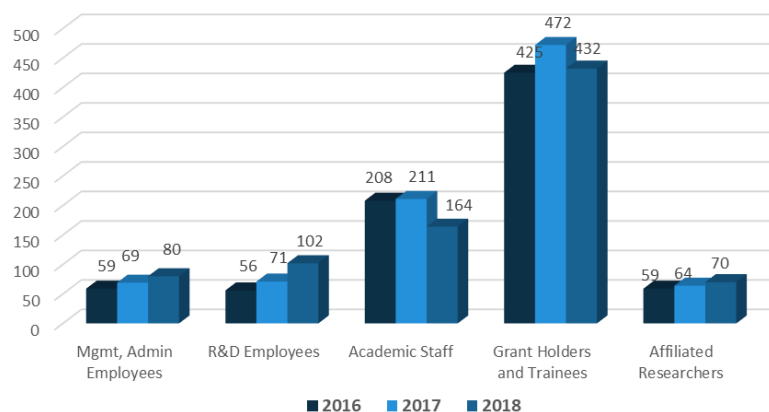


Figure 3.1 - Evolution of INESC TEC Human Resources

As can be seen in Figure 3.2, grant holders and trainees are the largest group of human resources (51%).

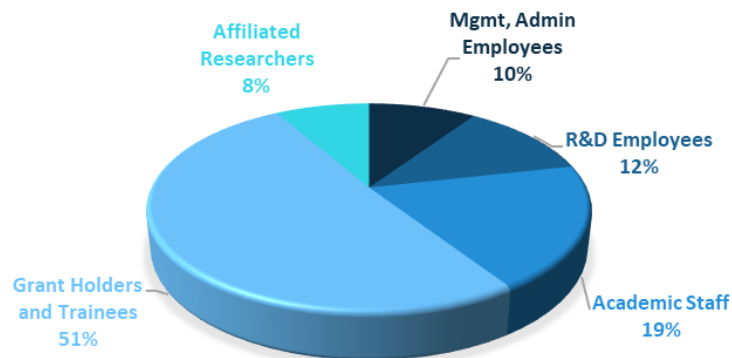


Figure 3.2 - Distribution of Human Resources

When compared with the numbers for 2017, the most noticeable difference in 2018 is the increase of 31 persons in R&D employees (46 with respect to 2016), as a result of the implementation of the Government's policies for scientific employment.

There is a decrease of 4% in the total number of integrated human resources. This contraction is mainly due to the reduction in academic staff (24%) and grant holders and trainees (7% in R&D and 39% in Management, Administrative and Technical).

The reduction in the academic staff is the result of an internal process, launched at the beginning of 2018, set in order to refresh research teams. Academic staff with a real time allocation to INESC TEC R&D activities lower than 50% were reclassified as affiliated researchers or external research collaborators.

Similarly, to 2017, there is a small increase in Human Resources in the support services, to cope with the continued growth of the institute, with some grant holders and trainees evolving to contract positions.

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	102	10	8	11	2	18	17	6	4	3	13	3	1	6		
		Academic Staff	155	14	7	11	6	10	7	12	13	1	24	22	14	14		
		Grant Holders and Trainees	418	53	17	22	19	53	37	23	30	4	50	24	37	49		
		Total Core Researchers	675	77	32	44	27	81	61	41	47	8	87	49	52	69		
		Total Core PhD	259	25	15	14	11	25	12	15	27	3	31	30	21	30		
	Affiliated Researchers		68	9	5			6	6	5	7	1	18	4		7		
	Administrative and Technical	Employees	17	1	2	4	1	1	2	3	1		1		1		4	
		Grant Holders and Trainees	4			1										3	2	
		Total Admin and Tech	21	1	2	5	1	1	2	3	1		1		1	3	6	
	Total Integrated HR		764	87	39	49	28	88	69	49	55	9	106	53	53	79	6	
	Total Integrated PhD		323	34	20	14	11	30	16	20	33	4	49	34	21	37		
Curricular Trainees			15			1			4	2	3	2	1	1				
External Research Collaborators			175	12	4		11	12	13	18	19	12	11	42	11	10	5	
External Administrative and Technical Staff			10					2	1	1	2		1			3		
External Students			120	26	9	1	5	7	2	3	5	3	8	20	13	18		
Total			1 084	125	52	51	44	109	89	73	84	26	127	116	78	110	11	

R&D Centres:

CTM	Centre for Telecommunications and Multimedia
CAP	Centre for Applied Photonics
CRAS	Centre for Robotics and Autonomous Systems
C-BER	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 Board and each Support Service.

Table 3.3 - Human Resources by type and Service

Type of Human Resources		Total	Board and Advisors	Organisation and Management Services					Business Development Services				Technical Support Services				
				AG	AJ	CF	CG	RH	SAAF	SAPE	SAL	GRI	SCOM	SCI	SIG	SAS	SIG
Integrated HR	Employees	59	9	1	2	8	10	4	1	4	2		5	2	4	3	4
	Academic Staff	9	9														
	Grant Holders and Trainees	8		1		2	1			1	1	1	1				
	Affiliated Researchers	2	2														
	Total Integrated HR	78	20	2	2	10	11	4	1	5	3	1	6	2	4	3	4
	Total Integrated PhD	16	12			1				2	1						
External Collaborators		26								2		23		1			
Total		104	20	2	2	10	11	4	1	7	3	24	6	3	4	3	4

Support Services:

AJ	Legal Support
CF	Finance and Accounting
CG	Management Control
RH	Human Resources
AG	Management Support
SAAF	Funding Opportunities
SAPE	Industry Partnerships
SAL	Technology Licensing
GRI	International Relations
SCOM	Communication
SI	Networks and Informatics
SIG	Management Information Systems
SAS	Systems Administration
SIG	Infrastructures Management

3.4 Activity in Projects

3.4.1 Global Indicators

Table 3.4 shows the breakdown of INESC TEC's funding by source and its evolution between 2014 and 2018.

Table 3.4 - Funding sources and evolution

Sources			Value (k€)					Δ (k€ %)	
			2014	2015	2016	2017	2018	2017-18	
Firm Projects	PN-FCT	National R&D Programmes - FCT	867	775	490	1 143	2 279	1 136	99%
	PN-PICT	National R&D Programmes - S&T Integrated Projects	1 170	785	1 464	2 644	2 428	-216	-8%
	PN-COOP	National Cooperation Programmes with Industry	551	316	263	1 060	1 251	191	18%
	PUE-FP	EU Framework Programmes	2 751	4 040	4 494	3 306	3 628	322	10%
	PUE-DIV	EU Cooperation Programmes - Other	114	290	632	686	707	21	3%
	SERV-NAC	R&D Services and Consulting - National	2 672	3 033	2 259	2 538	2 525	-13	-1%
	SERV-INT	R&D Services and Consulting - International	259	173	287	355	509	154	43%
	OP	Other Funding Programmes	531	802	703	1 040	841	-199	-19%
	Total Active Projects		8 914	10 214	10 592	12 773	14 168	1 395	11%
Closed Projects			34	229	418	140	309	169	121%
National Strategic Programme - Pluriannual			881	2 191	2 615	3 003	2 485	-517	-17%
National Strategic Programme - CIT							13	13	
National Strategic Programmes - Other			125	140	112	130	170	40	31%
Other Revenues			491	411	270	260	383	124	48%
Total Revenues			10 445	13 184	14 008	16 305	17 529	1 224	8%

Figure 3.3 illustrates the distribution of funding for the projects carried out in 2018, and its evolution since 2014. The activity level has grown steadily, with oscillations in the relative importance of the different funding sources, typically reflecting the cyclic nature of national and international financing programs.

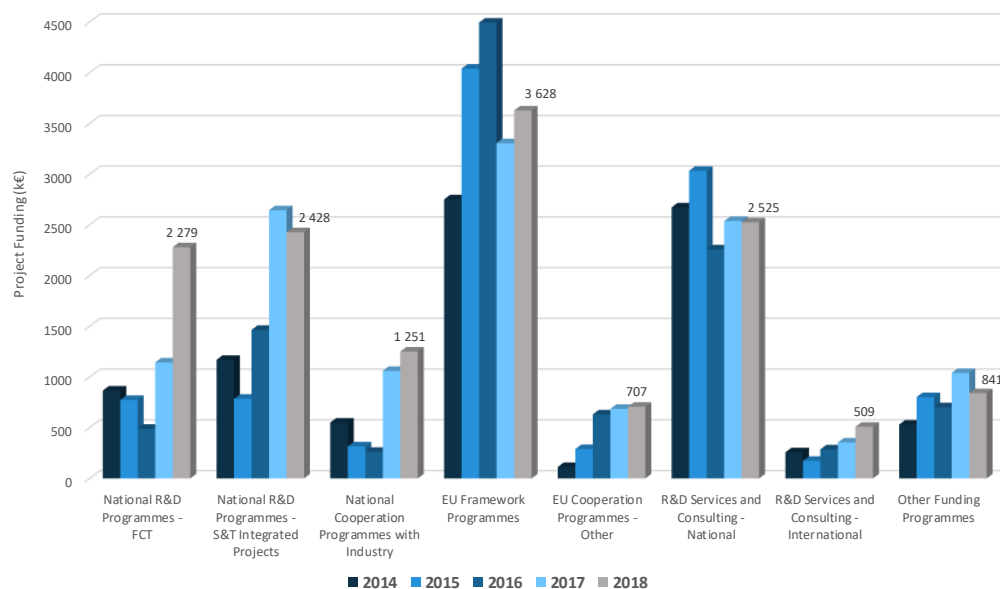


Figure 3.3 - Evolution of project funding by source (k€)

Figure 3.4 shows the funding distribution by source, in comparison with the previous year.

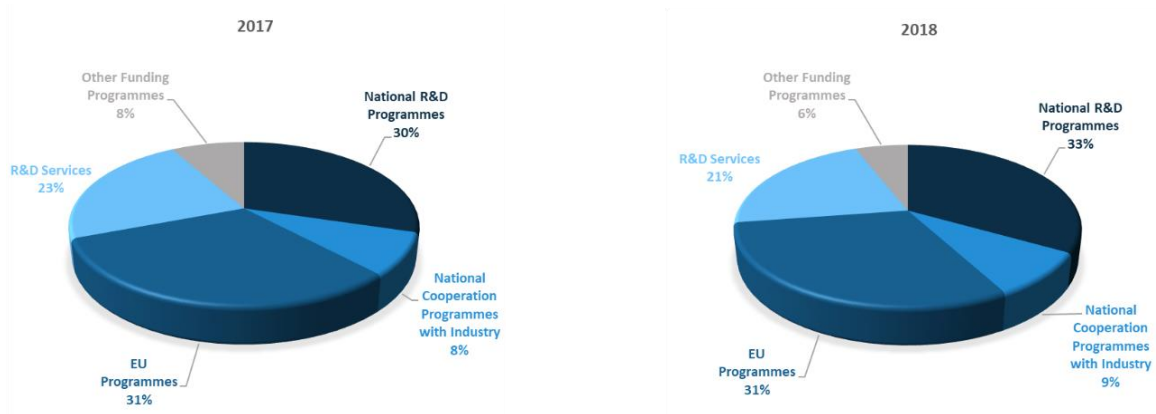


Figure 3.4 - Distribution of project funding by source - 2017 and 2018

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

Table 3.5 - Number of active projects projects and average funding by source

Type of Project		Number of Active Projects					Δ (%)	Average Funding (k€)	
		2014	2015	2016	2017	2018		2017	2018
PN-FCT	National R&D Programmes - FCT	41	32	22	32	66	34	36	35
PN-PICT	National R&D Programmes - S&T Integrated Projects	6	10	10	10	10		264	243
PN-COOP	National Cooperation Programmes with Industry	11	13	13	25	23	-2	42	54
PUE-FP	EU Framework Programmes	26	35	37	35	30	-5	94	121
PUE-DIV	EU Cooperation Programmes - Other	4	9	12	22	18	-4	31	39
SERV-NAC	R&D Services and Consulting - National	71	72	67	117	96	-21	22	26
SERV-INT	R&D Services and Consulting - International	8	6	11	14	19	5	25	27
OP	Other Funding Programmes	11	13	19	39	30	-9	27	28
Total		178	190	191	294	292	-2	43	49

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

- INESC TEC maintained a diversified and sustainable activity and funding model, with a turnover of about 17 M€, 262 R&D projects, and 28% of project funding from international sources. 2018 was, mostly, a year of consolidation of INESC TEC's activity, with an increase in activity of about 6%, consolidating growth observed in previous years of 14% in 2014, 26% in 2015, 6% in 2016 and 16% in 2017.
- In order to strengthen the support to its technology transfer and valorisation activities, INESC TEC applied successfully for competitive funding in the scope of a call of the CIT (Centros de Interface Tecnológico) Financing Program, having been awarded near 1 M€ per year for a period of 3 years.
- The balance between the different funding sources was successfully achieved by maintaining the level of funding for European projects, reinforcing the number of FCT projects (+34), and increasing in 43% the contract research and consulting activities with international companies.

3.4.2 R&D Centres Indicators

A detailed view of the total funding, in 2018, by source per R&D Centre, is given in Table 3.6 and Figure 3.5.

Table 3.6 - Project Funding (k€) per R&D Centre

Funding Source			R&D Centre													Special Projects
			CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	CSIG	LIAAD	CRACS	HASLAB	
Firm Projects	PN-FCT	2 279	257	214	337	182	405	156	169	148	15	183	64	81	68	0
	PN-PICT	2 428	290	220	101	354	34	173	31	210	53	230	242	295	195	0
	PN-COOP	1 251	274	0	200	1	56	364	133	23	0	126	41	0	34	0
	PUE-FP	3 628	189	0	530	0	855	501	357	0	95	350	107	77	566	0
	PUE-DIV	707	0	35	102	0	192	67	178	0	77	55	0	0	0	0
	SERV-NAC	2 525	253	34	33	7	870	510	291	109	46	148	93	45	79	7
	SERV-INT	509	116	15	115	0	98	32	41	0	0	32	0	0	61	0
	OP	841	32	0	94	0	27	0	0	12	18	123	13	0	91	430
	Total Active Projects	14 168	1 411	519	1 511	544	2 538	1 803	1 200	502	303	1 247	561	499	1 095	437
Total Closed Projects		309	8	22	0	0	199	3	5	2	0	64	6	0	-1	0
Total Funding		14 477	1 419	540	1 511	544	2 738	1 806	1 205	504	303	1 311	567	499	1 094	437

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

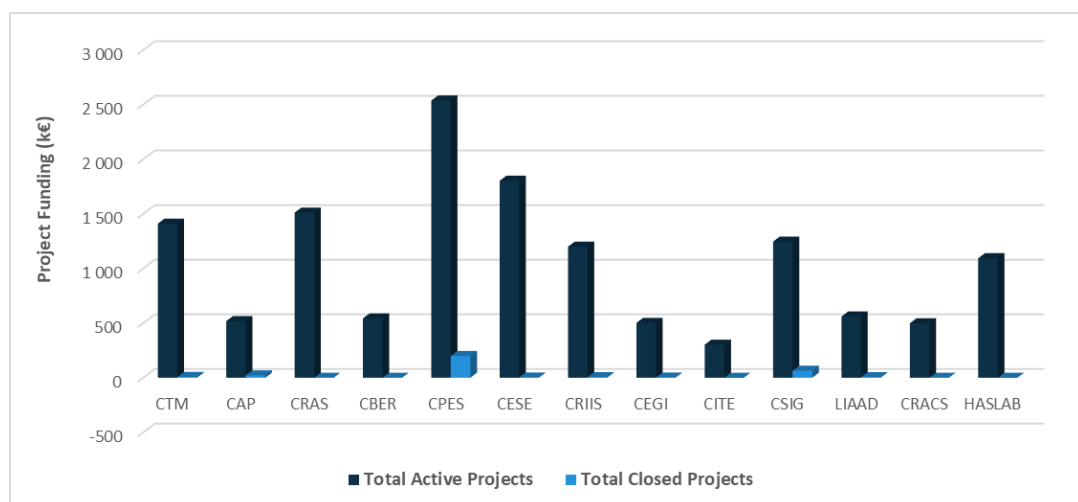


Figure 3.5 - Project Funding (k€) by R&D Centre

3.5 Publications

3.5.1 Global Indicators

Table 3.7 and Figure 3.6 show the number of INESC TEC publications in 2018 and its evolution since 2015.

The number of publications was obtained from different indexing sources (ISI and SCOPUS) gathered by the Authenticus platform, and 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.

Table 3.7 - Number of INESC TEC Publications

Publication Type	2015	2016	2017	2018
Indexed Journals	247	311	318	303
Indexed Conferences	440	476	492	438
Books	5	1	1	5
Book Chapters	40	37	27	38
PhD Theses - Members	26	38	34	40
PhD Theses – Supervised	66	56	56	60

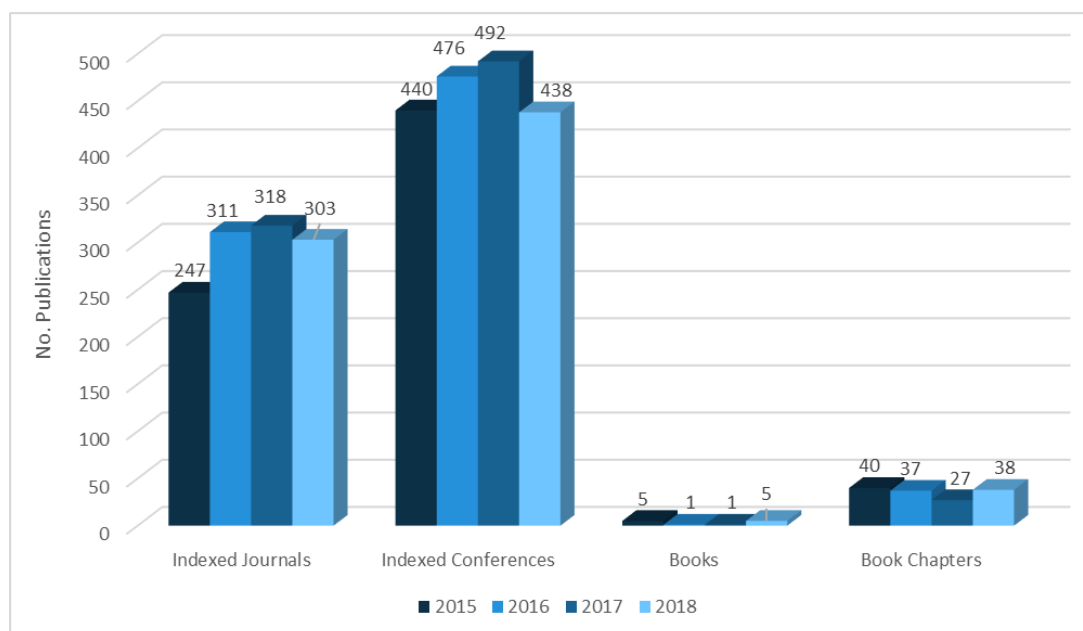


Figure 3.6 - Evolution of INESC TEC Publications

The total number of indexed publications slightly decreased in 2018 (8.5%), mainly articles in indexed conferences, and the articles in indexed journals remain quite stable. Due to the significant change in INESC TEC's research team, particularly an overall reduction of 17% Core PhDs, we present in Figure 3.7, the evolution of publications *per capita*.

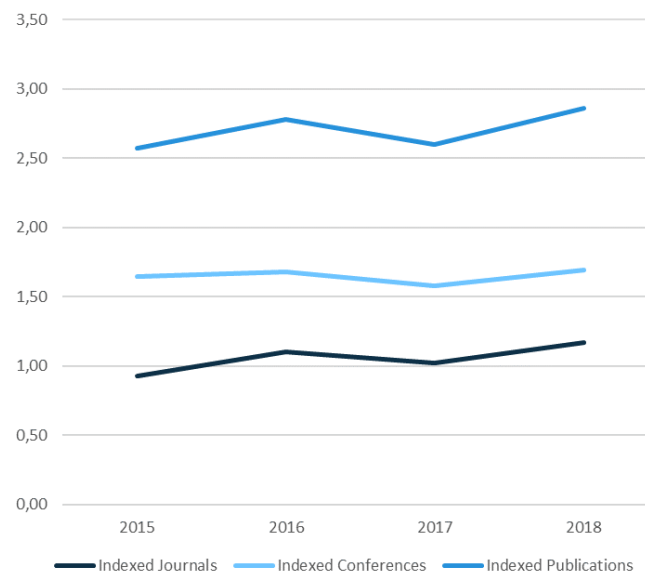


Figure 3.7 – Evolution of INESC TEC Publications per Core PhD

3.5.2 R&D Centres Indicators

Figure 3.8 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 is presented in later sections in the context of each Centre.

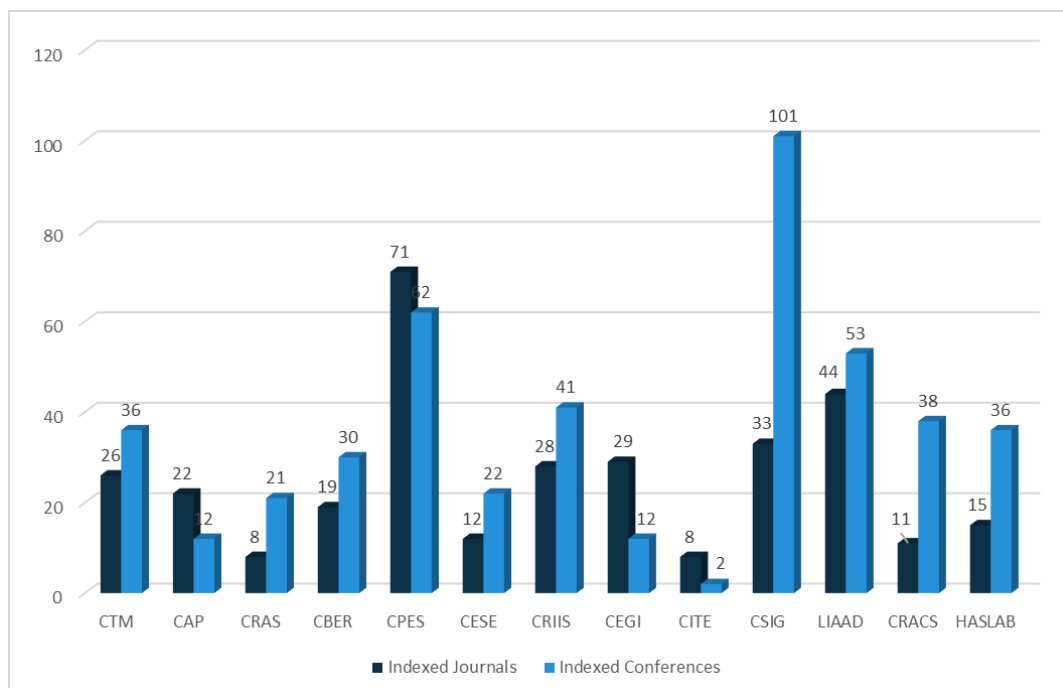


Figure 3.8 - Indexed Publications in Journals and Conferences per R&D Centre

For the publications in journals indexed by Scopus, Figure 3.9 shows its distribution per impact factor quartile. In 2018, INESC TEC publication effort has been mainly directed to indexed journals. Besides improving the per capita rate, the percentage of papers in the first quartile (Q1) improved from 58% in 2017 to 71% in 2018.

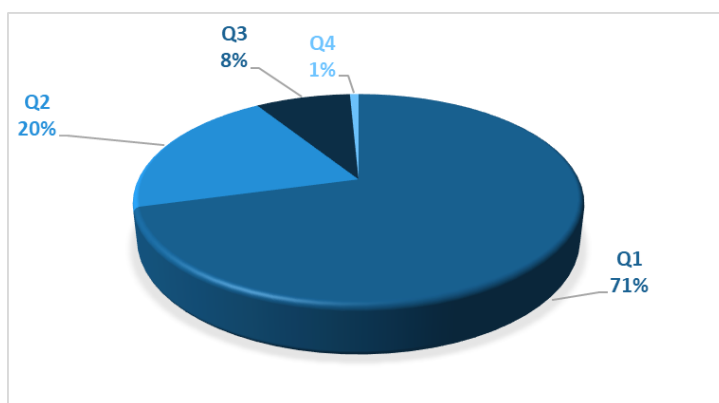


Figure 3.9 – Journal Impact Factor Quartile Distribution (Scopus)

3.6 IP Protection, Exploitation and Technology Transfer

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

Type of Result	2016	2017	2018
Invention disclosures	16	8	15
Software copyright registrations	1	0	3
Patent applications	5	5	12
Granted patents	1	1	6
Licence agreements	5	2	1
Spin-offs	0	0	2

3.7 Dissemination Activities

Table 3.9 - Results related with Dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	48	40	61
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	75	71	87
International events in which INESC TEC members participate in the program committees	236	219	280
Participation in events such as fairs, exhibitions or similar	83	40	76
Advanced training courses	19	32	41

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). The next sections present those four Clusters, their objectives and results obtained during 2018.

4.1 NETWORKED INTELLIGENT SYSTEMS

Coordinator: Jaime Cardoso

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

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

- CAP, addressing optical sensing, 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 address include: underwater robotics for environment protection and resource exploitation; flying or terrestrial robotics for surveillance of borders; distributed sensing for monitoring intelligent cities; continuous multi-sensor monitoring of human health; distributed robotics for provisioning of adaptive telecom infrastructures; behavioral, social, and predictive modelling of user pattern and mobility from wireless traces. The development of such systems will lead to new results in the NIS Centres. We address various problems in both fundamental theory and practical system implementation by applying statistical techniques, machine learning, and algorithmic techniques.



Figure 4.1 - Main dimensions of an autonomous networked intelligent system

Our research goal is to bridge the gap between theoretical/algorithmic techniques and their practicality in real-world networked systems. Challenges addressed in NIS related with sensing, communication, interpretation and action, see Figure 4.1, are strongly multidisciplinary and necessary for systems reacting to the environment. Participation of multiple and disparate disciplines will enable NIS to be distinctive and impactful.

The Cluster Council is presently composed of: Jaime Cardoso (coordinator), Filipe Ribeiro, Luís Pessoa, Rui Campos, Paula Viana and Hélder Oliveira (from CTM), Ireneu Dias and Paulo Marques (from CAP),

Aurélio Campilho and João Paulo Cunha (from C-BER), Aníbal Matos, Eduardo Silva and Carlos Pinho (from CRAS). Representatives of the other clusters are invited to participate in the meetings of the cluster council when appropriate.

4.1.2 Vision and contribution

4.1.2.1 Future vision of the domain

Influenced by several sources of information and different short to long-term trends, the Cluster NIS research activities, for the next five years, will be dominated by three main vectors:

Smaller, smarter, long endurance, collaborative intelligent/autonomous systems

For the coming five years, several advances and breakthroughs are expected in the field of networked devices. It is expected that in the future:

- advanced compilers will enable much faster conceptualization and fabrication for a host of different tasks;
- robots shall communicate in real-time and cooperate on projects, building strong teams;
- soft robots will be able to enter and explore environments previously unreachable by conventional methods, including: deep ocean waters, the terrain of Mars, and perhaps even the gushing rivers of blood inside our own bodies;
- biosensing will evolve from macro to nano dimensions (e.g. from wearables (macro)sensing to single bio-particle (nano)sensing);
- human-machine interfaces will promise new options for those suffering from stroke and paralysis;
- drones and micro-drones will be able to perform advanced tasks in harsh environments;
- city-scale projects that harness electric devices (IoT, but much larger in scope), traditional infrastructure and citizen data will be addressed;
- smartphone sales will start to decline; smart peripherals will see a bump. We expect to see many new kinds of wearables: connected performance clothing, headbands, shoes. Many of these will be used for continuous monitoring of well-being;
- medicine will become more and more personalized, through the interpretation and aggregation of imaging, text, multimodal medical exams, sensor data, and even demographic and geo-spatial data.
- machine vision will rival and surpass human vision in multiple tasks.

Also, from the advances in electronics and 3D printing technologies, the value of autonomous systems shall shift towards the intelligence and flexibility part of these systems. Competencies like navigation, perception, control, cooperation, and cognition, among others, will play a critical role.

Ongoing convergence of deep learning and communications

Today's communications systems generate a huge amount of traffic data, which can help to significantly enhance the design and management of networks and communication components when combined with advanced machine learning methods. Furthermore, recently developed end-to-end training procedures offer new ways to jointly optimize the components of a communication system. Also, in many emerging application fields of communication technology, e.g., smart cities or internet of things, machine learning methods are of central importance.

The ubiquity of Computer Vision

The current wave is the integration of AI in many areas of our society; computer vision – powered by deep learning – will be the next technology to reach the same level of maturity and integration.

4.1.2.2 Cluster Contribution and Strategic Research Lines

The Cluster envisions smaller, smarter, long endurance, collaborative intelligent/autonomous systems, as well as the convergence of deep learning and communications, and the ubiquity of computer vision. The relevant research activities include the following:

- Development of new sensors based on a better understanding of the relation between sensing and knowing. NIS will combine multiple expertise to develop new knowledge in this domain. Electronics, micro-fabrication, sensing and machine learning shall work together towards new, smaller, smarter and adaptable sensing systems.
- Solutions and protocols for the identification of sensors (where they are, what they do, to whom they belong to).
- The study and production of biodegradable sensors.
- Development of resilient sensors and data networks for autonomous systems, including those deployed at remote places and in extreme environments. NIS aims to develop new solutions addressing “unknown unknowns” in several areas and environments, such as Deep-Sea environments. Multiple disciplines have to be combined towards the development of technological solutions that contribute to reveal novel phenomena, life conditions, species and resources in extreme environments.
- Novel micro and nano-sensing technologies by integrating optical and RF bioradar approaches.
- New wireless networking solutions for extreme environments such as aerial and maritime. The focus is on wireless networks and mobile communications, extending infrastructure networks and enabling the Internet of Everything in terrestrial and maritime environments, contributing to truly ubiquitous connectivity. This includes the design of novel algorithms and mechanisms and requires theoretical and simulation modelling, implementation, and experimental evaluation of communications networks and their elements. The main expected contributions include network topology control, routing, radio resource management, and context-aware optimization using cross-layer techniques and machine learning for networking.
- Focus on the development of intelligent systems, combining content-understanding capabilities with any available additional information to enable sophisticated recognition. We aim at making contributions to machine learning algorithms that can efficiently receive expert knowledge and seamlessly combine evidence from multiple sources (particularly, visual), outputting a sparse and interpretable decision.
- Towards the development of the next generation of computer aided diagnosis tools to support medical decision making, we will adopt holistic approaches by considering multi-modal and multi-sensor data. Data to be used in the different scenarios include images of different types, as ultrasound images, radiological images or microscopic images of digital pathology slides. Other complementary data will be used as from liquid biopsy or from patient metadata.

In line with this contribution, the Cluster focuses on the following strategic research lines: (1) sensing, (2) communications, (3) computer vision, and (4) autonomous systems.

4.1.3 Main Achievements in 2018

- Design of a new laser direct writing system with linear movement combined with beam scanning (with infinite field of view).
- Several developments on different types of sensors, some leading to patent submissions:
 - ✓ Demonstration of magnetic field sensors based on optofluidics (microfluidics channels filled with magnetic fluids);

- ✓ Ring-Down Technique Using Fiber-Based Linear Cavity for Remote Sensing (Patent pending);
 - ✓ Demonstrated the identification and classification of healthy vs cancer cells using Intelligent optical fiber tweezers (patent submitted).
- Optimization of LIBS signal processing schemes and calibration transfer protocols to enable true quantification in complex samples (2 EP submitted);
 - Demonstration of compositional mapping in complex mineral using LIBS technology. Validation with the test case of lithium from Portuguese mines exploration;
 - Implementation of new low-cost interrogation system for fiber-based sensors in environmental applications;
 - Lensless, calibration free imaging through multimode optical fibres: a solid base in the area of imaging and wavefront shaping through complex media has been established, opening up pathways for interesting developments in this subject;
 - Submarine Lidar setup: a compact laboratory LIDAR prototype was setup, aiming at its integration in submarine operation in rovers or unmanned automatic marine vehicles, with the purpose of assisting 3D mapping of flooded mines and sea operation. The specifications of the system were established and tested in lab environment, before submarine integration and testing.
 - PISCES team was selected as one of nine finalists of the Shell Ocean Discovery XPrize international competition. The PISCES team approach is based on the combination of different marine robotic platforms to devise an effective and efficient solution for the exploration of the seabed. These platforms must be operated together and incorporate acoustic navigation and a mapping system.
 - Successful participation in the final demonstration of the SUNNY European project. This project aimed at the development of a monitoring system based on multiple UAVs with detection, identification and automatic classification capabilities, redundant air-to-air, air-ground communications, and a single command and control centre and aircraft with autonomous flight, capable of integrating the perception in the loop control. It also required the development of a multi-technology solution for UAV-UAV and UAV-Ground communications using TV White Spaces and the 2.3 GHz frequency band together with a Layer-2.5 routing protocol.
 - Successful participation in projects aiming at the autonomous exploration and mapping of Europe's flooded mines. Within the scope of the UNEXMIN project, the first field trials with the UX-1 robot were run at the flooded Kaatiala mine site in Finland. The tests and the final demonstration of the iVAMOS! Project took place at the Silvermines mine, Ireland. The tests were carried out through a virtual reality interface and were accompanied by the test of the innovative autonomous underwater vehicle (EVA – Exploration VAMOS AUV), which was developed by INESC TEC to support the mining activity.
 - Design and analysis of a low power CGRA accelerator for biomedical signal processing.
 - Dental pressure detection and nerve stimulation demonstration prototype.
 - Design, fabrication and measurement of a frequency up-down converter and antenna for underwater Wi-Fi communications.
 - Proposal of an underwater communications approach based on resonant inductive links.
 - Design of a full-custom circuit and physical layout of an ultra-low power Real-Time-Clock for the Internet-of-Things.
 - Design of novel topology control and routing algorithms for flying networks, which enable on-demand network infrastructure deployment for temporary events such as music festivals and disaster areas.

- Development of a novel MAC protocol running over standard IEEE 802.11 wireless cards for long-range, broadband ship-to-shore communications in alternative to Satellite communications, with the successful demonstration at the Lisbon Naval Base together with the Portuguese Navy.
- New approaches and algorithms integrated in a framework for the identification of advertisements in broadcasted content using a multimodal approach. Research achievements integrated in commercial equipment.
- Creation of a Word2Vec model for the (European-) Portuguese language.
- Development of machine learning approaches for relevant object detection in photos for a set of pre-defined scenarios: fashion, events and photojournalism.
- Development of machine learning approaches for the identification of personalities in multimedia content.
- Development of Robust Clustering-based Segmentation Methods for Fingerprint Recognition.
- Development of methods for driver drowsiness detection.
- Development of methods based on Elastic Deformations for Data Augmentation in Mass Detection in mammography.
- Automated Methods for the Decision Support of Cervical Cancer Screening using Digital Colposcopies.
- Best paper Award at the ICMLA 2018 - 17th Conference on Machine Learning and Application.
- Seizure Journal Editor's Choice for the paper "Quantitative and qualitative analysis of ictal vocalization in focal epilepsy syndromes".
- Development of transversal deep information learning based on supervised learning and multiple instance learning framework for image quality and abnormality detection in images. This generic methodology has been applied with success to different image data, published in top-ranked journals and achieved top-10 performance on histology, retinal segmentation and skin and eye surgery topics, in international competitions.
- One C-BER team in the top 10 of challenge Skin Lesion Analysis Towards Melanoma Detection.

4.2 POWER AND ENERGY

Coordinator: Manuel Matos

Core Centres: *Centre for Power and Energy Systems (CPES)*

Associated Centres: *Centre for Industrial Engineering and Management (CEGI), Centre for Telecommunications and Multimedia (CTM), Centre for Enterprise Systems Engineering (CESE), 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).*

4.2.1 Presentation

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 (EV) 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, soft computing and data science.

CPES is the core Centre of the Cluster, as it is clearly where the sector critical mass is concentrated, but the evolution of the energy system, particularly the electrical power system, has supported the involvement of other competences, held by associated Centres, due to the multidisciplinary nature of the problems and opportunities to address. There are already examples of this collaboration and joint projects, in the areas of information and communication technologies (CTM), data science (LIAAD), data platforms and hubs (HASLab), asset management (CEGI) and combined energy and process optimization in industry (CESE). More than sharing projects, the goal is to foster a multidisciplinary approach to support current applied research and technology transfer, but most of all, to design the scientific strategy for this particular domain, distributed among the different Centres of the cluster, that will guarantee the creation of new knowledge to support the future challenges of a digital and decarbonized energy system.

The cluster council is presently composed of: Manuel Matos (coordinator), Carlos Moreira, Jorge Pereira, Ricardo Bessa, Nuno Fidalgo, Clara Gouveia (all from CPES) and representatives of the Board. Representatives of the associated clusters are invited to participate in the meetings of the cluster council when appropriate.

4.2.2 Vision and contribution

4.2.2.1 Future vision of the domain

The PE cluster vision is aligned with the EU policies for digitalization, energy efficiency and increase RES integration, as described below in the following strategic research vectors. These vectors highlight the main challenges envisaged by the core Centre and define the requirements that other scientific competences, located in the associated Centres, need to develop to be able to respond to the future requirements of the sector.

TRANSFORMING THE ENERGY SECTOR THROUGH SYNERGIES BETWEEN ADVANCED MATHEMATICAL MODELLING AND DIGITAL TECHNOLOGIES

The digitalization of the energy sector requires a **multidisciplinary approach** and **co-creation of new business models**. Technology from other domains, namely **internet-of-things (IoT), sensors, blockchain and big data** platforms, need to be adapted and, in some cases, enhanced to comply with specific requirements and contribute to consumer empowerment, feasibility and replicability of new business models, smart grids and buildings. Digital solutions provide additional monitoring and control capabilities that create technical conditions for new business models, enable different stakeholders to create their value, and simultaneously maintain high levels of cybersecurity and data privacy in critical infrastructures like the electrical grid.

Nevertheless, **digital technologies are only a fundamental infrastructure** to integrate **advanced mathematics**¹, such as mathematical distributed optimization, data-driven optimization, hybridization of classical mathematical optimization, metaheuristics and/or machine learning, data assimilation and control theory. Basic research in this area will **increase the competitiveness of the PE Cluster and its Centres** and **materialize the application of artificial intelligence (AI) in the energy domain**, covering human-centric and grid-centric use cases. To maximize the R&D impact in a sector characterized by several cognitive bias from decision-makers and to have steep learning curves, R&D in data visualization, advanced training procedures for human operators (e.g. augment and virtual reality) and novel cost-benefit and multicriteria analysis methodologies for new technology, are essential. Finally, **scalability is a critical barrier and should be tackled at low TRL**, e.g. through high-performance computing, quantum programming and exploit distributed approaches with graphics processing unit (GPU).

CREATING A FULL DECARBONIZED POWER SYSTEM WITH NOVEL SOLUTIONS

The **full and enduring decarbonization** of the power system **requires significant advances in the state-of-the-art** and a combination of **new computational, hardware and regulatory solutions**. This future scenario is composed by a massive connection of power electronics interface generation, active participation of RES and consumers in ancillary services, integration of multi-energy carriers, cross-border exchange of energy and data.

The R&D needs will be identified by preliminary studies (simulating alternative operation scenarios) that will evaluate the electric power system behavior and anticipate the requirements that industry will have in the upcoming years. This should include new planning and operational methodologies for the electrical infrastructure, focused on distributed control architectures and expansion of pan-European grids. Moreover, it should consider ICT and mission-critical IoT to increase **grid resilience under extreme weather and hazard scenarios** and contribute with predictive strategies procedures for black-start, self-healing and islanding operations in systems dominated by grid inverter-based generation.

In a system with high RES integration, a **paradigm shift from deterministic to stochastic approaches** for both interconnected and isolated systems (e.g., islands) is mandatory. This will require new mathematical algorithms based on convexification and decomposition techniques and human-in-the-loop approaches, which provide fast and clear advices, and handle local technical problems that may be created by DRES.

BRIDGING THE GAP BETWEEN RESEARCH RESULTS AND INDUSTRY BUSINESS CASES WITH A MULTIDISCIPLINARY APPROACH

Concepts such as microgrids, multi-microgrids and active grid management have been implemented successfully in different pilots along Europe and technically supported by industrial actors (e.g., EFACEC, Siemens, GE). However, **two main barriers remain to achieve replicability and scalability**: (a) **regulation** has been a bottleneck for this paradigm to scale up; (b) **cybersecurity and interoperability** have also limited the implementation in the field of these innovative concepts.

In this context, **new regulatory frameworks** should be proposed to support disruptive models, such as peer-to-peer trading, but **taking into consideration the fundamentals of the electrical system, i.e., to satisfy with the proper quality of service the end-user needs**. This should cover different areas, such as power systems, economics and behavioral sciences. Combining domain knowledge from electric power systems with other areas, particularly **cybersecurity and interoperability** through ontologies and cross-domain IoT, will allow creating the **market conditions for large-scale deployment and replicability** of concepts developed by CPES in previous European and national projects.

¹ National Academies of Sciences, Engineering, and Medicine. (2016). Analytic research foundations for the next-generation electric grid. National Academies Press.

4.2.2.2 Cluster contribution and Strategic Research Lines

One of the key objectives for the PE cluster is to continue and improve the process of associating other Centres of INESC TEC, addressing the vision described in section 4.2.2.1, where the scientific competences of other clusters will help to maximize the impact of the research and innovation in this field. The PE cluster identified inside INESC TEC the following list of key competences to realize its Vision:

- O&M and asset management – CEGI
- Data mining, machine learning and deep learning – LIAAD, CTM
- Operations research – CEGI, CESE
- Blockchain, big data and human-computer interaction – HASLab, CSIG
- Cybersecurity – CRACS, HASLab, CTM
- Internet-of-things – CTM
- Robotic autonomous systems – CRAS
- Fiberoptic and non-intrusive sensors – CAP

In line with this contribution, the Cluster focuses on the following strategic research lines: (1) towards 100% RES integration and massive integration of power electronics-based interfaces; (2) large-scale modelling and optimization of energy systems; (3) data-driven methodologies for energy systems; (4) asset management and predictive maintenance; (5) cybersecurity and Internet of Things (IoT) for critical infrastructures (electricity generation, transmission and distribution).

4.2.3 Main Achievements in 2018

- Development of a Multi Year Long Term Transmission Expansion Planning Model considering uncertainties from the demand and hydro inflows using meta heuristic techniques and incorporating the full AC OPF model to characterize the operation of candidate system configurations resulting from possible expansion plans.
- Development of data-driven energy optimization strategies for a wastewater pumping station by using a combination of reinforcement learning and machine learning.
- Development of a probabilistic state estimator for low voltage grids based in analog-search algorithms.
- Industrialization of a multi-period optimal power flow tool.
- Development of grid load forecasting algorithms based in machine learning and deep learning algorithms.
- Development of stochastic optimal power flow algorithms for distribution grid predictive management.
- Use of convolutional network networks for classifying power system outage events from phase measurement units (PMU) data.
- A three-phase inverter prototype developed in CPES was field-proven for the first time in an islanded operation of a real microgrid in Évora – Portugal. The fault-ride-through control mechanism developed and validated in Smart Grids and Electric Vehicles Laboratory (SGEVL) using Power Hardware-In-the-Loop (PHIL) test infrastructure with real network models was proven robust and accurate.
- Definition of a grid code for new renewable generation systems to be connected to the Madeira island system. The code establishes specific connection requirements for converter-interfaced generators that were categorized in classes according to a previously defined conceptual model. Dynamic requirements and quasi-steady state connection requirements were defined.
- Extension of dynamic simulation platforms previously developed under a scope of “inverter-dominated islanded power systems” to a simulation platform for 100% power electronic power

systems, involving advanced modelling concept for grid forming inverters and its performance during fault conditions.

- Development of a “grey-box” dynamic equivalent model for active distribution networks, considering a heterogeneous mix of generation technologies alongside the latest European grid codes requirements. It aims to properly represent the transient behaviour of the system upon large voltage disturbances in the transmission side.
- Development of a data predictive control method for distributed energy resources aggregated in a virtual power plant. Two different approaches, i.e. reinforcement learning and supervised learning, were developed and compared to minimize the deviation between the operating point of the energy resources and an automatic generation control (AGC) signal.
- Development of a multi-temporal approach for the energy scheduling and voltage/var control problem in a PV-battery Microgrid Cluster (MGC) system during islanded operation conditions.
- A two-stage stochastic optimization model has been developed to support an aggregator of small prosumers in its market participation strategy.
- Development of advanced control strategies for Multi-Microgrids islanding operation through smart Transformers in order to enhance the possibility of islanding by coordinating the control flexibility of all the available resources.
- A proactive distribution management stochastic approach based on chance-constrained programming was developed to assist the DSO in the management of the distribution grid considering flexibility from distributed energy resources.
- A stochastic sequential AC OPF was developed to assist the DSO in the provision of reactive power flexibility to the TSO. The method takes advantage of DER to change their standard reactive power policies and provide reactive power according to the needs of the TSO/DSO coordination.
- A distributed/decentralized OPF was developed for unbalanced LV grids using ADMM approach to decompose the OPF problem into local/nodal sub-problems. Each node is responsible for solving its flow while collaborating with neighbour nodes.
- A computational tool was developed to optimize the ESS in order to define efficiently the degree of hybridization of the storage system (the number of cells of batteries and supercapacitors).
- In the context of energy conversion, a new modulation for the power converter designed as High-Frequency Link Matrix Converter (HFLMC) was developed. The proposed space vector modulation allows the control of the power factor in the power grid interface, as well as voltage and current at the load. An international patent application was submitted in order to protect the intellectual property of this work. The patent was already given in the United States and the regional processes in Europe and Japan are ongoing.

4.3 INDUSTRY AND INNOVATION CLUSTER

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

The Cluster Industry and Innovation at INESC TEC (c_I+I@INESC TEC) 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@INESC TEC result in high impact systems for decision support, operations automation, management and intelligence and in the provision of innovation management & technology transfer consultancy services in Industry, Retail, Healthcare, Energy, Mobility and Transports, Agriculture and Forestry.

The c_I+I@INESC TEC wants to position INESC TEC internationally as a leading research Centre in industry and innovation and as a first choice for supporting organisations to achieve high-levels of sustainable innovation and performance. It consists of four 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 and Manufacturing Intelligence;
- CRIIS, addressing of Industrial Robotics, Collaborative Robots, Mobile Robots and Intelligent Sensors and Dynamical Systems;
- CEGI, addressing Service Design, Decision Support, Performance Assessment, Asset Management and Prescriptive and Predictive Analytics;
- CITE, addressing Innovation Management, Technology Management and Technology Entrepreneurship.

The four core Centres of c_I+I@INESC TEC undertake research, technology transfer, consultancy services and executive education in complementary research domains (see Figure 1) strongly coupled and coordinated through the following collaboration axis: Innovation and Technology Management, 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 methodologies and 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.

4.3.2 Vision, Contribution and Research Lines

The cluster will undertake multi-disciplinary, system-oriented research and technology development for the strategic and operational management of industrial enterprises and networks. Its research will focus on connected and high customizable and sustainable transformation systems, helping companies from different sectors to achieve personalised and complex products and services, and to be flexible and resilient in their operations. It will direct its research strategy on these areas complying at the same time with the requirements of resource efficiency and circular economy implementation, as well as trying to achieve an optimal balance and integration between humans and machines. The cluster will also consolidate the leadership in knowledge and technology transfer on digital transformation, integration

of advanced manufacturing technologies and new business models, helping companies to fully embrace the 4th industrial revolution.

The Cluster has a vision of an ever-integrated supply chain across different industries (e.g., manufacturing and process industries). This vision materializes in a powerful production link that embeds Industry 4.0 concepts and transportation flows that are capable of using sensor information to replan daily activities. The cluster has been working on the hardware and operating systems that will advance manufacturing technologies with high flexibility, such as robotics. Nevertheless, to achieve the plenitude of this vision the impact in the overall decision-making strategies has still to be analysed. On one hand, focusing on the production link, the main contribution will be to evolve decision-making tools that will have to deal with production technologies with high flexibility, capable of performing different tasks with minimum reprogramming, of sensing the environment and working in environments designed for human-use. This new paradigm represents a challenge for the traditional production process modelling techniques, where machines are almost static resources and the flexibility is completely provided by the human resources. On the other hand, focusing on the entire supply chain, the cluster will explore the developments of the blockchain to address the new challenges brought up by on-demand external logistics.

Customer-centric and production optimisation in real time, as well the decentralization of decisions, will only be possible with highly flexible, realocable, adaptable and intelligent automation, control and robotics. The use of collaborative robots (mobile and manipulators); smart sensor networks, industrial vertical IoT-based information architectures and Human-robot collaboration and interface plays an important role in these processes and are key aspects of the Vision of the Cluster. Also, the cluster will focus on the development and implementation of intelligent systems, automation, management and decision support systems, among other technological solutions, in the areas of agriculture, forest and livestock in an integrated approach, fostering - the resilience, efficiency, competitiveness and sustainability of these areas towards an effective bio-economy.

Innovation has been recognised as a catalyst for future development of business and societies. Hence, all organisations claim it a priority on their strategy. However, in many cases, the question of a structured and supported process is left unanswered. From ideation to exploitation phase of innovation value chain, there is in fact a need to set up the right environment that supports a holistic culture of ideation and innovation within an organisation. Management of Innovation is the attainment of organisational innovation goals in an effective and efficient manner and is one of the key strategic tasks facing organisations of all shapes, sizes and sectors. Research suggests that the task of managing innovation is about creating firm, specific routines-repeated, reinforced patterns of behavior, which define its particular approach to the problem. However, technological innovation does not guarantee business success. New terminologies development efforts open new approaches for the entire business model. The design of the strategies to 'go to market' and 'capturing value' is a key factor for value creation. Technology management and Business models design often act as the bridge between technology and the ability to deliver a compelling customer value proposition.

In line with this contribution, the Cluster focuses on the following strategic research lines: (1) responsive, sustainable and resilient operations, including aspects from factory design to collaborative robotics and automation; (2) decision support in a digitised industry; (3) operational and strategic architectures for a data-driven industry; (4) technology adoption, management and policy for an inclusive industry; (5) mobility for the circular economy.

4.3.3 Main Achievements in 2018

- Reinforcement of the activities in the area of Asset Management, by increasing collaboration with Portuguese utilities.
- An intelligent dashboard that identifies operational inefficiencies in advanced health care management and healthcare logistics.
- Empirical test of the Theory of Performance Frontiers from Operations Management opening the possibility of evaluating firms' Corporate Social Responsibility using quantitative methods.

- Preparation, implementation and successful validation of several contract-based research projects supported by the developed reference framework based on 4.0 industry concepts and technologies, winning new clients of significant strategic importance for future research activity (e.g. GALP Energia and Grupo Amorim).
- Consolidation of the collaboration with IKEA Industry in the areas of factory design and operations planning.
- An hierarchical and hybrid performance assessment model considering key sustainability indicators in the Make-to-Order Supply Chains, common in industries such as the aerospace.
- An augmented reality human machine interface for cooperative assembly operations, providing information to the operator about the task to perform its work areas and those of the robot.
- 3D object detection pipeline, specially designed for enhancing the perception of robotic manipulators during pick and place operations.
- Development of a collaborative mobile manipulator that it is capable of autonomously navigate to the inside of a vehicle, where it performs several non-ergonomic fastening operations, and sharing both its working space and task with a human operator.
- An adaptive framework for automated cells modeling, simulation, and offline robot programming.
- Design and development of a robotic platform that incorporates an innovative robotic arm acting as a “hand” for grasping and pulling trolleys, tested in hospital environment.
- Development of AgIoT, an open source IoT solution that can be applied to the domain of Agrifood, and of SenseNPK, a sensing system for macronutrients estimation over ISOBUS system applied to HERCULANO slurry tanker.
- Definition of a common, open, scalable, and adaptable reference production system architecture, entitled Open Scalable Production System, which empowers advanced robotic systems to flexible, effective and intuitive integration with existing automation equipment and enterprise-level modules.
- Launch of the 3rd edition of Business Ignition Programme a ERDF co-funded project from U.Porto Inovação, CIIMAR and INESC TEC, that developed a state-of-the-art programme for build and test alternative business models for the exploitation of technologies developed in academia. Twelve technologies submitted and evaluated during the last edition of the programme.
- Pursuing of an international leadership positioning, through participation in the editorial boards of renowned international journals, participation in the scientific committee of well-known conferences, and leadership of European working groups and European projects.

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

The mission of the Computer Science Cluster is to achieve international excellence in both fundamental and applied research, with strong emphasis and impact on technology innovation and transfer that benefits society at large.

Our commitment encompasses many core areas from programming languages and rigorous software development to complex information systems, from data processing to large scale computing, from embedded systems to virtual environments, and from security to quantum computing, with the goal of bringing better intelligence into everything.

The Cluster addresses diversified, heterogeneous and yet complementary research areas. The main research areas are:

- Software engineering
- Programming languages
- Information and Database management systems
- Bigdata, Computational and Data science
- Machine learning and Model-driven decision support
- Distributed computing and systems
- Computer graphics and Virtual environments
- Cryptography, Information security and privacy
- Embedded and special purpose computing systems
- Accessibility and Assistive technologies

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.

4.4.2 Vision and Contribution

4.4.2.1 Future Vision of the domain

Computing is becoming ubiquitous, decentralized and mobile, reaching all devices, appliances and living beings, in real time, producing enormous amounts of data, which can produce a wealth of information if properly mined, challenging individual privacy and society fundamentals. More intelligent and autonomous systems will change the way we live and work. New interfaces will enable more immersive and inclusive interactions among humans and machines, blurring real and virtual environments.

4.4.2.2 Cluster Contribution and Strategic Research Lines

The Cluster is in a unique position to address many of the technological and societal challenges mentioned above, thanks to the complementary competences of its core research Centres, in areas such as advanced computing, security, privacy, big data, machine learning and immersive multisensorial human computer interfaces.

In line with this contribution, the Cluster focuses on the following strategic research lines: (1) big data and machine learning; (2) privacy-preserving computing; and (3) virtual environments, including immersive virtual environments, augmented and virtual reality.

4.4.3 Main Achievements in 2018

- Publication of “Indifferentiable Authenticated Encryption”, where the theoretical foundations for analysing and constructing strong forms of encryption schemes were launched, and of “Delta State Replicated Data Types”, that establishes the foundations for efficient synchronization of state in global systems, and that has already led to several industrial implementations.
- Consultancy projects with Amazon, on machine-checked security proofs for cryptographic protocols, and with Redis Labs, on multi-master replication and distributed systems.
- Organisation of the 13th European Conference on Computer Systems (EuroSys 2018) and of the 22nd edition of the International Conference on Theory and Practice of Digital Libraries (TPDL) in Porto.
- Implementation of a prediction-based pruning strategy for Probabilistic Inductive Logic Programming (PILP) systems aimed to reduce the search space based on the probabilistic evaluation of previously evaluated theories, with application of a PILP predictive model to breast cancer data.
- Leveraging on the work done in the HYRAX project, we now address the challenges put forward by the IoT security and privacy in a new Portugal-CMU project called Angerona.
- Enforcing privacy and security in public cloud storage with the implementation of a broker, named ARGUS, which acts as a proxy to the existing public cloud infrastructures by performing all the necessary authentication, cryptography and erasure coding.
- Design and implementation of LRMalloc, a novel lock-free memory allocator that leverages lessons of modern memory allocators and combines them with a lock-free scheme.
- Development of systems to automatically crawl and identify information that is potentially relevant to a general audience. The system bases its work in social media by filtering personal, trivial or fake information, and focusing on trendy or controversial topics.
- Graph mining: development of a new accurate method for comparing temporal networks based on graphlet-orbits transitions.
- Multisensory Virtual Reality and Augmented Reality, including 360° video, are reaching maturity, mainly due to an effort in creating intuitive authoring tools. This has been successfully implemented in distinct projects, from private contracts with the industry, for learning, training and communication, to scientific projects in areas like perception, science communication and museums.
- Conclusion of the Google DNI funded project Algorithmic Science News (ASN), and start of the project Stop PropagHate, another Google DNI funded project.
- European research was also reinforced with three new projects: iReceptor+, EUCAN CONNECT and TIPES. The first two are part of a more than a decade-long stream of EU-funded projects in e-health.
- Arquivo.pt prize awarded to the web portal “Conta-me histórias”, which, given a topical query, has the capability of going through the Portuguese web archive and produce a proto-narrative in the form of a chronological sequence of relevant statements extracted from the news.
- Best short paper award at ECIR 2018, the European Conference on Information Retrieval, with the title “A Text Feature Based Automatic Keyword Extraction Method for Single Documents”.
- Three books were published.
- Organization of the Advanced School on Data Science for Big Data, EAIA 2018 in Porto, which attracted more than 150 participants.

4.5 Main Indicators by Cluster

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	31	18	30	23
		Academic Staff	38	10	33	74
		Grant Holders and Trainees	111	53	94	160
		Total Core Researchers	180	81	157	257
		Total Core PhD	65	25	57	112
	Affiliated Researchers		14	6	19	29
	Administrative and Technical	Employees	8	1	6	2
		Grant Holders and Trainees	1	0	0	3
		Total Admin and Tech	9	1	6	5
	Total Integrated HR		203	88	182	291
Total Integrated PhD		79	30	73	141	
Curricular Trainees			1	0	11	3
External Research Collaborators			27	12	62	74
External Administrative and Technical Staff			0	2	4	4
External Students			41	7	13	59
Total			272	109	272	431

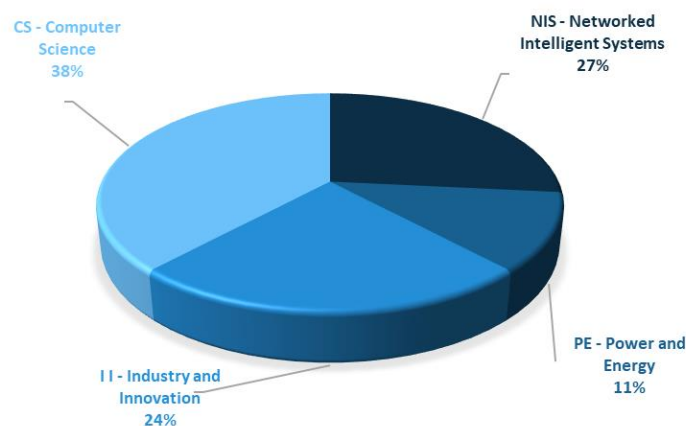


Figure 4.2 - Human Resources by Cluster

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	990	405	488	396
	PN-PICT	National R&D Programmes - S&T Integrated Projects	964	34	467	962
	PN-COOP	National Cooperation Programmes with Industry	475	56	519	201
	PUE-FP	EU Framework Programmes	719	855	953	1 100
	PUE-DIV	EU Cooperation Programmes - Other	137	192	322	56
	SERV-NAC	R&D Services and Consulting - National	327	870	956	365
	SERV-INT	R&D Services and Consulting - International	246	98	73	93
	OP	Other Funding Programmes	126	27	30	228
	Total Active Projects		3 984	2 538	3 808	3 401
Total Closed Projects		30	199	10	70	
Total Funding		4 014	2 738	3 818	3 470	

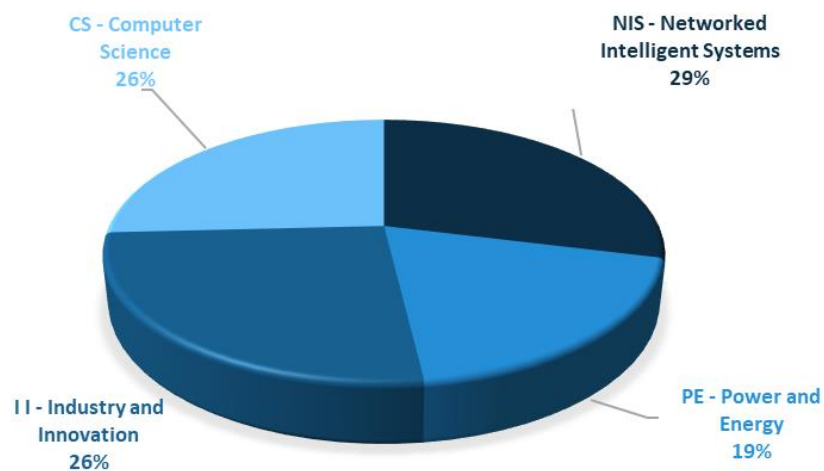


Figure 4.3 - Project Funding by Cluster

4.5.3 Publications

The information on publications for 2018 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

Publication Type	Clusters			
	NIS	PE	II	CS
Indexed Journals	75	71	77	103
Indexed Conferences	99	62	77	228
Books	1	0	1	3
Book Chapters	2	7	18	13
PhD Theses - Members	5	7	18	10
PhD Theses - Supervised	8	14	20	32

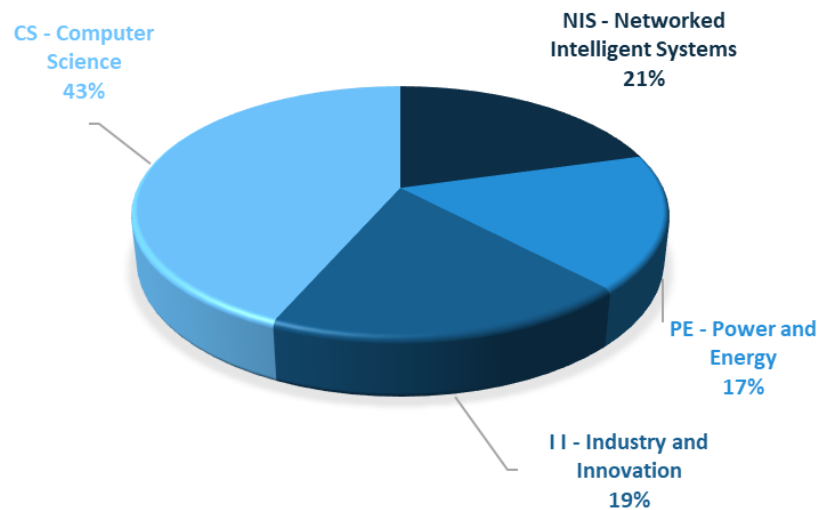


Figure 4.4 - Indexed Articles by Cluster

5 RESEARCH AND DEVELOPMENT CENTRES

5.1 CTM - CENTRE FOR TELECOMMUNICATIONS AND MULTIMEDIA

Coordinators: Jaime Cardoso and Filipe Ribeiro

5.1.1 Presentation of the Centre

The Centre for Telecommunications and Multimedia (CTM) consists of 100+ researchers addressing scientific and technological challenges related with 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:** Research and development of advanced systems and technologies enabling high capacity, efficient 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 (OET); Wireless Networks (WiN); Multimedia and Communications Technologies (MCT); Information Processing and Pattern Recognition (IPPR).

5.1.2 Contribution to the Vision of the Cluster

CTM strongly contributes to the NIS vision of autonomous networked intelligent hybrid systems enabled by ubiquitous sensing and processing of information. CTM contributes to the research in new sensors which are low power or nanoscale to enable the envisioned “electrosphere of sensors”. CTM is responsible for the communications aspects of NIS; CTM has focused its activities on wireless communications for dynamic and challenging scenarios, well aligned to the NIS vision. The CTM’s expertise in machine learning and audiovisual data interpretation and management provides the means to make sense of the acquired data; the semantic knowledge built from the integration of the network of sensors will allow acting over the environment as well as over the content.

Through NIS to other Clusters, CTM’s work can be an input to other scientific and development activities in INESC TEC. CTM’s work on the fundamentals of Artificial Intelligence on novel algorithms for Machine Learning can be used by all Clusters. Also relevant for the CS Cluster is CTM unique expertise on multimedia, including the manipulation of new media formats such as Multiview, panoramic, 3D and 360° audio and video, the semantically and context-aware management and handling of media content and the development of personalised and adaptable multimedia services. Its unique communications line at the institute provides the fundamentals to any digital transformation in any application at any environment, the capacity to transmit high volume of data and ways to contextualize it. For PE Cluster, solutions to transmit metering data from millions of smart meters and other utilities resources with critical requirements; for the II Cluster, solutions to support massive machine to machine type communication required by the industry IoT; for CS cluster, ways to tag and to wirelessly transmit massive volumes of data required by the multimedia applications.

5.1.3 Research and Innovation Progress in 2018

The number of total Core Researchers remained stable, providing the means to the successful execution of the R&D and industry collaboration projects running in the Centre. The market job in our areas of activity is becoming very competitive, increasing the difficulty of hiring high quality young Researchers. This may impact our activity in the next years.

In 2018, CTM global funding was also well aligned with previous years. Although the funding from National Programmes (R&D and Cooperation with industry) has increased markedly, the funding from EU Programmes decreased by a similar value. In terms of integrated value chain and the Technology Readiness Level (TRL) of CTM projects, although most of our activity is centred in Knowledge Production

(TRL 1-3) and Applied Research (TRL 4-5), our activities still intersect Development (TRL 6-7) and touches Technology Transfer (TRL7 8-9).

In 2018, CTM was extremely successful in raising Individual PhD FCT Scholarships, with eight scholarships awarded to CTM Researchers. Simultaneously, CTM was also extremely successful in raising FCT Research Projects, with nine projects initiated from 2017 Call for SR&TD Project Grants. These two achievements should set the path to raise the excellence and increase the main indicators in the Science axis.

The 2018 edition of the VISUM summer school organized by CTM Members was extremely successful, attracting participants from all around the world, strongly contributing to the international visibility of CTM. It is also worth to highlight the work in the research line of maritime communications, with the successful demonstration at the Lisbon Naval Base together with the Portuguese Navy of new solutions for broadband ship-to-shore communications. Finally, the development of an automatic tool to improve perforators detection in Angio CT in DIEAP flap breast reconstruction has already led to a new CTM patent.

5.1.4 Main Achievements in 2018

The main broad achievements obtained by **CTM in 2018** were the following:

- More than 20 articles published in relevant scientific journals, the majority of them in journals classified by SCOPUS as “1st Quartile” and “2nd Quartile”;
- Eight Individual PhD FCT Scholarships were awarded to CTM Researchers in the 2018 Call for PhD Scholarships;
- Nine FCT Research Projects were raised and initiated, from the 2017 Call for SR&TD Project Grants;
- CTM researchers organized two advanced training courses; the events took place in Porto;
- The CTM Open Day was organised by CTM researchers in May 11th. The event, focused on “Artificial Intelligence: Redefining research on Communications and Multimedia”, invited Industry and Academia to participate in the discussion forum and to visit CTM and participate in activities conducted by CTM researchers.

The main achievements obtained by the **OET Area in 2018** were the following:

- Coordination of the final demonstration in H2020 project iBROW;
- Experimental evaluation of resonant tunnelling diode oscillators employing advanced modulation formats;
- FPGA-based implementation of a frequency spreading FBMC-OQAM baseband modulator.
- A parallel-pipelined architecture for an OFDM baseband modulator with dynamic frequency scaling for 5G systems;
- A scalable computing array to parallelize and accelerate the execution of cellular genetic algorithms with application to the minimum energy broadcast problem;
- Approach to reduce the high-dimensional data collected from IJTAG operation through compressed sensing using LDPC-based feature reduction and machine learning;
- Design and analysis of a low power CGRA accelerator for biomedical signal processing;
- High speed programmable ring oscillator using InGaZnO Thin-Film Transistors;
- High-gain transimpedance amplifier for flexible radiation dosimetry using InGaZnO Thin-Film Transistors;
- Design and simulation of a meta-material based impedance matching surface for microwave imaging.
- Design of a low-pass CMOS sigma-delta converter;
- Proposal of saliva testing as a means of health monitoring;

- Dental pressure detection and nerve stimulation demonstration prototype;
- Design of an implant for neuromuscular electrical stimulation;
- Modelling of Radiofrequency-Induced Hyperthermia within Electric Circuit Simulators;
- Design of a self-calibratable phased locked loop circuit;
- Design, fabrication and measurement of a switched antenna array for maritime communications;
- Design, fabrication and measurement of a frequency up-down converter and antenna for underwater Wi-Fi communications;
- Design of a CMOS phase modulator for polar transmitters;
- Design of an integrated circuit implementing a dynamic load modulation scheme for digital transmitters;
- Proposal of an underwater communications approach based on resonant inductive links;
- FPGA implementation and evaluation of a symmetric double sided two way ranging (SDS-TWR) algorithm for geolocation purposes in harsh environments;
- Design of a full-custom circuit and physical layout of an ultra-low power Real-Time-Clock for the Internet-of-Things;
- Design and experimental evaluation of a noninvasive technique for vegetation water content perception;

The main achievements obtained by the **WiN Area in 2018** were the following:

- Design of novel topology control and routing algorithms for flying networks, which enable on-demand network infrastructure deployment for temporary events such as music festivals and disaster areas;
- Development of a novel MAC protocol running over standard IEEE 802.11 wireless cards for long-range, broadband ship-to-shore communications in alternative to Satellite communications, with the successful demonstration at the Lisbon Naval Base together with the Portuguese Navy;
- Design of a novel energy-efficient algorithm for green Wi-Fi networks, addressing the reduction of the energy consumption of Wi-Fi access points by dynamically configuring their operation mode according to the user traffic demand;
- Development of a multi-technology solution for UAV-UAV and UAV-Ground communications using TV White Spaces and the 2.3 GHz frequency band together with a Layer-2.5 routing protocol, with the successful demonstration at the final review of the FP7 SUNNY project;
- Development of the Offline Experimentation approach enabling the replication of real experiments in ns-3 environment in the same exact conditions as the actual experiment, with a potential huge impact in the networking community when it comes to the repeatability and reproducibility of networking experiments, namely in emerging networking scenarios such as flying networks and maritime networks;
- Design of Quality of Service Estimator for flying networks using a Machine Learning approach;
- Development of a Machine Learning Approach for Path Loss Estimation in Emerging Wireless Networks;
- Submission of new project proposals enabling the continuation of the work being developed along our strategic research lines, including flying networks and maritime networks.

The main achievements obtained by the **MCT Area in 2018** were the following:

- New approaches and algorithms integrated in a framework for the identification of advertisements in broadcasted content using a multimodal approach. Research achievements integrated in commercial equipment;

- Development of a word embedding framework for enhancing semantic and syntactic relationships of metadata for media description;
- Creation of large training corpus representative of the Portuguese language to be used for word embedding approaches to NLP;
- Creation of a Word2Vec model for the (European-)Portuguese language;
- Development of machine learning approaches for relevant object detection in photos for a set of pre-defined scenarios: fashion, events and photojournalism;
- Development of machine learning approaches for the identification of personalities in multimedia content;
- Development of an assisted metadata annotation tool for enhancing and refining region-based multimedia content description;
- Development of algorithms for context acquisition and reasoning on mobile devices;
- Development of algorithms for the identification of perceptually relevant regions in photos;
- Development of an open source Sound Morphing MATLAB toolbox for modelling and transformation of musical sounds;
- Development of a method for enhancing band-limited musical recordings using convolutional autoencoders;
- Development of a Drum break-informed audio decomposition and transformation using non-negative matrix factorisation;
- Development of new content visualisation approaches for large multimedia collections;
- Submission of new H2020 project proposals enabling the continuation of the work being developed along our strategic research lines, namely immersive multimedia applications, digital television and new media services, machine learning applications for audio visual data, sound and music computing, image and video processing.

The main achievements obtained by the **IPPR Area in 2018** were the following:

- Development of algorithms for interpretability using Deep Neural Networks;
- Development of a method based on a uniform performance index for ordinal classification with imbalanced classes;
- Development of a class imbalance ordinal method for Alzheimer's disease classification;
- Development of Robust Clustering-based Segmentation Methods for Fingerprint Recognition;
- Development of Deep Learning approaches for Hemangioma lesion segmentation.
- Development of methods for driver drowsiness detection;
- Development of algorithms based on transfer learning for fall detection;
- Development of methods based on Elastic Deformations for Data Augmentation in Mass Detection in mammography;
- Development of methods for minutiae extraction in fingerprint based on deep learning;
- Development of algorithms for Binary Ranking for Ordinal Class Imbalance;
- Development of algorithms for Multimodal Learning in the Recognition of Sign Language;
- Development of algorithms for Emotion Recognition based on Physiological Inspired Deep Neural Networks;
- Development of algorithms for prediction of cervical cancer diagnosis based on supervised deep learning embeddings;
- Deep Learning Approaches for the Forensic Evaluation of Sexual Assault;
- Development of algorithms for Ordinal Image Segmentation using Deep Neural Networks;
- Deep Image Segmentation methods based on Quality Inference;

- Automated Methods for the Decision Support of Cervical Cancer Screening using Digital Colposcopies;
- Development of a Regression Model for Predicting Shape Deformation after Breast Conserving Surgery;
- The development of an automatic tool to improve perforators detection in Angio CT in DIEAP flap breast reconstruction;
- Development of algorithms for Deep Homography Based Localization on Videos of Endoscopic;
- Organisation of VISUM 2018 Summer School;
- Participate in the organisation of 1 international scientific event, ICIAR 2018;
- Participation in the round table at C-Health congress entitled Use technology to "take care";
- Approval of 5 FCT projects in the area of Computer Vision and Machine Learning applied to: Lung Cancer, Biometrics for self-driving cars, Colour Analysis related to sulphonamides detection in water, microscopic analysis of for blood samples characterization and Cervical Cancer;
- Best MSc thesis award by APRP.

5.1.5 Centre Organisational Structure and Research Team

The Centre for Telecommunications and Multimedia is coordinated by Jaime Cardoso and Filipe Ribeiro and is organised in 4 areas: Optical and Electronic Technologies (OET), led by Luís Pessoa; Wireless Networks (WiN), led by Rui Campos; Multimedia and Communications Technologies (MCT), led by Paula Viana; Information Processing and Pattern Recognition (IPPR), led by Hélder Oliveira. The Secretariat is supported by Renata Rodrigues. The Coordination Council of CTM includes the Coordinators, Area Leaders and the Administrative Assistant. The Scientific Council of CTM includes most of the PhD Members of the Centre. The CTM representatives in INESC TEC Scientific Council are Henrique Salgado and Paula Viana.

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			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	7	7	10	3
		Academic Staff	21	22	14	-8
		Grant Holders and Trainees	46	49	53	4
		Total Core Researchers	74	78	77	-1
		Total Core PhD	36	34	25	-9
	Affiliated Researchers		8	8	9	1
	Administrative and Technical	Employees	1	1	1	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	1	1	1	0
	Total Integrated HR		83	87	87	-8
	Total Integrated PhD		43	41	34	-7
	Curricular Trainees		2	0	0	0
External Research Collaborators		8	7	12	5	
External Administrative and Technical Staff		0	0	0	0	
External Students		6	20	26	6	
Total		99	114	125	11	

5.1.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform and from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CTM - Project funding

Funding Source		Total Income (k€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	28	31	257	227
PN-PICT	National R&D Programmes - S&T Integrated Projects	333	497	290	-208
PN-COOP	National Cooperation Programmes with Industry	70	160	274	114
PUE-FP	EU Framework Programmes	431	223	189	-33
PUE-DIV	EU Cooperation Programmes - Other	104	22		-22
SERV-NAC	R&D Services and Consulting - National	120	129	253	124
SERV-INT	R&D Services and Consulting - International	75	29	116	86
OP	Other Funding Programmes	18	100	32	-68
Closed Projects		46	7	8	1
Total Funding		1 225	1 199	1 419	220

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	31	27	26	-1
Indexed Conferences	47	45	36	-9
Books				
Book Chapters	1	1		-1
PhD Theses - Members	6	4	3	-1
PhD Theses - Supervised	9	4	7	3

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

Type of Result	2016	2017	2018
Invention disclosures	9	1	1
Software copyright registrations	0	0	0
Patent applications	1	2	2
Granted patents	1	1	5
Licence agreements	3	1	0
Spin-offs	0	0	0

Table 5.6 - CTM - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	8	2	2
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	12	10	6
International events in which INESC TEC members participate in the program committees	37	28	52
Participation in events such as fairs, exhibitions or similar	29	3	5
Advanced training courses	4	2	2

5.1.7 List of Projects

Table 5.7 – CTM - List of project

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	WISE	Manuel Ricardo	01/06/2016	31/05/2019
PN-FCT	EVOXANT	André Marçal	15/06/2016	14/06/2019
PN-FCT	TEC4SEA-1	Rui Lopes Campos	01/09/2017	30/08/2020
PN-FCT	CompMash	Matthew Davies	01/10/2017	30/11/2021
PN-FCT	CLARE	Jaime Cardoso	01/07/2018	30/06/2021
PN-FCT	LUCAS	Hélder Filipe Oliveira	26/07/2018	25/07/2021
PN-FCT	ENDURANCE	Luís Manuel Pessoa	01/07/2018	29/06/2020
PN-FCT	PEPCC	João Canas Ferreira	01/10/2018	30/09/2021
PN-FCT	AUTOMOTIVE	Ana Maria Rebelo	01/10/2018	30/09/2021
PN-FCT	HEMOSwimmers	Hélder Filipe Oliveira	26/07/2018	25/07/2021
PN-FCT	S-MODE	Hélder Filipe Oliveira	01/07/2018	30/06/2021
PN-COOP	MareCom	Rui Lopes Campos	01/03/2016	
PN-COOP	5G	Manuel Ricardo	01/01/2018	31/12/2020
PN-COOP	CHIC	Paula Viana	01/10/2017	30/09/2020
PN-COOP	WI-GREEN	Rui Lopes Campos	01/10/2016	
PN-COOP	BCCT.Plan	Hélder Filipe Oliveira	01/11/2016	31/10/2019

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-COOP	Cloud-Setup	Pedro Miguel Carvalho	01/07/2016	
PN-COOP	ROMOVI-1	Manuel Cândido Santos	07/01/2017	31/08/2019
PN-PICT	FOUREYES	Paula Viana	01/07/2015	30/06/2019
PN-PICT	SMILES-6	Manuel Ricardo	01/07/2015	30/06/2019
PN-PICT	CORAL-TOOLS-1	Rui Lopes Campos	01/01/2016	
PN-PICT	NanoStima-RL1-3	Henrique Salgado	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL5	Jaime Cardoso	01/07/2015	30/06/2019
PUE-FP	TERAPOD	Luís Manuel Pessoa	01/09/2017	31/08/2020
PUE-FP	FotoInMotion	Maria Teresa Andrade	01/01/2018	31/12/2020
SERV-NAC	Where.is	Luís Manuel Pessoa	01/12/2017	30/11/2019
SERV-NAC	UGREEN	Rui Lopes Campos	01/10/2017	30/09/2019
SERV-NAC	Arquitetura_IoT	Filipe André Ribeiro	01/12/2017	31/12/2018
SERV-NAC	ConnectedRefinery	Manuel Ricardo	01/01/2018	31/01/2019
SERV-NAC	TennisApp	Pedro Miguel Carvalho	01/09/2018	31/08/2019
SERV-NAC	NB-IoT	Filipe André Ribeiro	26/11/2018	25/05/2019
SERV-NAC	FollicleCounter	Hélder Filipe Oliveira	01/12/2018	31/07/2019
SERV-NAC	Consultoria	Manuel Ricardo	01/01/2010	
SERV-INT	RAWFIE-1	Rui Lopes Campos	01/09/2016	28/02/2019
SERV-INT	UnWSNet	Rui Lopes Campos	01/06/2018	31/05/2019
SERV-INT	SIMBED	Rui Lopes Campos	01/04/2018	31/03/2019
OP	Visum2018	Ana Maria Rebelo	01/01/2018	31/12/2018

Type of Project:

- PN-FCT National R&D Programmes - FCT
- PN-PICT National R&D Programmes - S&T Integrated Projects
- PN-P2020 National R&D Programmes - Portugal 2020
- PUE-H2020 EU Framework Programme
- SERV-NAC National R&D Services and Consulting
- SERV-INT International R&D Services and Consulting

5.1.8 List of Publications

International Journals with Scientific Referees

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Books

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Chapter/Paper in Books

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1. Aramaki, M, Davies, MEP, Martinet, RK, Ystad, S, "Music Technology with Swing - 13th International Symposium, CMMR 2017, Matosinhos, Portugal, September 25-28, 2017, Revised Selected Papers", CMMR, vol.11265, 2018

Dissertations (PhD)

1. Pinto, P., "Admission Control based on End-to-end Delay Estimation to Enhance the Support of Real-Time Traffic in Wireless Sensor Networks";
2. Ren, X., "IC protection against JTAG/IJTAG-based attacks";
3. Zolfagharnasab, H., "Toward a 3D Planning Approach for Breast Conserving Surgery";

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 organisation is non-hermetic and the development of solutions implies multidisciplinary and cooperative work from the different fields of the available expertise.

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 organisation of scientific meetings, the collaboration with the Department of Physics and Astronomy (DFA) of the Faculty of Science 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 Contribution to the Vision of the Cluster

CAP produces sensing technology to enable detection of physical, chemical and biological parameters. These are essential perception tools for the advanced system produced by other cluster partners, such as the robotics team.

In this context, CAP will consolidate the tendency of the recent years, cooperation with the other members of the NIS cluster in the incorporation of our sensors as perception tools for more advanced systems. Examples to consider include the following:

- Imaging Lidar technologies for enhancing the imaging capabilities of AUV and other vehicles;
- Analytical LIBS and UV VIS system, to provide real time analysis tools for incorporation in robots exploring hazardous environments;
- Fiber optic remotely interrogated sensors to provided monitoring awareness of critical facilities: eg. strain, temperature, corrosion monitoring of on shore and offshore facilities and vehicles.

5.2.3 Research and Innovation Progress in 2018

The recruitment of new researchers and the low participation in Horizon2020 and projects with industry partners were previously identified as weaknesses.

The first weakness was dealt with the upgrade of a dedicated laboratory with advanced photonics projects in order to raise interest in potential young researchers, with promising results in what concerns the recruitment of PhD students.

Concerning H2020 proposals, a strong effort was put in their submission but the success came more from the integration of the CAP research capabilities in more integrated proposals with other centers of INESC TEC, mainly CRAS. In what concerns projects with industry it was possible to achieve small budget proof-of-concept, preliminary, contracts that may induce bigger proposals in the following years.

The scientific outputs were in line with planned indicators but the funding mix needs to be addressed more deeply, in order to alleviate it from financial dependencies of national public funding, trying to diversify income sources, namely economic valorization projects with industry.

5.2.4 Main Achievements in 2018

The main achievements include the following:

- Update of the Bragg gratings fabrication set-up for fine control of the refractive index modification over the desired volume inside the fiber; spatial confirmation and amplitude of refractive index modification using refracted near-field techniques;
- Fabrication of long period gratings on the turning point on SMF-28 fibers; Comparison between UV and femtosecond written gratings regarding temperature resistance and sensitivity to temperature and strain;
- Design of a new laser direct writing system with linear movement combined with beam scanning (with infinite field of view);
- Demonstration of the contribution of the several loss mechanisms if femtosecond laser written waveguides in multicomponent glasses (Eagle 2000);
- Demonstration of magnetic field sensors based on optofluidics (microfluidics channels filled with magnetic fluids);
- Multipath Interferometer Polished Microsphere for Enhanced Temperature Sensing;
- Cleaved Silica Microsphere for Temperature Measurement;
- Center of Gravity Estimation Using a Reaction Board Instrumented with Fiber Bragg Gratings;
- Temperature Compensated Strain Sensor Based on Long-Period Gratings and Microspheres;
- Temperature independent refractive index measurement using a fiber Bragg grating on abrupt tapered tip;
- Ring-Down Technique Using Fiber-Based Linear Cavity for Remote Sensing (Patent pending);
- Development of improved fabrication methods for polymeric fiber optic tweezers;
- Demonstrated the identification and classification of healthy vs cancer cells using Intelligent optical fiber tweezers (patent submitted);
- Implementation of novel LIBS system using optical fiber laser;
- Optimization of LIBS signal processing schemes and calibration transfer protocols to enable true quantification in complex samples (2 EP submitted);
- Demonstration of compositional mapping in complex mineral using LIBS technology. Validation with the test case of lithium from Portuguese mines exploration;
- Validation of new dCO₂ sensor in model aquaculture tanks;
- Demonstration of nutrient detection in irrigation systems using direct spectroscopic analysis and advanced signal analysis;
- Implementation of new low cost interrogation system for fiber based sensors in environmental applications;
- Lensless, calibration free imaging through multimode optical fibres: a solid base in the area of imaging and wavefront shaping through complex media has been established, opening up pathways for interesting developments in this subject. The developed imaging setups allow: imaging behind diffuse media using the shower curtain effect, providing the capability to image complex patterns in a scenario where direct observation yields no apparent object information; light manipulating through a diffuse medium via a transmission matrix characterization: tight focused light spots are produced at the output of the diffuse medium. This can be useful both for imaging and for micro- manipulating small particles; ability to arbitrarily manipulate light through

both a diffuse medium and an optical fibre using optimization algorithms, generating a single a focused spot, multiple focused sports and arbitrary wavefronts after complex media.

- Submarine Lidar setup: a compact laboratory LIDAR prototype was setup, aiming at its integration in submarine operation in rovers or unmanned automatic marine vehicles, with the purpose of assisting 3D mapping of flooded mines and sea operation. The specifications of the system were established and tested in lab environment, before submarine integration and testing;
- New solvers of generalized non-linear nonlocal schrodinger equation using gpu super computing;
- New solvers for optical propagation in quantum fluids and quantum gases including optomechanical effects;
- Proposal of improved measurement technique of dispersion relation in nonlocal nonlinear optical media;
- New metamaterials for optical sensing;
- New designs of optical Fibre sensors using integrated nanoplasmonics;
- Application of deeplearning to new generation of solvers for fluid equations;
- Application of deeplearning in non-linear Fourier analysis.

5.2.5 Centre Organisational Structure and Research Team

The Centre for Applied Photonics is coordinated by Paulo Marques and Ireneu Dias and is organised around the following strategic lines of research and its leaders:

- Integrated optics and Microfabrication: Paulo Marques
- Advanced Optical Imaging: Carla Rosa
- Physical Sensors: Orlando Frazão
- Biosensors: Pedro Jorge
- High performance simulations for quantum and nonlinear photonics: Ariel Guerreiro

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			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	5	5	8	3
		Academic Staff	9	9	7	-2
		Grant Holders and Trainees	15	18	17	-1
		Total Core Researchers	29	32	32	0
		Total Core PhD	16	16	15	-1
	Affiliated Researchers		7	8	5	-3
	Administrative and Technical	Employees	2	2	2	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	2	2	2	0
		Total Integrated HR	38	42	39	-4
Total Integrated PhD		22	21	20	-1	
Curricular Trainees		0	0	0	0	
External Research Collaborators		2	1	4	3	
External Administrative and Technical Staff		0	0	0	0	
External Students		13	10	9	-1	
Total		53	53	52	-1	

5.2.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			Δ (k€)
		2016	2017	2018	2017-18
PN-FCT	National R&D Programmes - FCT		9	214	205
PN-PICT	National R&D Programmes - S&T Integrated Projects	155	238	220	-18
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	117	80		-80
PUE-DIV	EU Cooperation Programmes - Other	27	7	35	28
SERV-NAC	R&D Services and Consulting - National		16	34	18
SERV-INT	R&D Services and Consulting - International	40		15	15
OP	Other Funding Programmes	7	3		-3
Closed Projects		23	24	22	-2
Total Funding		369	378	540	162

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	36	36	22	-14
Indexed Conferences	15	39	12	-27
Books				
Book Chapters	1			
PhD Theses - Members	4	3		-3
PhD Theses - Supervised	4	3		-3

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

Type of Result	2016	2017	2018
Invention disclosures	0	1	2
Software copyright registrations	0	0	0
Patent applications	0	1	3
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs	0	0	0

Table 5.6 - CAP - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	0	2	5
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	3	4	2
International events in which INESC TEC members participate in the program committees	3	4	0
Participation in events such as fairs, exhibitions or similar	1	4	3
Advanced training courses	0	1	1

5.2.7 List of Projects

Table 5.7 - CAP – List of Projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	TEC4SEA-2	Pedro Jorge	01/09/2017	30/08/2020
PN-FCT	FLAPSYS	Pedro Jorge	01/03/2018	28/02/2021
PN-FCT	ENDOR	Orlando Frazão	01/06/2018	31/05/2021
PN-FCT	MetBots	Rui Costa Martins	26/07/2018	24/07/2020
PN-FCT	GreenNanoSensing	Ariel Guerreiro	01/07/2018	30/06/2021
PN-PICT	CORAL-SENSORS	Pedro Jorge	01/01/2016	
PN-PICT	CORAL-TOOLS-2	Pedro Jorge	01/01/2016	
PN-PICT	NanoStima-RL1-1	Carla Carmelo Rosa	01/07/2015	30/06/2019
PUE-DIV	AGRINUPES-1	Pedro Jorge	01/04/2017	31/03/2020
PUE-DIV	SAFEWATER	Pedro Jorge	03/04/2018	02/04/2021
SERV-INT	TECCON2	Pedro Jorge	01/01/2016	30/06/2019
SERV-NAC	SENVIB	Orlando Frazão	11/09/2018	31/12/2018
SERV-NAC	LED	Paulo Vicente Marques	19/12/2018	18/06/2020

Type of Project:

PN-FCT National R&D Programmes - FCT
PN-PICT National R&D Programmes - S&T Integrated Projects
PN-P2020 National R&D Programmes - Portugal 2020
PUE-H2020 EU Framework Programme
SERV-NAC National R&D Services and Consulting
SERV-INT International R&D Services and Consulting

5.2.8 List of Publications

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1. Ascorbe, J, Coelho, L, Santos, JL, Frazao, O, Corres, JM, "Temperature Compensated Strain Sensor Based on Long Period Gratings and Microspheres", IEEE Photonics Technology Letters, pp.1-1, 2018
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3. Costa Coelho, LCC, Soares dos Santos, PSS, da Silva Jorge, PAD, Santos, JL, Marques Martins de Almeida, JMMM, "Real-time Early Warning Strategies for Corrosion Mitigation in Harsh Environments", Journal of Lightwave Technology, pp.1-1, 2018
4. de Almeida, JMMM, Vasconcelos, H, Jorge, PAS, Coelho, L, "Plasmonic Optical Fiber Sensor Based on Double Step Growth of Gold Nano-Islands", Sensors, vol.18, pp.1267, 2018
5. Escada, J, Coelho, LCC, Dias, THVT, Lopes, JAM, dos Santos, JMF, "Photoelectron extraction efficiency into Ar-CF4 and Xe-CF4 gas mixtures", Journal of Instrumentation, vol.13, SEP, 2018
6. Ferreira, M, Gomes, A, Kowal, D, Statkiewicz Barabach, G, Mergo, P, Frazão, O, "The fiber connection method using a tapered silica fiber tip for microstructured polymer optical fibers", Fibers, vol.6, pp.4, 2018
7. Ferreira, TD, Silva, NA, Guerreiro, A, "Superfluidity of light in nematic liquid crystals", Physical Review A, vol.98, 2018
8. Gomes, AD, Monteiro, CS, Silveira, B, Frazao, O, "A Brief Review of New Fiber Microsphere Geometries", Fibers, vol.6, pp.48, 2018
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16. Oliveira, R, Roriz, P, Marques, MB, Frazao, O, "Center of gravity estimation using a reaction board instrumented with fiber Bragg gratings", Photonic Sensors, vol.8, pp.1-6, MAR, 2018
17. Paiva, JS, Jorge, PAS, Rosa, CC, Cunha, JPS, "Optical Fiber Tips for Biological Applications: from Light Confinement, Biosensing to Bioparticles Manipulation", Biochimica et Biophysica Acta (BBA) - General Subjects, 2018
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21. Santos, MM, Jorge, PAS, Coimbra, J, Vale, C, Caetano, M, Bastos, L, Iglesias, I, Guimarães, L, Reis Henriques, MA, Teles, LO, Vieira, MN, Raimundo, J, Pinheiro, M, Nogueira, V, Pereira, R, Neuparth, T, Ribeiro, MC, Silva, E, Castro, LFC, "The last frontier: Coupling technological developments with scientific challenges to improve hazard assessment of deep-sea mining", Science of the Total Environment, vol.627, pp.1505-1514, 2018
22. Silveira, B, Gomes, A, Becker, M, Schneidewind, H, Frazao, O, "Bunimovich Stadium-Like Resonator for Randomized Fiber Laser Operation", Photonics, vol.5, pp.17, 2018

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3. De Almeida, JMMM, Vasconcelos, H, Jorge, PAS, Coelho, L, "Plasmonic optical fiber sensor based on double step growth of gold nano-islands", Optics InfoBase Conference Papers, vol.Part F124-OFS 2018, 2018
4. Dos Santos, PSS, Jorge, PAS, De Almeida, JMMM, Coelho, L, "Low-cost interrogation system for long period fiber gratings as sensing devices", Optics InfoBase Conference Papers, vol.Part F124-OFS 2018, 2018
5. Gomes, AD, Kobelke, J, Bierlich, J, Schuster, K, Bartelt, H, Frazão, O, "Optical fiber probe for viscosity measurements", Optics InfoBase Conference Papers, vol.Part F124-OFS 2018, 2018
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7. Marques, PVS, Amorim, VA, Maia, JM, Alexandre, D, Viveiros, D, "Fabrication of Monolithic Add-Drop Filters in Pure Silica by Femtosecond Laser Writing", International Conference on Transparent Optical Networks, vol.2018-July, 2018

8. Monteiro, CS, Coelho, L, Barbosa, SM, Guimarães, D, "Development of a new system for real-time detection of radon using scintillating optical fibers", Optics InfoBase Conference Papers, vol.Part F124-OFS 2018, 2018
9. Paiva, JS, Ribeiro, RSR, Jorge, PAS, Rosa, CC, Azevedo, MM, Sampaio, P, Cunha, JPS, "Experimental and theoretical evaluation of the trapping performance of polymeric lensed optical fibers: single biological cells versus synthetic structures", Biophotonics: Photonic Solutions for Better Health Care VI, 2018
10. Rodrigues, SM, Paiva, JS, Ribeiro, RSR, Soppera, O, Jorge, PAS, "Improved Fabrication of Polymeric Optical Fiber Tweezers for Single Cell Detection", 26th International Conference on Optical Fiber Sensors, 2018
11. Silva, GE, Caldas, P, Santos, JL, Santos, JC, "Measurement thermal conductivity of water using a all-fiber sensor based on a metallic coated hybrid LPG-FBG structure", Optics InfoBase Conference Papers, vol.Part F124-OFS 2018, 2018
12. Vasconcelos, H, De Almeida, JMMM, Jorge, PAS, Coelho, L, "Optical fiber sensor Mach-Zehnder interferometer based on TiO₂ coated long period fiber grating", Optics InfoBase Conference Papers, vol.Part F124-OFS 2018, 2018

Books

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Chapter/Paper in Books

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Publications (Editor)

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Dissertations (PhD)

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5.3 CRAS - CENTRE FOR ROBOTICS AND AUTONOMOUS SYSTEMS

Coordinators: Eduardo Silva and Aníbal Matos

Co-coordinator: Carlos Pinho

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. CRAS aims at becoming a worldwide reference in field robotics and autonomous systems and is already internationally recognised for its innovative robotics solutions for operation in complex environments – relevant examples are underwater environments, and particularly deep-sea water.

CRAS has a special scientific focus in the multi-sensor perception, navigation, positioning, and sensor fusion competences. Within the Cluster NIS - Networked Intelligent Systems, CRAS accomplishes its mission, by directing its activities towards 4 main areas of research: autonomous navigation; long term deployments; sensing, mapping, and intervention; multiple platform operations.

CRAS activities are mainly positioned within TRL levels 5-8, associated with design, development and integration of robotic platforms with increasing degrees of autonomy. These activities have contributed to the deployment of innovative solutions in multiple application domains, such as safety security and defence, underwater mining, deep sea exploration and infrastructure inspection.

5.3.2 Contribution to the Vision of the Cluster

The NIS Cluster joins together a set of Centres with complementary competences, enabling it to develop several futuristic scenarios encompassing autonomous systems, innovative communications and sensors, collecting and transmitting information that can be processed using artificial intelligent tools.

Due to its development and integration of robotic platforms capabilities, CRAS has this unique position and responsibility, within Cluster NIS, to pursue and drive the achievement of new scientific and technological breakthroughs. One of the contributions to the Cluster is the support and integration of new sensors and communications. For this contribution line, within the next 5 years, CRAS aims to push the results of Coral project to be integrated within robotic platforms, such as: sensors for monitoring gamma radiation, remote fibre sensors, biosensors, chemical sensors, sensing probes, imaging, DNA bio sampler, underwater radio communications, underwater wireless optical communications, wireless energy transfer, LIBS real time grade assessment.

Regarding computer vision, a new automatic image processing system (adapted from the health domain) could be developed and integrated in robotic platforms in order to process analysis of microbial life in real-time.

CRAS itself aims at enabling/supporting the other Centres to access deep-sea. For this purpose, it is CRAS objective, by 2022, to operate in the deep sea with its own vehicles, where new sensors and new subsystems for navigation will be integrated, together with broadband wireless communications and wireless energy transfer underwater. Cooperation between robots and the challenges associated to miniaturized robotics will also be addressed. Also, the continuous miniaturization of robotic platforms is an objective for CRAS.

5.3.3 Research and Innovation Progress in 2018

CRAS research activities are organized along four research lines: autonomous navigation; long term deployments; sensing, mapping, and intervention; and multiple platform operations.

In 2018, the overall CRAS activity was aligned with the previous years, allowing for a consolidation of the core research team. Several large projects of different TRLs with strong involvement of CRAS researchers ended in 2018. Two of them were major European (SUNNY and VAMOS) projects that culminated with successful major field demonstrations. Within these projects, CRAS developed technologies with TRLs

from 6 to 7. At the same time, several FCT funded projects started in 2018 allowing for the reinforcement of CRAS activities in lower TRLs, permitting a more balanced coverage of the TRL scale.

CRAS researchers were also strongly involved in the setup of two infrastructures included in the national research infrastructures roadmap – TEC4SEA and EMSO-PT.

5.3.4 Main Achievements in 2018

CRAS lead PISCES team was selected as one of nine finalists of the Shell Ocean Discovery XPrize international competition. With the participation of 25 countries, distributed by 19 teams, the objective of this competition is to develop innovative technological projects that allow exploring and mapping the seabed, providing solutions to current problems and even revealing new resources for the benefit of humanity. The PISCES team approach is based on the combination of different marine robotic platforms to devise an effective and efficient solution for the exploration of the seabed. These platforms must be operated together and incorporate acoustic navigation and a mapping system.

CRAS successfully participated in the final demonstration of the SUNNY European project. This project aimed at the development of a monitoring system based on multiple UAVs with detection, identification and automatic classification capabilities, redundant air-to-air, air-ground communications, and a single command and control centre and aircraft with autonomous flight, capable of integrating the perception in the loop control. CRAS was the responsible entity for the development of the on-board processing systems for aircraft, for its use and integration in aircraft and for all the information that is sent for further analysis in the command station and system control.

Within the scope of the UNEXMIN project CRAS participated in the first field trials with the UX-1 robot. The two-week trial at the flooded Kaatiala mine site in Finland proved to be a great success with the robot tested in different operational scenarios. UNEXMIN is an EU-funded project that is developing a novel robotic system, primarily for the autonomous exploration and mapping of Europe's flooded mines. The Robotic Explorer platform will use non-invasive methods for autonomous 3D mine mapping for gathering valuable geological, mineralogical and spatial information. This could possibly open up new exploration scenarios so strategic decisions on the re-opening of Europe's abandoned mines could be supported by data that cannot currently be obtained by any other way, without major costs. CRAS team is deeply involved in the design of the robotic system and also on the development of its navigation and perception capabilities.

The tests and the final demonstration of the iVAMOS! Project took place at the Silvermines mine, Ireland, between 24 September and 2 November. A team of CRAS researchers carried out tests with the positioning, navigation and “awareness” systems, which were developed by INESC TEC, allowing the efficient and automatic operation of the system (which includes a robotic mining machine with 27 tonnes, a supporting boat), through a virtual reality interface. It also includes the innovative autonomous underwater vehicle (EVA – Exploration VAMOS AUV), which was developed by INESC TEC to support the mining activity. The goal of iVAMOS! is to develop a robotic prototype for the underwater mining, as well as associated launch and collection equipment, and also to carry out tests in operating scenarios in order to assess its efficiency and economic impact.

5.3.5 Centre Organisational Structure and Research Team

The Centre for Robotics and Autonomous Systems is coordinated by Eduardo Silva, Aníbal Matos and Carlos Pinho. 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.

Table 5.2 - CRAS - Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	5	8	11	3
		Academic Staff	10	10	11	1
		Grant Holders and Trainees	25	31	22	-9
		Total Core Researchers	40	49	44	-5
		Total Core PhD	7	14	14	0
	Affiliated Researchers		0	0	0	0
	Administrative and Technical	Employees	2	2	4	2
		Grant Holders and Trainees	1	1	1	0
		Total Admin and Tech	3	3	5	2
	Total Integrated HR		43	52	49	2
	Total Integrated PhD		7	14	14	0
Curricular Trainees		3	1	1	0	
External Research Collaborators		1	0	0	0	
External Administrative and Technical Staff		0	0	0	0	
External Students		2	0	1	1	
Total		49	53	51	-2	

5.3.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT		94	337	243
PN-PICT	National R&D Programmes - S&T Integrated Projects	33	127	101	-26
PN-COOP	National Cooperation Programmes with Industry	19	183	200	17
PUE-FP	EU Framework Programmes	1 143	845	530	-315
PUE-DIV	EU Cooperation Programmes - Other	103	115	102	-14
SERV-NAC	R&D Services and Consulting - National	95	97	33	-64
SERV-INT	R&D Services and Consulting - International		131	115	-16
OP	Other Funding Programmes	19	11	94	82
Closed Projects					
Total Funding		1 412	1 603	1 511	-92

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

Publication Type	Total Publications			Δ 2017-2018
	2016	2017	2018	
Indexed Journals	2	9	8	-1
Indexed Conferences	24	30	21	-9
Books				
Book Chapters	3	4	1	-3
PhD Theses - Members	1	1	2	1
PhD Theses - Supervised	1	1	1	

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

Type of Result	2016	2017	2018
Invention disclosures	1	1	1
Software copyright registrations	0	0	0
Patent applications	1	0	2
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs	0	0	0

Table 5.6 - CRAS - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	1	1	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	4	4	2
International events in which INESC TEC members participate in the program committees	5	6	6
Participation in events such as fairs, exhibitions or similar	1	4	4
Advanced training courses	2	2	3

5.3.7 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
PN-FCT	TEC4SEA	Eduardo Silva	01/09/2017	30/08/2020
PN-FCT	ROSM	André Dias	01/10/2017	02/10/2019
PN-FCT	EMSO-PT	Aníbal Matos	01/07/2017	29/06/2020
PN-FCT	DIIUS	Andry Maykol Pinto	26/07/2018	25/07/2021
PN-FCT	ENDURANCE-1	Nuno Cruz	01/07/2018	29/06/2020
PN-FCT	GROW-1	Eduardo Silva	01/10/2018	31/12/2020
PN-COOP	DeepFloat	Eduardo Silva	09/03/2016	
PN-COOP	SIDENAV	Eduardo Silva	01/12/2016	
PN-COOP	FEEDFIRST	Eduardo Silva	01/01/2018	31/12/2020
PN-COOP	HiperSea	Eduardo Silva	01/07/2018	30/06/2021
PN-PICT	CORAL-SENSORS-1	Eduardo Silva	01/01/2016	
PN-PICT	CORAL-TOOLS	Eduardo Silva	01/01/2016	
PUE-DIV	SpilLess	Eduardo Silva	01/02/2017	31/03/2019
PUE-DIV	PROTOATLANTIC	Eduardo Silva	01/11/2017	31/10/2020
PUE-DIV	INTENDU	Aníbal Matos	01/03/2018	28/02/2021
PUE-FP	SUNNY	Eduardo Silva	01/01/2014	
PUE-FP	VAMOS	Eduardo Silva	01/02/2015	
PUE-FP	STRONGMAR	Eduardo Silva	01/01/2016	
PUE-FP	UNEXMIN	Eduardo Silva	01/02/2016	31/10/2019
SERV-INT	AutoMon	Aníbal Matos	01/04/2017	31/03/2019
SERV-NAC	Demo_Drone	José Miguel Almeida	01/05/2015	
SERV-NAC	Modulmar	Eduardo Silva	01/10/2018	30/09/2020
SERV-INT	EDA-SAVEWATE	Nuno Cruz	25/01/2012	24/06/2019
SERV-INT	RAWFIE	Aníbal Matos	01/09/2016	28/02/2019
OP	IntheBlack	Eduardo Silva	05/03/2018	30/09/2018
OP	Xprize	Nuno Cruz	01/04/2018	31/12/2018

Type of Project:

- PN-FCT National R&D Programmes - FCT
- PN-PICT National R&D Programmes - S&T Integrated Projects
- PN-P2020 National R&D Programmes - Portugal 2020
- PUE-H2020 EU Framework Programme
- SERV-NAC National R&D Services and Consulting
- SERV-INT International R&D Services and Consulting

5.3.8 List of Publications

International Journals with Scientific Referees

- dos Santos, PV, Alves, JC, Ferreira, JC, "An FPGA array for cellular genetic algorithms: Application to the minimum energy broadcast problem", Microprocessors and Microsystems, vol.58, pp.1-12, 2018

2. Freitas, S, Silva, H, Almeida, J, Silva, E, "Hyperspectral Imaging for Real-Time Unmanned Aerial Vehicle Maritime Target Detection", Journal of Intelligent and Robotic Systems: Theory and Applications, pp.1-20, 2018
3. Gaspar, AR, Nunes, A, Pinto, AM, Matos, A, "Urban@CRAS dataset: Benchmarking of visual odometry and SLAM techniques", Robotics and Autonomous Systems, 2018
4. Leal, F, Malheiro, B, Burguillo, JC, "Context-aware tourism technologies", The Knowledge Engineering Review, vol.33, 2018
5. Leite, A, Pinto, A, Matos, A, "A Safety Monitoring Model for a Faulty Mobile Robot", ROBOTICS, vol.7, SEP, 2018
6. Santos, MM, Jorge, PAS, Coimbra, J, Vale, C, Caetano, M, Bastos, L, Iglesias, I, Guimarães, L, Reis Henriques, MA, Teles, LO, Vieira, MN, Raimundo, J, Pinheiro, M, Nogueira, V, Pereira, R, Neuparth, T, Ribeiro, MC, Silva, E, Castro, LFC, "The last frontier: Coupling technological developments with scientific challenges to improve hazard assessment of deep-sea mining", Science of the Total Environment, vol.627, pp.1505-1514, 2018
7. Silva, MF, Malheiro, B, Guedes, P, Duarte, AJ, Ferreira, P, "Collaborative Learning with Sustainability-driven Projects: A Summary of the EPS@ISEP Programme", International Journal of Engineering Pedagogy (iJEP), vol.8, pp.106, 2018
8. Veloso, B, Leal, F, Gonzalez Velez, H, Malheiro, B, Carlos Burguillo, JC, "Scalable data analytics using crowdsourced repositories and streams", Journal of Parallel and Distributed Computing, vol.122, pp.1-10, 2018

International Conference Proceedings with Scientific Referees

1. Almeida, J, Ferreira, A, Matias, B, Lomba, C, Martins, A, Silva, E, "¡VAMOS! Underwater Mining Machine Navigation System", 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018
2. Almeida, J, Martins, A, Almeida, C, Dias, A, Matias, B, Ferreira, A, Jorge, P, Martins, R, Bleier, M, Nuechter, A, Pidgeon, J, Kapusniak, S, Silva, E, "Positioning. Navigation and Awareness of the ¡VAMOS! Underwater Robotic Mining System", 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018
3. Azevedo Perdicoulis, TPA, Lopes dos Santos, PL, "The secrets of Segway revealed to students: revisiting the inverted pendulum", 2018 13th APCA International Conference on Control and Soft Computing (CONTROLO), pp.43-48, 2018
4. Borghuis, L, Calon, B, MacLean, J, Portefaix, J, Quero, R, Duarte, A, Malheiro, B, Ribeiro, C, Ferreira, F, Silva, MF, Ferreira, P, Guedes, P, "Escargot Nursery – An EPS@ISEP 2017 Project", Advances in Intelligent Systems and Computing - Teaching and Learning in a Digital World, pp.884-895, 2018
5. Coelho, A, Lopes, M, Ferreira, B, Campos, R, Ricardo, M, "Experimental evaluation of shore to unmanned surface vehicle Wi-Fi communications", 2018 Wireless Days, WD 2018, Dubai, United Arab Emirates, April 3-5, 2018, pp.86-91, 2018
6. Freitas, S, Almeida, C, Silva, H, Almeida, J, Silva, E, "Supervised classification for hyperspectral imaging in UAV maritime target detection", 18th IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2018, pp.84-90, 2018
7. Freitas, S, Silva, H, Almeida, J, Martins, A, Silva, E, "Supervised vs unsupervised approaches for real time hyperspectral imaging maritime target detection", 2018 OCEANS - MTS/IEEE Kobe Techno-Oceans, OCEANS - Kobe 2018
8. Gaspar, AR, Nunes, A, Pinto, A, Matos, A, "Comparative Study of Visual Odometry and SLAM Techniques", Advances in Intelligent Systems and Computing, vol.694, pp.463-474, 2018
9. Leal, F, Gonzalez Velez, H, Malheiro, B, Carlos Burguillo, JC, "Semantic Profiling and Destination Recommendation based on Crowd-sourced Tourist Reviews", Distributed Computing and Artificial

- Intelligence, 14th International Conference, DCAI 2017, Porto, Portugal, 21-23 June, 2017, vol.620, pp.140-147, 2018
10. Leal, F, Malheiro, B, Burguillo, JC, "Trust and Reputation Modelling for Tourism Recommendations Supported by Crowdsourcing", Advances in Intelligent Systems and Computing - Trends and Advances in Information Systems and Technologies, pp.829-838, 2018
 11. Lima, MML, Romano, RA, dos Santos, PL, Pait, F, "An extended instrument variable approach for nonparametric LPV model identification", IFAC Papersonline, vol.51, pp.81-86, 2018
 12. Lönnqvist, E, Cullié, M, Bermejo, M, Tootsi, M, Smits, S, Duarte, A, Malheiro, B, Ribeiro, C, Ferreira, F, Silva, MF, Ferreira, P, Guedes, P, "Wearable UV Meter – An EPS@ISEP 2017 Project", Advances in Intelligent Systems and Computing - Teaching and Learning in a Digital World, pp.896-907, 2018
 13. Mahon, C, Baptista, M, Majewska, M, Tscholl, M, Bergervoet, S, Malheiro, B, Silva, MF, Ribeiro, C, Justo, J, Ferreira, P, Guedes, P, "Outdoor Intelligent Shader: An EPS@ISEP 2018 Project", Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality, Salamanca, Spain, October 24-26, 2018, pp.122-127, 2018
 14. Martins, A, Almeida, J, Almeida, C, Dias, A, Dias, N, Aaltonen, J, Heininen, A, Koskinen, KT, Rossi, C, Dominguez, S, Voros, C, Henley, S, McLoughlin, M, van Moerkerk, H, Tweedie, J, Bodo, B, Zajzon, N, Silva, E, "UX 1 system design - A robotic system for underwater mining exploration", 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp.1494-1500, 2018
 15. Martins, A, Almeida, J, Almeida, C, Matias, B, Kapusniak, S, Silva, E, "EVA a hybrid ROV/AUV for underwater mining operations support", 2018 OCEANS - MTS/IEEE Kobe Techno-Oceans, OCEANS - Kobe 2018, 2018
 16. Pedrosa, D, Dias, A, Martins, A, Almeida, J, Silva, E, "Control-law for oil spill mitigation with an autonomous surface vehicle", 2018 OCEANS - MTS/IEEE Kobe Techno-Oceans, OCEANS - Kobe 2018, 2018
 17. Pinto, VH, Cruz, NA, Almeida, RM, Goncalves, CF, "ALARS - Automated Launch And Recovery System for AUVs", OCEANS 2018 MTS/IEEE Charleston, 2018
 18. Saraiva, PG, dos Santos, PL, Pait, F, Romano, RA, Perdicoulis, TP, "An Iterative MOLI-ZOFT Approach for the Identification of MISO LTI Systems", 2018 13th APCA International Conference on Control and Soft Computing (CONTROLO), pp.346-351, 2018
 19. Veloso, B, Gama, J, Malheiro, B, "Self Hyper-Parameter Tuning for Data Streams", Discovery Science - Lecture Notes in Computer Science, pp.241-255, 2018
 20. Veloso, B, Malheiro, B, Burguillo, JC, Foss, JD, Gama, J, "Personalised Dynamic Viewer Profiling for Streamed Data", Advances in Intelligent Systems and Computing - Trends and Advances in Information Systems and Technologies, pp.501-510, 2018
 21. Viana, N, Guedes, P, Machado, D, Pedrosa, D, Dias, A, Almeida, JM, Martins, A, Silva, E, "Underwater Acoustic Signal Detection and Identification Study for Acoustic Tracking Applications", OCEANS 2018 MTS/IEEE Charleston, OCEAN 2018, 2018

Books

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Chapter/Paper in Books

1. Alves, B, Veloso, B, Malheiro, B, "APASail—An Agent-Based Platform for Autonomous Sailing Research and Competition", Robotic Sailing 2017, pp.31-38, 2018

Publications (Editor)

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Dissertations (PhD)

1. Cruz, N., "Adaptive Ocean Sampling with Modular Robotic Platforms";
2. Dias, A., "Multi-Robot 3D Target Estimation Under Uncertainty";

5.4 C-BER - CENTRE FOR BIOMEDICAL ENGINEERING RESEARCH

Coordinators: Aurélio Campilho and João Paulo Cunha

5.4.1 Presentation of the Centre

The mission of C-BER – Centre for Biomedical Engineering Research is “to promote scientific knowledge excellence through fundamental and applied research, advanced training and innovation in Biomedical Engineering”. C-BER activities are aligned with the vision of the Cluster on Networked Intelligent Systems (NIS). To accomplish its mission, C-BER is organised in three Labs (Biomedical Imaging Lab, BioInstrumentation Lab and NeuroEngineering Lab), and is guided by the following goals:

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

5.4.2 Contribution of the Vision of the Cluster

NIS established for the medium term, four main research lines: Sensing, Communications, Computer Vision, and Autonomous Systems. In the Sensing and Computer Vision research lines, C-BER has important contributions and are also in the five years’ horizon, in cooperation with other Centres and within the Centre itself. In Sensing, we investigated and continue to develop research in Optical Fiber Trapping (Tweezers) and Back-Scattered AI Signal Analysis in collaboration with CAP. Particularly relevant was the proposed method to differentiate cancer cells trapped by a polymeric lensed fiber tip. Results suggest that it can be a valuable contribution for early cancer identification and for other diseases. A patent and several Journal papers have been published. C-BER is strongly in line with the Computer Vision research line, particularly associated with human health scenarios. We are following and continue to follow artificial intelligence methodologies, machine learning and computer vision approaches for NCDs, such as cancer, respiratory diseases and diabetes, by developing research on prediction, early detection or diagnosis of pathologies in hospital or large screening scenarios. We will take as case studies different types diabetic complications as diabetic retinopathy or diabetic macular oedema, or several case studies of cancer, affecting different organs as the lung, the breast, the thyroid, and the ovarian and uterus. We will adopt holistic approaches by considering multi-modal and multi-sensor data. Data to be used in the different scenarios include images of different types, as ultrasound images, computed tomographic images or microscopic images of digital pathology slides. Other complementary data will be used as from liquid biopsy, of from patient metadata.

C-BER also contributes to bring autonomous networked intelligent systems into medicine, biology and human health, by pursuing R&D in biosensors, resilient, smarter and more reliable sensor technologies and systems.

5.4.3 Research and Innovation Progress in 2018

In 2018, the number of core C-BER researchers remained stable, and continue to be an attractive centre to young researchers to develop MSc and PhD theses. However, the market job in some domains of C-BER activity, particularly in Machine Learning, is very competitive and some of our young researchers moved to National and International Companies. On the other hand, there is an increase of difficulty in hiring high quality researchers, at both MSc or PhD level.

In terms of R&D funding in 2018, C-BER had an increase of about 40% global funding, all from National Programmes. In terms of integrated value chain and the Technology Readiness Level (TRL) of C-BER projects, most of our activity is centred in Knowledge Production (TRL 1-3) and Applied Research (TRL 4-5).

Scientifically, the year of 2018 has been one more year of growth of C-BER in many of the main scientific indicators, as can be observed in the tables at the Activity Indicators section 1.1.6. A particularly relevant indicator is the number of papers in peer-reviewed indexed international journals that have evolved from 1.36/PhD in 2016 to 1.82/PhD in 2018 as we archived the 20 papers for a total of 11 integrated PhDs. Nevertheless, a slight decrease of publications in indexed conferences was registered.

Along recent years C-BER has been highly active in generating intellectual property with a ratio of 2 patent submission per year (2 patent applications in 2018 of a total of 6 in the last 3 years). This strategy is now achieving its results as in February 2019, we have formally created the first C-BER spin-off startup - InSignals Neurotech - in partnership with the UK based Frontier IP Group plc (FIP.L London Stock Exchange) that has licensed one of the patents for Neurosurgery aid technology.

In 2018 we have also achieved most of the planned objectives we have planned in the Activity plan submitted in 2017, namely:

- We have largely increased the internal cooperation with other Centres of the cluster NIS, namely CAP and CTM.
- Participated and submitted 4 large H2020 EU projects.
- Attract new PhD and MSc students top students in their classes.
- Roll-out of several R&D results to partner hospitals and clinical partners. e.g. the iHandU ver.2 wearable device was successfully deployed and is under routine use at the neurosurgery OR of the S. João University Hospital in Porto in all Deep Brain Stimulation (DBS) surgeries.

5.4.4 Main Achievements in 2018

Awards:

- Best paper Award at the ICMLA 2018 - 17th Conference on Machine Learning and Application. Paper: Asim Smailagic, Pedro Costa; Hae Noh, Devesh Walawalkar, Kartik Khandelwal, Adrian Galdran, Mostafa Mirshekari, Jonathon Fagert, Susu Xu, Pei Zhang, Aurélio Campilho, MedAL: Accurate and Robust Deep Active Learning for Medical Image Analysis, ICMLA 2018 - 17th Conference on Machine Learning and Application, 481 – 488, 2018. <https://www.icmla-conference.org/icmla18/awards.html>;
- Paper: <https://ieeexplore.ieee.org/document/8614103> Paper was selected among 167 papers presented at the conference (109 full papers and 58 short papers);
- VR2Market was distinguished by "Exame Informática" Magazine with the "Os Melhores do Portugal Tecnológico 2018" (The Best of the Technological Portugal) award in the innovation category;
- Seizure Journal Editor's Choice for the paper "Quantitative and qualitative analysis of ictal vocalization in focal epilepsy syndromes", co-authored by C-BER members and colleagues from the Faculty of Medicine of the University of Munich. According to Markus Reuber, the distinction was well-deserved because, at a time when medical image has been dominating the systems for diagnosis support, the article not only "focuses specifically on ictal audio features, but also reminds us that an ideal diagnosis process must engage all our senses". "The epileptologists not only need to keep their eyes wide open, but they also need to stop, look and LISTEN". We are very proud to have clinical impact with our R&D results and contribute to improve the life of epileptic patients.

Patents submitted:

- "Device and Method for Detecting and Identifying Extracellular Vesicles in a Liquid Dispersion Sample" Patent pending, Ref^a. PT115123.
- "Method and Device for Detecting Stress Using Beat-to-Beat ECG Features", Patent pending, Ref. PT110584, WO PCT/IB2018/056558.

Successful participation in international competitions:

Development of transversal deep information learning based on supervised learning and multiple instance learning framework for image quality and abnormality detection in images. This generic methodology has been applied with success to different image data, published in top-ranked journals (see papers (1), (2) and (3)) and achieved top-10 performance on histology, retinal segmentation and skin and eye surgery topics, in international competitions. The successful participation in these competitions is very relevant, as it is recognized by the community as a demonstration of expertise of the competitors in addressing real problems with state-of-the-art winning approaches:

1. Teresa Araújo, Ana Maria Mendonça, and Aurélio Campilho, Parametric Model Fitting-based Approach for Retinal Blood Vessel Caliber Estimation, PLOS ONE, 13(4), art. No. e0194702, 2018 (open access);
2. P. Costa, A Galdran, A Smailagic, A Campilho, A Weakly-Supervised Framework for Interpretable Diabetic Retinopathy Detection on Retinal Images, IEEE Access, 6, 18747-18758, 2018;
3. P. Costa, A Galdran, MI Meyer, M Niemeijer, M Abràmoff, AM Mendonça, A Campilho, End-to-end adversarial retinal image synthesis, IEEE Transactions on Medical Imaging, 37 (3), 781-791, 2018;
4. J. Rouco, C Carvalho, A Domingues, E Azevedo, A Campilho, A robust anisotropic edge detection method for carotid ultrasound image processing, Procedia Computer Science 126, 723-732, 2018. DOI: <https://doi.org/10.1016/j.procs.2018.08.006>.

Successful participation in the challenges:

1. CATARACTS: Challenge on Automatic Tool Annotation for cataRACTS (two C-BER teams in the top 10) <https://cataracts.grand-challenge.org/results/> (the results will be published in Medical Image Analysis journal, a top Biomedical Engineering journal);
2. Skin Lesion Analysis Towards Melanoma Detection: (one C-BER team in the top 10) <https://challenge.kitware.com/#phase/584b0afacad3a51cc66c8e24>;
3. IDRID - Diabetic Retinopathy Segmentation and Grading Challenge: (one C-BER team top three results in detection of fovea and optic disc and optic disc segmentation tasks) <https://idrid.grand-challenge.org/leaderboard/>

Dissemination activities:

- A. Campilho, Deep Learning for Pathology Detection. A Case Study on Diabetic Retinopathy Detection, Symposium on Bioengineering, Porto, April 2018 [invited lecture], <https://goo.gl/LsvsNk>;
- Plataforma automática para o Diagnóstico da Retinopatia Diabética, SCREEN-DR, Porto Canal, April 2018, <https://goo.gl/n4ipVE>;
- Ana Maria Mendonça. From data to quality assessment and pathology detection;
- A case study on the screening of diabetic retinopathy, Encontro com a Ciência e Tecnologia em Portugal, Lisboa, July 2018;
- Carlos Ferreira, LNDetector: Aplicações de deep learning em CT do torax, Universidade de Trás-os-Montes e Alto Douro, 2018;
- Catarina Carvalho, Ana Domingues, Teresa Araújo, Carlos Ferreira, Simão Ferreira, Guilherme Aresta, Demos and projects presentations, GMEPE/PAHCE 2018 – Global Medical Engineering Physics Exchanges, Porto, March 2018. <http://embs.ieee-pt.org/events/gmepe-pahce-2018/>;

- Carlos Ferreira, Simão Faria, Patrick Sousa, Ana Domingues, Demos and projects presentations, ENEEB 2018 - Encontro Nacional de Estudantes de Engenharia Biomédica, March 2018, <http://embs.ieee-pt.org/events/eneeb-2018/>;
- Teresa Araújo, Ana Domingues, Dia Aberto ao Conhecimento INESC TEC, SCREEN-DR and Carotid CAD, Demos and projects presentations, INESC TEC, September 2018.

5.4.5 Centre Organisational Structure and Research Team

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

Table 5.2 – C-BER - Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	1	3	2	-1
		Academic Staff	6	6	6	0
		Grant Holders and Trainees	15	21	19	-2
		Total Core Researchers	22	30	27	-3
		Total Core PhD	8	11	11	0
	Affiliated Researchers		3	4	0	-4
	Administrative and Technical	Employees	0	0	1	1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	0	0	1	1
	Total Integrated HR		25	34	28	-3
	Total Integrated PhD		11	15	11	-4
Curricular Trainees		3	1	0	-1	
External Research Collaborators		2	4	11	7	
External Administrative and Technical Staff		0	0	0	0	
External Students		2	8	5	-3	
Total		32	47	44	-3	

5.4.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	85	147	182	35
PN-PICT	National R&D Programmes - S&T Integrated Projects	76	199	354	155
PN-COOP	National Cooperation Programmes with Industry			1	1
PUE-FP	EU Framework Programmes				
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	20	26	7	-19
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes				
Closed Projects		6	1		
Total Funding		187	372	544	171

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	15	17	19	2
Indexed Conferences	18	27	30	3
Books			1	1
Book Chapters	1		1	1
PhD Theses - Members		1		-1
PhD Theses - Supervised	1	1		-1

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

Type of Result	2016	2017	2018
Invention disclosures	3	2	2
Software copyright registrations	0	0	2
Patent applications	3	1	2
Granted patents	0	0	5
Licence agreements	0	0	0
Spin-offs	0	0	0

Table 5.6 - C-BER - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	0	2	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1	2	7
International events in which INESC TEC members participate in the program committees	2	5	8
Participation in events such as fairs, exhibitions or similar	4	1	4
Advanced training courses	0	1	0

5.4.7 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	30/06/2019
PN-FCT	LNDetector	Aurélio Campilho	01/06/2016	31/05/2019
PN-FCT	SCREEN-DR	Aurélio Campilho	01/04/2016	31/03/2020
PN-FCT	PERFECT-1	João Paulo Cunha	01/07/2018	29/06/2020
PN-COOP	TexBoost	Miguel Velhote Correia	01/07/2017	30/06/2020
PN-PICT	NanoStima-RL1	João Paulo Cunha	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL5-1	Aurélio Campilho	01/07/2015	30/06/2019
PN-PICT	SMILES-1	João Paulo Cunha	01/07/2015	30/06/2019
SERV-NAC	Bio-Early	João Paulo Cunha	01/10/2015	
SERV-NAC	Consultoria	João Paulo Cunha	01/01/2016	

Type of Project:

- PN-FCT National R&D Programmes - FCT
- PN-PICT National R&D Programmes - S&T Integrated Projects
- PN-P2020 National R&D Programmes - Portugal 2020
- PUE-H2020 EU Framework Programme
- SERV-NAC National R&D Services and Consulting
- SERV-INT International R&D Services and Consulting

5.4.8 List of Publications

International Journals with Scientific Referees

- Araujo, T, Mendonca, AM, Campilho, A, "Parametric model fitting-based approach for retinal blood vessel caliber estimation in eye fundus images", PLOS ONE, vol.13, pp.e0194702, 2018
- Boetzel, K, Olivares, A, Cunha, JP, Gorris Saez, JMG, Weiss, R, Plate, A, "Quantification of gait parameters with inertial sensors and inverse kinematics", Journal of Biomechanics, vol.72, pp.207-214, 2018
- Bogaerts, S, Carvalho, CD, De Groef, A, Suetens, P, Peers, K, "Non-uniformity in pre-insertional Achilles tendon is not influenced by changing knee angle during isometric contractions", Scandinavian Journal of Medicine & Science in Sports, vol.28, pp.2322-2329, NOV, 2018

4. Costa, P, Galdran, A, Meyer, MI, Niemeijer, M, Abramoff, M, Mendonca, AM, Campilho, A, "End-to-end Adversarial Retinal Image Synthesis", IEEE Transactions on Medical Imaging, pp.1-1, 2018
5. Costa, P, Galdran, A, Smailagic, A, Campilho, A, "A Weakly-Supervised Framework for Interpretable Diabetic Retinopathy Detection on Retinal Images", IEEE Access, vol.6, pp.18747-18758, 2018
6. Dias, D, Silva Cunha, JPS, "Wearable health devices—vital sign monitoring, systems and technologies", Sensors, vol.18, 2018
7. Galdran, A, "Image dehazing by artificial multiple-exposure image fusion", SIGNAL PROCESSING, vol.149, pp.135-147, AUG, 2018
8. Goncalves, L, Novo, J, Cunha, A, Campilho, A, "Learning Lung Nodule Malignancy Likelihood from Radiologist Annotations or Diagnosis Data", Journal of Medical and Biological Engineering, 2018
9. Hartl, E, Knoche, T, Choupina, HMP, Remi, J, Vollmar, C, Cunha, JPS, Noachtar, S, "Quantitative and qualitative analysis of ictal vocalization in focal epilepsy syndromes", Seizure, vol.60, pp.178-183, 2018
10. Paiva, JS, Cardoso, J, Pereira, T, "Supervised learning methods for pathological arterial pulse wave differentiation: A SVM and neural networks approach", International Journal of Medical Informatics, vol.109, pp.30-38, JAN, 2018
11. Paiva, JS, Jorge, PAS, Rosa, CC, Cunha, JPS, "Optical Fiber Tips for Biological Applications: from Light Confinement, Biosensing to Bioparticles Manipulation", Biochimica et Biophysica Acta (BBA) - General Subjects, 2018
12. Paiva, JS, Ribeiro, RSR, Cunha, JPS, Rosa, CC, Jorge, PAS, "Single Particle Differentiation through 2D Optical Fiber Trapping and Back-Scattered Signal Statistical Analysis: An Exploratory Approach", Sensors, vol.18, pp.710, 2018
13. Ribeiro, RT, Silva Cunha, JPS, "A regression approach based on separability maximization for modeling a continuous-valued stress index from electrocardiogram data", Biomedical Signal Processing and Control, vol.46, pp.33-45, SEP, 2018
14. Rocha, AP, Pereira Choupina, HMP, Vilas Boas, MD, Fernandes, JM, Silva Cunha, JPS, "System for automatic gait analysis based on a single RGB-D camera", PLOS ONE, vol.13, pp.e0201728, 2018
15. Rodrigues, S, Paiva, JS, Dias, D, Aleixo, M, Filipe, R, Cunha, JPS, "A Wearable System for the Stress Monitoring of Air Traffic Controllers During An Air Traffic Control Refresher Training and the Trier Social Stress Test: A Comparative Study", The Open Bioinformatics Journal, vol.11, pp.106-116, 2018
16. Rodrigues, S, Paiva, JS, Dias, D, Aleixo, M, Filipe, RM, Cunha, JPS, "Cognitive impact and psychophysiological effects of stress using a biomonitoring platform", International Journal of Environmental Research and Public Health, vol.15, pp.1080, 2018
17. Rodrigues, S, Paiva, JS, Dias, D, Paulo, J, "Stress among on-duty firefighters: an ambulatory assessment study", PeerJ, vol.6, pp.e5967, 2018
18. Rodrigues, S, Paiva, JS, Dias, D, Pimentel, G, Kaiseler, M, Cunha, JPS, "Wearable Biomonitoring Platform for the Assessment of Stress and its Impact on Cognitive Performance of Firefighters: An Experimental Study", Clinical Practice & Epidemiology in Mental Health, vol.14, pp.250-262, 2018
19. Rodrigues, SM, Paiva, JS, Ribeiro, RSR, Soppera, O, Cunha, JPS, Jorge, PAS, "Fabrication of Multimode-Single Mode Polymer Fiber Tweezers for Single Cell Trapping and Identification with Improved Performance", Sensors, vol.18, pp.2746, 2018

International Conference Proceedings with Scientific Referees

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2. Ancuti, C, Ancuti, CO, Timofte, R, Van Gool, L, Zhang, L, Yang, MH, Patel, VM, Zhang, H, Sindagi, VA, Zhao, RH, Ma, XP, Qin, Y, Jia, LM, Friedel, K, Ki, S, Sim, H, Choi, JS, Kim, SY, Seo, S, Kim, S, Kim, M, Mondal, R, Santra, S, Chanda, B, Liu, JL, Mei, KF, Li, JC, Luyao, , Fang, FM, Jiang, AW, Qu, XC, Liu, T, Wang, PF, Sun, B, Deng, JF, Zhao, YH, Hong, M, Huang, JY, Chen, YZ, Chen, ER, Yu, XL, Wu, TT, Genc, A, Engin, D, Ekenel, HK, Liu, WZ, Tong, T, Li, G, Gao, QQ, Li, Z, Tang, DF, Chen, YL, Huo, ZY, Alvarez Gila, A, Galdran, A, Bria, A, Vazquez Corral, J, Bertalmo, M, Demir, HS, Adil, OF, Phung, HX, Jin, X, Chen, JL, Shan, CW, Chen, ZB, "NTIRE 2018 Challenge on Image Dehazing: Methods and Results", Proceedings 2018 IEEE/CVF Conference on computer vision and pattern recognition workshops (CVPRW), pp.1004-1014, 2018
3. Arad, B, Ben Shahr, O, Timofte, R, Van Gool, L, Zhang, L, Yang, MH, Xiong, ZW, Chen, C, Shi, Z, Liu, D, Wu, F, Lanaras, C, Galliani, S, Schindler, K, Stiebel, T, Koppers, S, Seltsam, P, Zhou, RF, El Helou, M, Lahoud, F, Shahpaski, M, Zheng, K, Gao, LR, Zhang, B, Cui, XM, Yu, HY, Can, YB, Alvarez Gila, A, van de Weijer, J, Garrote, E, Galdran, A, Sharma, M, Koundinya, S, Upadhyay, A, Manekar, R, Mukhopadhyay, R, Sharma, H, Chaudhury, S, Nagasubramanian, K, Ghosal, S, Singh, AK, Singh, A, Ganapathysubramanian, B, Sarkar, S, "NTIRE 2018 Challenge on Spectral Reconstruction from RGB Images", PROCEEDINGS 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops (CVPRW), pp.1042-1051, 2018
4. Araújo, T, Aresta, G, Galdran, A, Costa, P, Mendonça, AM, Campilho, A, "UOLO - Automatic Object Detection and Segmentation in Biomedical Images", Deep Learning in Medical Image Analysis and Multimodal Learning for Clinical Decision Support - Lecture Notes in Computer Science, pp.165-173, 2018
5. Aresta, G, Araújo, T, Jacobs, C, Ginneken, Bv, Cunha, A, Ramos, I, Campilho, A, "Towards an Automatic Lung Cancer Screening System in Low Dose Computed Tomography", Image Analysis for Moving Organ, Breast, and Thoracic Images - Third International Workshop, RAMBO 2018, Fourth International Workshop, BIA 2018, and First International Workshop, TIA 2018, Held in Conjunction with MICCAI 2018, Granada, Spain, September 16 and 20, 2018, Proceedings, vol.11040, pp.310-318, 2018
6. Coelho, P, Pereira, A, Leite, A, Salgado, M, Cunha, A, "A Deep Learning Approach for Red Lesions Detection in Video Capsule Endoscopies", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.10882 LNCS, pp.553-561, 2018
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9. Ferreira, FT, Sousa, P, Galdran, A, Sousa, MR, Campilho, A, "End-to-End Supervised Lung Lobe Segmentation", 2018 International Joint Conference on Neural Networks (IJCNN), 2018
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14. Hruska, J, Adão, T, Pádua, L, Marques, P, Cunha, A, Peres, E, Sousa, AMR, Morais, R, Sousa, JJ, "Machine learning classification methods in hyperspectral data processing for agricultural applications", Proceedings of the International Conference on Geoinformatics and Data Analysis - ICGDA '18, 2018
15. Melo, T, Mendonça, AM, Campilho, A, "Creation of Retinal Mosaics for Diabetic Retinopathy Screening: A Comparative Study", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.10882 LNCS, pp.669-678, 2018
16. Machado, M, Aresta, G, Leitaó, P, Carvalho, AS, Rodrigues, M, Ramos, I, Cunha, A, Campilho, A, "Radiologists' Gaze Characterization During Lung Nodule Search in Thoracic CT", 2018 International Conference on Graphics and Interaction (ICGI), 2018
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19. Moura, Jd, Novo, J, Penas, S, Ortega, M, Silva, JA, Mendonça, AM, "Automatic Characterization of the serous Retinal Detachment Associated with the subretinal Fluid Presence in Optical Coherence Tomography Images", Procedia Computer Science, vol.126, pp.244-253, 2018
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Books

1. Campilho, A, Karray, F, ter Haar Romeny, B, "Image Analysis and Recognition", *Lecture Notes in Computer Science*, 2018

Chapter/Paper in Books

1. Pádua, L, Adão, T, Narciso, D, Cunha, A, Magalhães, L, Peres, E, "Towards modern cost-effective and lightweight Augmented Reality setups", *Virtual and Augmented Reality: Concepts, Methodologies, Tools, and Applications*, vol.1, pp.396-423, 2018

Publications (Editor)

1. Campilho, A, Karray, F, Haar Romeny, B, "Image Analysis and Recognition - 15th International Conference, ICIAR 2018, Póvoa de Varzim, Portugal, June 27-29, 2018, Proceedings", *ICIAR*, vol.10882, 2018

Dissertations (PhD)

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5.5 CPES - CENTRE FOR POWER AND ENERGY SYSTEMS

Coordinators: Manuel Matos and Ricardo Bessa

5.5.1 Presentation of the Centre

The Centre for Power and Energy Systems (CPES) is the core Centre of the Cluster Power and Energy. Within this Cluster, CPES holds specific expertise in power systems analysis (steady-state and dynamic), probabilistic and fuzzy modelling, reliability, optimisation and decision-aid, computational intelligence, energy analytics and forecasting, with special focus on large scale integration of Renewable Energy Sources (RES), Distributed Energy Resources (DER) operation, Electric Vehicles (EV) deployment and Energy and Flexibility management, under the Smart Grid paradigm.

CPES activity is organised in six areas:

- DMS/EMS and network automation
- System planning and reliability
- RES & DER integration (Renewable Energy Sources and Distributed Energy Resources)
- Electricity markets
- X-energy management systems
- Multi-energy networks

Part of the activity of the group is developed in its Laboratory of Smart Grids and Electric Vehicles (SGEV) that supports real environment, testing and validation of major developments.

Over the last 5 years, this Centre has made several contributions to electrical network planning and operation, namely the inclusion of DER in forecasting and network optimization tools embedded in different voltage levels, aligned with the Smart Grid concept. Relevant steps were taken on the inclusion of computational intelligence in control algorithms that were tested and demonstrated under real conditions in several pilots.

This Centre is a world reference in large scale integration of RES and DER. CPES has two IEEE Fellows (one in the IEEE Distinguished Lecturer Program) and is a strong player in EU H2020 (coordinator in some projects) and contracts with national and international companies, with a robust track record in technology transfer and consulting. One researcher received the IEEE PES Renewable Energy Excellence Award 2103. Another received a recognition award 2013 from CIGRE. Yet other researchers won the 2014, 2017 and 2018 IEEE PES competitions in meta-heuristics applications to difficult power systems problems. Several post-graduate students won the Portugal best MSc thesis prizes attributed by: the Portuguese TSO (REN) in 2014-17; the Portuguese association of renewable GENCO (APREN)- in 2015 and 2016 and by Portuguese pattern recognition association (APRP) in 2017. Because of this expertise, INESC TEC won the recognition of best 2016 innovation partner of EDP (the major player in the Portuguese wholesale and retail markets, besides being the DSO).

The research results produced by CPES cover a large range in the technology readiness level (TRL), ranging from level 2, where fundamental research is carried out, to level 8, where prototyping and demonstration of technology is performed.

Members of CPES are in the board of several Societies and Steering Committees responsible for organizing some of the most important worldwide conferences in power systems (IEEE PowerTech, PSCC, ISAP, PMAPS, IREP). They are also part of the Editorial Board of top Elsevier and IEEE journals.

5.5.2 Contribution to the Vision of the Cluster

CPES is the core Centre of the Power and Energy Cluster, therefore its research lines and areas of activity are fully aligned with the vision of the Cluster. CPES is conducting research in advanced mathematical modelling for optimization of electrical grids and energy consumption, as well as large-scale time series forecasting. The decarbonization of the energy sector is a key goal in the Centre research agenda and is being handled at the software and hardware level and using the laboratorial infrastructure for testing

and validation. Finally, the Centre in 2018 identified a set of INESC TEC competences that can leverage pre-existing know-how and help to materialize concepts such as microgrids, e-mobility and smart energy systems (cybersecurity, internet-of-things (IoT), interoperability, data platforms/hubs and blockchain).

The area of activity of CPES in energy management systems can contribute to push energy efficiency in industrial consumers beyond traditional actions (e.g., investment in more efficiency equipment such as LED lights) and integrate data collected from IoT platforms (aligned with industry 4.0) in data-driven energy optimization schemes. Moreover, opportunities generated by dynamic tariffs for both energy and network-use also create regulatory conditions to explore flexibility from industrial processes and contribute to decrease energy costs. Finally, another contribution from CPES is decision-aid methods and new business models for industrial consumers that consider the role of renewable energy and participation in different types of electricity markets (e.g., ancillary services, capacity markets). This also covers the agriculture sector, where its seasonal activity is the perfect case to apply demand-side management and business models based on digital solutions (e.g., peer-to-peer, variable contracted power). This contribution fits the Vision of two other Clusters: Power and Industry; Industry and Innovation.

The energy analytics and forecasting and decision-aid and optimization scientific domains from CPES can also contribute to the Computer Science cluster, namely in meta-heuristics optimization, uncertainty modelling and forecasting and data-driven optimization with reinforcement learning. CPES has been developing basic research in these areas, which have a broad application in other domains.

5.5.3 Research and Innovation Progress in 2018

This section takes as reference the planned activities of CPES for 2018, described in the PLAN OF ACTIVITIES of INESC TEC for 2018. In each case a comparison is provided between the foreseen and actual results. The structure of the 2018 plan is maintained, although the activity areas of CPES have been reformulated during 2018.

New developments in DMS/EMS & System Operation

- Integration of multi-temporal optimization algorithms to improve the current Advanced Distribution Management Systems (ADMS) - ONGOING
- Improvement of LV state estimation algorithm through the automatic selection of real-time measurement as well as the development of new algorithms for the network phase identification and topology identification - ONGOING

New developments in System Planning and Reliability

- Development of tools for planning the DSO mandatory investments efforts for a time horizon of five years. - DONE
- Determination of loss profiles to be used in the electricity market in the year of 2019. - DONE
- A decision aid tool to help DSO decide the most adequate investments on the network, according to the established network quality targets. - DONE
- Loss analysis in the Portuguese network – characterize losses (technical and non-technical) for HV, MV and LV networks - ONGOING
- Support the long-term planning (and long term forecasting) studies in a climate changing environment and increase the competences on sustainable policies - ONGOING
- In the context of Smart Cities and Communities, coordinated operation of multi energy systems - DONE (a new activity area was defined).

New developments in Network Studies and RES & DER integration

- Relevant results within the networks' stability studies, especially when representing the system as whole, require new distribution network modelling strategies should be revised. - ONGOING

- In order to operate the future power system with very high share of inverters securely and stably, appropriate control algorithms and operation procedures should be identified. – ONGOING (isolated power systems)
- Exploiting Smart Transformers (ST) within the smart grid context for increased controllability. - ONGOING
- Focusing on the emergency operation of distribution networks, the micro-grid concept will be revisited in order to enable the secure operation of small islands within the MV distribution network. - DONE

New developments in Electricity Markets and Regulation

- New models so that flexibility aggregators can contract flexibility services from end consumers and provide this new resource to the DSO. - ONGOING
- Development of models to schedule batteries in view of the fact that the corresponding investment can only be justified if they provide multiservice. - DONE
- Development of long term Transmission Expansion Planning, TEP, problem and solution algorithms in a market environment. - ONGOING

New developments in Energy Analytics and Forecasting

- Development of a data-driven predictive control algorithm, which relies in reinforcement learning, for the optimization of the energy consumption of a wastewater treatment facility. Includes a patent request to protect this energy efficiency method. - DONE
- “Virtual battery” model for modelling the domestic consumers’ flexibility and to keep behind-the-meter data private, to be integrated in a home energy management system prototype. - DONE
- A cognitive architecture (Deep SpatioTemporal Inference Network - DeSTIN) will be explored to extract information from low voltage (LV) network smart meters (active power, voltage magnitude) that improves the visualization of alarms by human operators and helps to better distinguish normal and emergency operating conditions. - DONE
- Paper titled “Literature Survey on Synergies between Industry 4.0 and Smart Grids” (definition of a common framework for the future work) - DELAYED
- Collaboration with NOS to improve the energy efficiency of data centers cooling systems - DELAYED
- Creation of data-driven energy models for devices, systems, spaces and buildings - ONGOING
- Creation an internal “think-tank” and elaborate an internal seed project for electrical mobility. - REMOVED

New developments in Decision Making, Optimisation and Computational Intelligence RTD

- Research on the stochastic optimal power flow (OPF) problem by combining chance-constrained optimization, convex relaxation and linear approximation to manage computational tractability of the problem. - ONGOING
- Application of alternating direction method of multipliers (ADMM) to the three-phase unbalanced OPF problem. - DONE
- Data-driven optimization of energy-intensive processes by exploring reinforcement-learning algorithms - ONGOING
- Innovative optimization tools to leverage demand response services. – ONGOING

New developments in Forecasting RTD

- Development of techniques to extract information from geographically distributed measurements collected by sensors. - DELAYED
- Recent advances in deep learning, namely long short-term memory (LSTM) units, adapted and modified to forecast active/reactive power load in smart grids and the residual curves of the wholesale electricity market. - DELAYED
- Neural networks to analyse the available wholesale electricity market data and characterize circumstances that affect the evolution of prices. - ONGOING
- Conditional extreme value theory for modelling the extreme tails of price and renewable energy forecasts. - ONGOING

New developments in Reliability RTD

- Development of tools for the adequacy assessment of MV/LV 3-phase unbalanced grids with renewables and storage systems - ONGOING
- Tools for the adequacy assessment of the static and operational reserve in a multiarea environment. - DONE

New developments in Static and Dynamic Analysis of Energy Grids RTD

- New algorithms for monitoring, controlling and managing LV distribution networks. ONGOING

New developments in Power Electronics RTD

- Improve circuit design, outline design methodologies and make reference designs for dc/dc and dc/ac conversion, and types of circuits that become feasible due to new wide-bandgap (WBG) semiconductors. - ONGOING
- Validation using virtual prototyping and hardware-in-the loop testbeds for DC/DC converter for photovoltaic or battery interfacing in a microgrid testbed; and an ac-drive inverter for high-speed machines, on a high-speed testbed. REMOVED
- Implementation and test of Inertia emulation control capabilities on Three-Phase power inverter. - DONE
- Methods and tools to build power electronics converters dc/dc and dc/ac with fault tolerance and diagnosis in order to improve the reliability of power converters. - ONGOING
- Study and development of new operation modes and scenarios for power converters (backup, voltage source mode, energy/power buffer, etc.); - DELAYED
- Development and comparative evaluation of different topologies for hybrid inverters with interface with batteries, photovoltaic panels and the electric grid. - ONGOING
- Study and analysis of modern semiconductor technologies (based on gallium nitride, silicon carbide, etc.) to further optimize the efficiency and the performance of power converters. - DELAYED
- Design and development of new filter topologies for electromagnetic compatibility aiming to comply with relevant international standards required for product certification. - DELAYED
- Implementation of complete data model to integrate commercial lithium-ion battery packs adequate for residential energy storage and with full safety/performance certification; - ONGOING
- Development of new user interfaces (UI) with improved end-user experience and intuitiveness; - DONE
- Development of data models and interfaces with other devices within the smart home infrastructure based on modern web services (REST, SOAP). - DONE

New inter-area projects

- Joint project of CPES and CEGI for EDP Produção in the asset management area; - DONE
- Project ESGRID on the smart grids domain. - ONGOING

Proposals

- Participation in consortia to answer different calls from the European Union, in the framework of H2020 . 4 PROPOSALS APPROVED:
 - ✓ Topic: Enabling next-generation of smart energy services valorising energy efficiency and flexibility at demand-side as energy resource. Call ID: LC-SC3-EE-13-2018-2019-2020. INESC TEC budget: 233 125€
 - ✓ Topic: Interoperable and smart homes and grids. ID: DT-ICT-10-2018-19. INESC TEC budget: 1 747 100€
 - ✓ Topic: Business case for industrial waste heat/cold recovery. Call ID: LC-SC3-EE-6-2018-2019-2020. INESC TEC budget: 245 500€
 - ✓ Topic: Demonstration of solutions based on renewable sources that provide flexibility to the energy system. Call ID: LC-SC3-RES-17-2019. INESC TEC budget: 794 000€
- A proposal for energy efficiency and distributed energy resources (DER) sizing in the agriculture sector (was submitted to Horizon 2020 funds (DT-RUR-12-2018, ICT Innovation for agriculture – Digital Innovation Hubs for Agriculture), in collaboration with CRIIS. - PROPOSAL NOT APPROVED FOR FUNDING
- A proposal for an R&D contract with IKEA was submitted for energy planning of their factories. - APPROVED
- A proposal about weather intelligence for smart energy grids was submitted to Marie Skłodowska-Curie Innovative Training Networks (MSCA-ITN-2018). - NO DECISION YET ABOUT FUNDING
- Proposal with EFACEC about power transformer monitoring and maintenance planning for National funds (Portugal 2020. - REMOVED

Organization of scientific events

- CPES organization of dedicated events for the ongoing H2020 projects. - DONE

Advanced Training

- Course for REN technical staff on emergent topics of modern power systems. - DONE
- Organization with EFACEC of a course for operators from Angola - DONE
- EES-UETP course on “Advanced Data Analytics for Energy Systems”. - DONE

5.5.4 Main Achievements in 2018

- Development of a Multi Year Long Term Transmission Expansion Planning Model considering uncertainties from the demand and hydro inflows using meta heuristic techniques and incorporating the full AC OPF model to characterize the operation of candidate system configurations resulting from possible expansion plans.
- Development of data-driven energy optimization strategies for a wastewater pumping station by using a combination of reinforcement learning and machine learning.
- Development of a probabilistic state estimator for low voltage grids based in analog-search algorithms.
- Industrialization of a multi-period optimal power flow tool.

- Development of grid load forecasting algorithms based in machine learning and deep learning algorithms.
- Development of stochastic optimal power flow algorithms for distribution grid predictive management.
- Use of convolutional network networks for classifying power system outage events from phase measurement units (PMU) data.
- A three-phase inverter prototype developed in CPES was field-proven for the first time in an islanded operation of a real microgrid in Évora – Portugal. The fault-ride-through control mechanism developed and validated in Smart Grids and Electric Vehicles Laboratory (SGEVL) using Power Hardware-In-the-Loop (PHIL) test infrastructure with real network models was proven to be robust and accurate.
- Definition of a grid code for new renewable generation systems to be connected to the Madeira island system. The code establishes specific connection requirements for converter-interfaced generators that were categorized in classes according to a previously defined conceptual model. Dynamic requirements and quasi-steady state connection requirements were defined.
- Extension of dynamic simulation platforms previously developed under a scope of “inverter-dominated islanded power systems” to a simulation platform for 100% power electronic power systems, involving advanced modelling concept for grid forming inverters and its performance during fault conditions.
- Development of a “grey-box” dynamic equivalent model for active distribution networks, taking into account a heterogeneous fleet of generation technologies alongside the latest European grid codes requirements. It aims to properly represent the transient behaviour of the system upon large voltage disturbances in the transmission side.
- Development of a data predictive control method for distributed energy resources aggregated in a virtual power plant. Two different approaches, i.e. reinforcement learning and supervised learning, were developed and compared to minimize the deviation between the operating point of the energy resources and an automatic generation control (AGC) signal.
- Development of a multi-temporal approach for the energy scheduling and voltage/var control problem in a PV-battery Microgrid Cluster (MGC) system during islanded operation conditions.
- A two-stage stochastic optimization model has been developed to support an aggregator of small prosumers in its market participation strategy.
- Development of advanced control strategies for Multi-Microgrids islanding operation through smart Transformers in order to enhance the possibility of islanding by coordinating the control flexibility of all the available resources.
- A proactive distribution management stochastic approach based on chance-constrained programming was developed to assist DSO in the management of the distribution grid considering flexibility from distributed energy resources.
- A stochastic sequential AC OPF was developed to assist the DSO in the provision of reactive power flexibility to the TSO. The method takes advantage of DER to change their standard reactive power policies and provide reactive power according to the needs of the TSO/DSO coordination.
- A distributed/decentralized OPF was developed for unbalanced LV grids using ADMM approach to decompose the OPF problem into local/nodal sub-problems. Each node is responsible for solving its flow while collaborating with neighbour nodes.
- A computational tool was developed to optimize the ESS in order to define efficiently the degree of hybridization of the storage system (the number of cells of batteries and supercapacitors).
- In the context of energy conversion, a new modulation for the power converter designed as High-Frequency Link Matrix Converter (HFLMC) was developed. The proposed space vector modulation is able to control the power factor in the power grid interface as well as voltage and current at

load. An international patent application was submitted in order to protect the intellectual property of this work. The patent was already given in the United States and the regional processes in Europe and Japan are ongoing.

5.5.5 Centre Organisational Structure and Research Team

The Centre for Power and Energy Systems is coordinated by Manuel Matos (coordinator), Ricardo Bessa (assistant coordinator), Jorge Pereira (assistant to the coordination) and is organised in the following Activity and Business Areas:

- DMS/EMS and network automation. Responsible: Clara Gouveia
- System planning and reliability. Responsible: Leonel Carvalho
- RES & DER integration. Responsible: Bernardo Silva
- Electricity markets. Responsible: José Villar
- X-energy management systems. Responsible: David Rua
- Multi-energy networks. Responsible: Filipe Joel Soares

Research in low TRL is organised in the following Scientific Domains:

- Energy analytics and forecasting Responsible: Nuno Fidalgo
- Energy economics and regulation. Responsible: João Tomé Saraiva
- Industrial electronics. Responsible: Rui Esteves Araújo
- Static and dynamic analysis of power systems. Responsible: Carlos Moreira
- Decision-aid and optimization. Responsible: Manuel Matos

The SGEV research infrastructure is transversal to all areas and scientific domains and the responsible is Miguel Miranda.

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

Table 5.2 - CPES - Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	12	14	18	4
		Academic Staff	12	12	10	-2
		Grant Holders and Trainees	51	48	53	5
		Total Core Researchers	75	74	81	7
		Total Core PhD	22	25	25	0
	Affiliated Researchers		3	3	6	3
	Administrative and Technical	Employees	2	2	1	-1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	2	2	1	-1
	Total Integrated HR		80	79	88	2
	Total Integrated PhD		25	28	30	2
Curricular Trainees		2	0	0	0	
External Research Collaborators		9	11	12	1	
External Administrative and Technical Staff		0	1	2	1	
External Students		1	9	7	-2	
Total		92	100	109	9	

5.5.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform and from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CPES - Project funding

Funding Source		Total Income (k€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes – FCT	62	254	405	151
PN-PICT	National R&D Programmes - S&T Integrated Projects	8	28	34	7
PN-COOP	National Cooperation Programmes with Industry		65	56	-9
PUE-FP	EU Framework Programmes	1 279	642	855	212
PUE-DIV	EU Cooperation Programmes – Other	62	292	192	-99
SERV-NAC	R&D Services and Consulting - National	631	821	870	49
SERV-INT	R&D Services and Consulting - International	114	182	98	-85
OP	Other Funding Programmes	57	55	27	-27
Closed Projects		106	23	199	176
Total Funding		2 318	2 362	2738	375

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	36	46	71	25
Indexed Conferences	70	74	62	-12
Books				
Book Chapters	3	2	7	5
PhD Theses - Members	3	1	7	6
PhD Theses - Supervised	5	4	14	10

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

Type of Result	2016	2017	2018
Invention disclosures	1	0	4
Software copyright registrations	0	0	0
Patent applications	0	0	1
Granted patents	0	0	1
Licence agreements	1	0	0
Spin-offs	0	0	0

Table 5.6 - CPES - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	6	6	9
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1	2	2
International events in which INESC TEC members participate in the program committees	20	12	18
Participation in events such as fairs, exhibitions or similar	0	5	2
Advanced training courses	1	1	4

5.5.7 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	
PN-FCT	INFUSE	Vladimiro Miranda	01/04/2016	31/03/2019
PN-FCT	ESGRIDS	João Peças Lopes	01/01/2017	31/12/2019
PN-FCT	SGEVL	Luís Seca	01/07/2017	29/06/2020
PN-FCT	UNITED	João Catalão	01/06/2018	31/05/2021
PN-COOP	NEXTSTEP	Clara Sofia Gouveia	01/12/2016	30/11/2019
PN-PICT	iMAN-5	Luís Seca	01/07/2015	30/06/2019
PN-PICT	CORAL-TOOLS-4	Carlos Moreira	01/01/2016	
PUE-DIV	REStable	Carlos Moreira	01/04/2016	31/03/2019
PUE-DIV	GReSBAS	Filipe Joel Soares	01/04/2016	30/09/2019
PUE-DIV	SmartGuide	André Guimarães Madureira	01/04/2016	31/03/2019
PUE-DIV	Smares	Carlos Moreira	01/04/2016	
PUE-DIV	INDuGRID	Carlos Moreira	01/09/2016	31/08/2019
PUE-FP	EleCtra	José Nuno Fidalgo	01/12/2013	
PUE-FP	SENSIBLE	Ricardo Jorge Bessa	01/01/2015	
PUE-FP	AnyPLACE	David Emanuel Rua	01/01/2015	
PUE-FP	InteGrid	Ricardo Jorge Bessa	01/01/2017	30/06/2020

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PUE-FP	TDX-ASSIST	Leonel Magalhães Carvalho	01/10/2017	30/09/2020
PUE-FP	EU-SysFlex	Bernardo Silva	01/11/2017	31/10/2021
PUE-FP	FEEdBACk	Filipe Joel Soares	01/11/2017	31/10/2020
SERV-INT	SECRETS	Luís Seca	01/12/2013	31/05/2019
SERV-NAC	EFACEC-DMS	Jorge Correia Pereira	15/04/2001	
SERV-NAC	CP_T_Dinamicas	João Tomé Saraiva	01/02/2015	31/10/2019
SERV-NAC	Cidade_sustentavel	Filipe Joel Soares	01/01/2016	30/06/2019
SERV-NAC	MORA	Leonel Magalhães Carvalho	05/04/2016	
SERV-NAC	ADMS4LV	Clara Sofia Gouveia	01/04/2016	
SERV-NAC	SACC	Filipe Joel Soares	01/01/2016	30/06/2019
SERV-NAC	Hidrica_reversivel	João Peças Lopes	01/03/2016	
SERV-NAC	PANACEa	José Nuno Fidalgo	08/08/2016	07/09/2019
SERV-NAC	Graciosa	João Peças Lopes	25/11/2016	
SERV-NAC	Generation_RAM	João Peças Lopes	30/11/2016	
SERV-NAC	INTERLIG_PT_MA	Bernardo Silva	01/03/2017	31/08/2019
SERV-NAC	SOLAR4DR	Ricardo Jorge Bessa	01/01/2018	
SERV-NAC	INFRA_PT	João Peças Lopes	20/07/2017	06/11/2019
SERV-NAC	MIBEL	Filipe Joel Soares	11/09/2017	
SERV-NAC	HIP-1	Ricardo Jorge Bessa	10/01/2018	
SERV-NAC	GridCodeMadeira	João Peças Lopes	20/05/2018	19/10/2018
SERV-NAC	OTGEN3	João Peças Lopes	01/09/2017	31/05/2018
SERV-NAC	EstinvestQoS	José Nuno Fidalgo	01/12/2017	31/07/2018
SERV-NAC	Prob2	José Nuno Fidalgo	01/12/2017	31/07/2018
SERV-NAC	AO_Perdas	Luís Seca	01/01/2018	31/12/2018
SERV-NAC	Perfis_Perdas	José Nuno Fidalgo	01/01/2018	
SERV-NAC	Farad2	João Peças Lopes	01/05/2018	31/07/2018
SERV-NAC	LowCarbon	João Peças Lopes	02/04/2018	01/09/2018
SERV-NAC	GEST_STORAGE	Clara Sofia Gouveia	02/04/2018	01/01/2019
SERV-NAC	HEAD-1	João Peças Lopes	01/01/2018	30/04/2019
SERV-NAC	PriceMining	Ricardo Jorge Bessa	01/05/2018	31/12/2018
SERV-NAC	Storage_Maria	Carlos Moreira	07/06/2018	06/12/2018
SERV-NAC	TarifasRenovMadeira	João Tomé Saraiva	19/07/2018	18/11/2018
SERV-NAC	REG_CODE_RAM	João Peças Lopes	25/07/2018	24/11/2018
SERV-NAC	Consultoria	Manuel Matos	01/01/2008	
SERV-INT	Med_TSO	Leonel Magalhães Carvalho	28/04/2017	27/04/2019
SERV-INT	Itesla_IPST	Helena Vasconcelos	01/06/2017	
SERV-INT	fof.PLAN	Ricardo Jorge Bessa	01/01/2018	31/07/2018
OP	CoordEES-UETP	João Peças Lopes	01/04/2007	
OP	IREP'2017	João Peças Lopes	01/01/2017	
	Lab_redes_eletricas	Carlos 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-P2020 National R&D Programmes - Portugal 2020
- PUE-H2020 EU Framework Programme
- SERV-NAC National R&D Services and Consulting
- SERV-INT International R&D Services and Consulting

5.5.8 List of Publications

International Journals with Scientific Referees

1. Aghaei, J, Nikoobakht, A, Mardaneh, M, Shafie khah, M, Catalao, JPS, "Transmission switching, demand response and energy storage systems in an innovative integrated scheme for managing the uncertainty of wind power generation", International Journal of Electrical Power and Energy Systems, vol.98, pp.72-84, 2018
2. Baharvandi, A, Aghaei, J, Niknam, T, Shafie Khah, M, Godina, R, Catalao, JPS, "Bundled Generation and Transmission Planning under Demand and Wind Generation Uncertainty based on a Combination of Robust and Stochastic Optimization", IEEE Transactions on Sustainable Energy, pp.1-1, 2018
3. Bahramara, S, Yazdani Damavandi, M, Contreras, J, Shafie Khah, M, Catalao, JPS, "Modeling the Strategic Behavior of a Distribution Company in Wholesale Energy and Reserve Markets", IEEE Transactions on Smart Grid, pp.1-1, 2018
4. Bahrami, S, Amini, MH, Shafie khah, M, Catalao, JPS, "A Decentralized Electricity Market Scheme Enabling Demand Response Deployment", IEEE Transactions on Power Systems, pp.1-1, 2018
5. Bahrami, S, Amini, MH, Shafie Khah, M, Catalao, JPS, "A Decentralized Renewable Generation Management and Demand Response in Power Distribution Networks", IEEE Transactions On Sustainable Energy, vol.9, pp.1783-1797, OCT, 2018
6. Beires, P, Vasconcelos, MH, Moreira, CL, Pecs Lopes, JAP, "Stability of autonomous power systems with reversible hydro power plants: A study case for large scale renewables integration", Electric Power Systems Research, vol.158, pp.1-14, 2018
7. Cartaxo, E, Valois, I, Miranda, V, Costa, M, "Issuances of Automotive Vehicles and the Impacts on Air Quality in the Largest City in the Brazilian Amazon", Sustainability, vol.10, NOV, 2018
8. Carvalho, LD, Leite da Silva, AML, Miranda, V, "Security-Constrained Optimal Power Flow via Cross-Entropy Method", IEEE Transactions on Power Systems, vol.33, pp.6621-6629, 2018
9. Chen, Y, Wei, W, Liu, F, Shafie khah, M, Mei, SW, Catalao, JPS, "Optimal contracts of energy mix in a retail market under asymmetric information", Energy, vol.165, pp.634-650, 2018
10. Coelho, A, Soares, F, Merino, J, Riano, S, Lopes, JP, "Control Room Requirements for Voltage Control in Future Power Systems", Energies, vol.11, pp.1659, JUL, 2018
11. Cruz, MRM, Fitiwi, DZ, Santos, SF, Catalao, JPS, "A comprehensive survey of flexibility options for supporting the low-carbon energy future", Renewable and Sustainable Energy Reviews, vol.97, pp.338-353, 2018
12. Cruz, MRM, Fitiwi, DZ, Santos, SF, Mariano, SJPS, Catalao, JPS, "Prospects of a meshed electrical distribution system featuring large-scale variable renewable power", Energies, vol.11, 2018
13. Dogansahin, K, Kekezoglu, B, Yumurtaci, R, Erdinc, O, Catalao, JPS, "Maximum Permissible Integration Capacity of Renewable DG Units Based on System Loads", Energies, vol.11, JAN, 2018
14. Frade, PMS, Santana, JJE, Shafie khah, M, Catalao, JPS, "Impact of tertiary reserve sharing in Portugal", Utilities Policy, vol.55, pp.167-177, 2018
15. Frade, PMS, Vieira Costa, JVGA, Osorio, GJ, Santana, JJE, Catalao, JPS, "Influence of Wind Power on Intraday Electricity Spot Market: A Comparative Study Based on Real Data", Energies, vol.11, pp.2974, 2018
16. Godina, R, Rodrigues, EMG, Pouresmaeil, E, Catalao, JPS, "Optimal residential model predictive control energy management performance with PV microgeneration", Computers and Operations Research, 2018

17. Godina, R, Rodrigues, EMG, Pouresmaeil, E, Matias, JCO, Catalao, JPS, "Model Predictive Control home energy management and optimization strategy with demand response", Applied Sciences (Switzerland), vol.8, 2018
18. Hajibandeh, N, Shafie Khah, M, Osorio, GJ, Aghaei, J, Catalao, JPS, "A heuristic multi-objective multi-criteria demand response planning in a system with high penetration of wind power generators", Applied Energy, vol.212, pp.721-732, 2018
19. Hemmati, R, Azizi, N, Shafie Khah, M, Catalao, JPS, "Decentralized frequency-voltage control and stability enhancement of standalone wind turbine-load-battery", International Journal of Electrical Power & Energy Systems, vol.102, pp.1-10, NOV, 2018
20. Iria, J, Soares, F, Matos, M, "Optimal supply and demand bidding strategy for an aggregator of small prosumers", Applied Energy, 2018
21. Kabiri, M, Amjady, N, Shafie khah, M, Catalao, JPS, "Enhancing power system state estimation by incorporating equality constraints of voltage dependent loads and zero injections", International Journal of Electrical Power and Energy Systems, vol.99, pp.659-671, 2018
22. Kordkheili, HH, Banejad, M, Kalat, AA, Pouresmaeil, E, Catalao, JPS, "Direct-Lyapunov-Based Control Scheme for Voltage Regulation in a Three-Phase Islanded Microgrid with Renewable Energy Sources", Energies, vol.11, pp.1161, MAY, 2018
23. Lujano Rojas, JM, Dufo Lopez, R, Bernal Agustin, JL, Dominguez Navarro, JA, Catalao, JPS, "Probabilistic methodology for estimating the optimal photovoltaic capacity in distribution systems to avoid power flow reversals", IET Renewable Power Generation, vol.12, pp.1045-1064, 2018
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26. Massrur, HR, Niknam, T, Aghaei, J, Shafie Khah, M, Catalao, JPS, "A stochastic mid-term scheduling for integrated wind-thermal systems using self-adaptive optimization approach: A comparative study", Energy, vol.155, pp.552-564, 2018
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6. Neyestani, N., "Sustainable distribution network planning considering multi-energy systems and plug-in electric vehicles parking lots";
7. Gomes, P., "Transmission expansion planning - a dynamic multiobjective approach considering uncertainties";

5.6 CESE - CENTRE FOR ENTERPRISE SYSTEMS ENGINEERING

Coordinators: Américo Lopes Azevedo and António Lucas Soares

5.6.1 Presentation of the Centre

CESE mission is to advance the scientific knowledge in enterprise systems engineering, providing unique expertise targeting complex industrial organisation challenges that foster high impact management and ICT systems and generate innovative services for industrial organisations. CESE wants to position as a leading research Centre focused on connected, sustainable and customizable production systems through the engineering of innovative enterprise systems. It aims to become the first choice in helping industrial organisations to improve competitiveness and sustainability of their supply chains and achieve high-performance levels of their inner business processes.

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, Logistics and Technology Management.

CESE core competencies are Systems Design, Operational Research (including Modelling, Optimization and Simulation), Information Management and Analytics, Design Science and Explanatory Research, and Creative Thinking and Problem Structuring.

5.6.2 Contribution to the Vision of the Cluster

CESE undertakes multi-disciplinary, system-oriented research and technology development for the strategic and operational management of industrial enterprises and networks. CESE research focuses on connected and high customizable and sustainable transformation systems, helping companies, from different sectors, to achieve personalised and complex products and services, being flexible and resilient in their operations. CESE will direct its research strategy on these areas complying at the same time with the requirements of resource efficiency and circular economy implementation, as well as trying to achieve an optimal balance and integration between humans and machines. CESE will also consolidate the leadership in knowledge and technology transfer on digital transformation, integration of advanced manufacturing technologies and new business models, helping companies to fully embrace the 4th industrial revolution.

The research strategy of CESE is aligned with the strategic research lines of the Cluster Industry and Innovation.

5.6.3 Research and Innovation Progress in 2018

The centre progressed in the several research domains through activities developed in research projects, PhD projects and innovation actions and services. Advances were achieved by addressing the increasing complexity and scope of the manufacturing problems.

Manufacturing and Services Operations Management

- New planning and scheduling heuristics and optimization and simulation tools to deal with tailored production processes, for small series, high-customization were addressed in activities that resulted in (i) balancing mixed-model assembly systems in the footwear industry with a variable neighbourhood descent method, and (ii) hybrid modelling of MTO/ETO (make to order/engineer to order) manufacturing environments for performance assessment;
- Novel optimization-simulation approaches to address uncertainty in production scheduling and planning research activities produced outcomes in (i) simulation-optimization approaches for

the decision-support on the planning and scheduling of automated assembly lines; and (ii) multicriteria location-routing problems with sectorization.

- Study of the barriers and enablers for the adoption of Industry 4.0 technologies, namely: (i) development of a conceptual framework for the identification of influential contexts of the adoption decision of advanced manufacturing technologies and (ii) study of Industry 4.0 in Tamega e Sousa's region in a twofold perspective: industry vs IT enterprise.
- In innovation actions and services, the centre achieved results above the established objectives, in particular with projects developed with large companies and groups, such as IKEA and Grupo Amorim.

In these research domains, several papers in international conferences and journals were prepared and published.

Enterprise and Industrial ICT

Development of Plug&Produce software for advanced robotics in logistic and production areas continued (DM4Manufacturing project);

- Architectures for integration of IoT interconnected devices at the shop-floor with the manufacturing execution systems (MES) were explored in several projects.

Collaborative Networks and Supply Chains

- Research on digital platforms for smart factories continued this year within the Manusquare EU project, where developments on semantic information architectures and a blockchain based reputation system are being undertaken;
- The research line covering from studies to design of methods and tools for the transformation of existing networks into collaborative networks encompassed the publication of results on the usage of digital platforms to support SME internationalization in the context of industrial business associations;
- Development of methodologies for the selection of practices for supply chain management towards increasing resource-efficiency and resilience continued with the PhD project addressing the an information management perspective of risk and visibility in supply chains, also in the scope of the E4Web project;
- Norte Digital Innovation Hub continues its implantation and expansion through several dissemination activities.

Business Analytics and Decision Support Systems

- Research on the growing uncertainty levels and risks, in strongly dynamic environments through powerful and ergonomic Decision Support Systems continues in activities such as simulation-optimization approaches for the decision-support on the planning and scheduling of automated assembly lines, multicriteria location-routing problems with sectorization and a unified decision-making framework for strategic decision-making in the pharmaceutical industry;
- Research on industrial recommendation systems was consolidated in several publications, namely Metalearning and Recommender Systems: A literature review and empirical study on the algorithm selection problem for Collaborative Filtering.

Transport, Logistics and Mobility

- Research on advanced optimization and simulation models, along with data and knowledge management procedures have encompassed activities such as methodology development for impact assessment of air quality traffic-related measures, assessing the importance of transportation activity data for urban emission inventories or exploring multiple eco-routing guidance strategies in a commuting corridor.

Natural Resources Management

- In 2018 the new research domain on Natural Resources Management continued to be developed, focusing on forestry and biomass logistic supply-chain management. Projects Biotecfor and Gotecfor address digital technologies for forest supply chain optimization.

In 2017, medium term management objectives were defined and already partially tackled in 2018:

- To improve the scientific performance (publications quality and quantity);
- To implement strategies to attract high quality PhD students and scholarship holders;
- To define a strategy for the projects portfolio;
- To develop a roadmap for existing and new high-value services to offer;
- To increase the contribution of CESE for the visibility of INESC TEC in society.

5.6.4 Main Achievements in 2018

Manufacturing and Services Operations Management

CESE has prepared, implemented and successfully validated several contract-based research projects supported by the developed reference framework based on 4.0 industry concepts and technologies. Thus, it was possible to consolidate in 2018 the offering of new added value services to companies seeking to develop their competitiveness in a sustainable way. It is important to point out that it was possible, with the new set of new added value services, previously created in 2017, to acquire new clients of significant strategic importance for future research activity (e.g. GALP Energia and Grupo Amorim). Furthermore, during 2018, CESE consolidated the collaboration with IKEA Industry in the areas of factory design and operations planning. These projects addressed optimization of the production systems operating in contexts of significant variability in demand and uncertainty in operations processing time. The followed approach is based on advanced simulation techniques and optimization models to understand the impact of key parameters and resources configuration.

Enterprise and Industrial ICT

In the scope of Adaptpack project, it was possible to consolidate knowledge in IoT, in particular software platforms to configure and manage intelligent automation devices (e.g. PLC, intelligent sensors);

Collaborative Networks and Supply Chains

In this field and aligned with the growing relevance of the product customization activities, CESE pursued research addressing Make-to-Order Supply Chains (SC), common in industries as the aerospace. The complexity of these manufacturing SCs, allied to the major differences when compared to mass manufacturing (e.g. demand volume), and the varied manufacturing activities that exist, call for the use of tailored solutions for performance assessment, where a critical sustainability perspective should be considered. Given this, and using simulation as a research method, it was developed a hierarchical and hybrid performance assessment model considering key sustainability indicators.

Natural Resources Management

The research domain of Natural Resources Management was reinforced during 2018 through the leadership of CESE in the FCT project Easyflow - Sustainability in forest-based supply chains. Another FCT project was approved (TECFEL) under a similar topic of dynamic planning of forest-based supply chains, in collaboration with CEGI. CESE is actively participating in two other projects, in developing decision support systems for biomass feedstock supply chain, in collaboration with CRIIS. The work done under these projects is supporting 3 on-going PhD thesis at the PRODEGI and two master thesis of FEUP, concluded in 2018. Some of the main achievements in 2018 is the publication of three journal papers. The results were also presented in 6 presentations in national and international events. This work is instrumental for reinforcing the leading role of INESC TEC in the operacionalization of the ForestWISE: collaborative laboratory for the integrated management of forests and fires.

5.6.5 Centre Organisational Structure and Research Team

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

Table 5.2 - CESE - Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	12	14	17	3
		Academic Staff	11	10	7	-3
		Grant Holders and Trainees	33	34	37	3
		Total Core Researchers	56	58	61	3
		Total Core PhD	16	16	12	-4
	Affiliated Researchers		4	3	6	3
	Administrative and Technical	Employees	2	2	2	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	2	2	2	0
	Total Integrated HR		62	63	69	-1
	Total Integrated PhD		19	18	16	-2
Curricular Trainees		7	9	4	-5	
External Research Collaborators		8	7	13	6	
External Administrative and Technical Staff		0	0	1	1	
External Students		1	1	2	1	
Total		78	80	89	9	

5.6.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			Δ (k€)
		2016	2017	2018	2017-18
PN-FCT	National R&D Programmes – FCT	76	122	156	33
PN-PICT	National R&D Programmes - S&T Integrated Projects	101	143	173	31
PN-COOP	National Cooperation Programmes with Industry	118	367	364	-3
PUE-FP	EU Framework Programmes	391	221	501	280
PUE-DIV	EU Cooperation Programmes – Other	108	114	67	-47
SERV-NAC	R&D Services and Consulting – National	259	431	510	79
SERV-INT	R&D Services and Consulting - International	58	13	32	19
OP	Other Funding Programmes	37			
Closed Projects		41	24	3	-22
Total Funding		1 187	1 435	1 806	371

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	18	15	12	-3
Indexed Conferences	38	24	22	-2
Books				
Book Chapters	3	2	2	
PhD Theses - Members	4	3	7	4
PhD Theses - Supervised	5	4	7	3

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

Type of Result	2016	2017	2018
Invention disclosures	1	2	1
Software copyright registrations	1	0	0
Patent applications	0	0	0
Granted patents	0	0	0
Licence agreements	1	0	1
Spin-offs	0	0	0

Table 5.6 - CESE - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	1	1	2
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1	0	0
International events in which INESC TEC members participate in the program committees	12	3	8
Participation in events such as fairs, exhibitions or similar	7	3	3
Advanced training courses	0	0	0

5.6.7 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 Cristina Barros	01/06/2014	
PN-FCT	VR2Market-1	Ana Cristina Barros	15/07/2014	30/06/2019
PN-FCT	EasyFlow	Alexandra Sofia Marques	01/06/2016	31/05/2019
PN-FCT	DM4Manufacturing-1	César Toscano	01/11/2016	31/10/2019
PN-FCT	3SLM	António Lucas Soares	10/08/2017	09/08/2019
PN-FCT	opti-MOVES	Tânia Daniela Fontes	26/07/2018	24/01/2021
PN-FCT	StoSS	Ana Maria Rodrigues	15/10/2018	14/10/2021
PN-COOP	PrecisionCork	Pedro Ribeiro	15/05/2016	
PN-COOP	3GEnergy	António Lucas Soares	01/09/2016	
PN-COOP	ADIRA_I4.0	António Correia Alves	01/09/2016	31/08/2019
PN-COOP	AdaptPack	Pedro Ribeiro	01/09/2016	31/08/2019
PN-COOP	MAPPLE	António Correia Alves	01/09/2016	
PN-COOP	FAMEST	Rui Diogo Rebelo	01/11/2017	31/10/2020
PN-COOP	GOTECFOR-1	Alexandra Sofia Marques	01/01/2017	31/12/2020
PN-COOP	PRODUTECH_SIF	António Correia Alves	01/10/2017	30/09/2020
PN-PICT	iMAN	Américo Azevedo	01/07/2015	30/06/2019
PUE-DIV	MANTIS	Hugo Miguel Ferreira	01/05/2015	
PUE-DIV	BIOTECFOR-1	Alexandra Sofia Marques	01/01/2017	31/12/2019
PUE-FP	BEinCPPS	César Toscano	01/11/2015	
PUE-FP	Futuring	António Lucas Soares	01/09/2016	
PUE-FP	ScalABLE4.0-1	César Toscano	01/01/2017	30/06/2020
PUE-FP	Fasten	Samuel Moniz	01/11/2017	31/10/2020
PUE-FP	MANU-SQUARE	António Lucas Soares	01/01/2018	31/12/2020
PUE-FP	NEXT-NET	Ana Cristina Barros	01/10/2017	30/09/2019
PUE-FP	DIVA-1	Alexandra Sofia Marques	01/04/2018	31/03/2021
SERV-NAC	ParqueEscolar	Luís Guardão	01/11/2009	30/06/2019
SERV-NAC	CMLDM	Carlos Manuel Soares	16/05/2016	
SERV-NAC	SmartRetail	Rui Diogo Rebelo	13/12/2016	12/06/2019
SERV-NAC	RIDDIG	António Correia Alves	03/05/2017	31/08/2019
SERV-NAC	CFERRA	António Correia Alves	01/12/2017	30/11/2019
SERV-NAC	MDIGIREC	Rui Diogo Rebelo	01/12/2017	
SERV-NAC	LM_Escalona	Luís Guardão	01/01/2018	31/03/2019
SERV-NAC	SmartSL4.0	Rui Diogo Rebelo	01/01/2018	31/12/2019
SERV-NAC	NewShoeFactory	Rui Diogo Rebelo	15/01/2018	11/05/2018
SERV-NAC	GLP-i4.0	Américo Azevedo	01/02/2018	30/04/2019
SERV-NAC	RTDT	Samuel Moniz	01/01/2018	30/04/2018
SERV-NAC	SimOptBoF	Samuel Moniz	02/04/2018	01/08/2018
SERV-NAC	OLIVA	Rui Diogo Rebelo	01/06/2018	31/08/2018
SERV-NAC	ACCi40	Rui Diogo Rebelo	03/06/2018	02/12/2018
SERV-NAC	COATING4.0	Rui Diogo Rebelo	01/05/2018	31/03/2019
SERV-NAC	ETMA4.0	António Correia Alves	05/11/2018	04/11/2019
SERV-NAC	Consultoria	António Lucas Soares	01/01/2009	
SERV-INT	IzaroGrey	António Correia Alves	01/01/2007	

Type of Project:

PN-FCT National R&D Programmes - FCT

PN-PICT National R&D Programmes - S&T Integrated Projects

PN-P2020 National R&D Programmes - Portugal 2020
PUE-H2020 EU Framework Programme
SERV-NAC National R&D Services and Consulting
SERV-INT International R&D Services and Consulting

5.6.8 List of Publications

International Journals with Scientific Referees

1. Bandeira, JM, Fernandes, P, Fontes, T, Pereira, SR, Khattak, AJ, Coelho, MC, "Exploring multiple eco-routing guidance strategies in a commuting corridor", International Journal of Sustainable Transportation, pp.1-13, 2018
2. Barbosa, C, Azevedo, A, "Hybrid modelling of MTO/ETO manufacturing environments for performance assessment", International Journal of Production Research, pp.1-25, 2018
3. Cunha, T, Soares, C, de Carvalho, ACPLF, "Metalearning and Recommender Systems: A literature review and empirical study on the algorithm selection problem for Collaborative Filtering", Information Sciences, vol.423, pp.128-144, JAN, 2018
4. de Sa, CR, Azevedo, P, Soares, C, Jorge, AM, Knobbe, A, "Preference rules for label ranking: Mining patterns in multi-target relations", Information Fusion, vol.40, pp.112-125, MAR, 2018
5. de Sa, CR, Duivesteijn, W, Azevedo, P, Jorge, AM, Soares, C, Knobbe, A, "Discovering a taste for the unusual: exceptional models for preference mining", Machine Learning, vol.107, pp.1775-1807, 2018
6. Dias, D, Amorim, JH, Sa, E, Borrego, C, Fontes, T, Fernandes, P, Pereira, SR, Bandeira, J, Coelho, MC, Tchepel, O, "Assessing the importance of transportation activity data for urban emission inventories", Transportation Research Part D: Transport and Environment, vol.62, pp.27-35, 2018
7. Fontes, T, Li, PL, Barros, N, Zhao, PJ, "A proposed methodology for impact assessment of air quality traffic-related measures: The case of PM2.5 in Beijing", Environmental Pollution, vol.239, pp.818-828, AUG, 2018
8. Marques, A, Rasinmaki, J, Soares, R, Amorim, P, "Planning woody biomass supply in hot systems under variable chips energy content", Biomass and Bioenergy, vol.108, pp.265-277, 2018
9. Marques, CM, Moniz, S, de Sousa, JP, "Strategic decision-making in the pharmaceutical industry: A unified decision-making framework", Computers & Chemical Engineering, 2018
10. Rivolli, A, Soares, C, de Carvalho, ACPLF, "Enhancing multilabel classification for food truck recommendation", Expert Systems, vol.35, pp.e12304, AUG, 2018
11. Sadeghi, P, Rebelo, RD, Ferreira, JS, "Balancing mixed-model assembly systems in the footwear industry with a variable neighbourhood descent method", Computers & Industrial Engineering, vol.121, pp.161-176, JUL, 2018
12. Scholz, J, De Meyer, A, Marques, AS, Pinho, TM, Boaventura Cunha, J, Van Orshoven, J, Rosset, C, Kunzi, J, Kaarle, J, Nummala, K, "Digital Technologies for Forest Supply Chain Optimization: Existing Solutions and Future Trends", Environmental Management, 2018

International Conference Proceedings with Scientific Referees

1. Azevedo, A, "Collaborative Transformation Systems - Path to Address the Challenges Around the Competitiveness of Mature Countries", Collaborative Networks of Cognitive Systems, vol.534, pp.21-32, 2018
2. Cerqueira, V, Pinto, F, Torgo, L, Soares, C, Moniz, N, "Constructive Aggregation and Its Application to Forecasting with Dynamic Ensembles", Machine Learning and Knowledge Discovery in Databases - European Conference, ECML PKDD 2018, Dublin, Ireland, September 10-14, 2018, Proceedings, Part I, vol.11051, pp.620-636, 2018

3. Costa, E, Soares, AL, de Sousa, JP, "Exploring the CIMO-Logic in the Design of Collaborative Networks Mediated by Digital Platforms", Collaborative Networks of Cognitive Systems - 19th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2018, Cardiff, UK, September 17-19, 2018, Proceedings, vol.534, pp.266-277, 2018
4. Cunha, T, Soares, C, de Carvalho, ACPLF, "A label ranking approach for selecting rankings of collaborative filtering algorithms", Proceedings of the 33rd Annual ACM Symposium on Applied Computing, SAC 2018, Pau, France, April 09-13, 2018, vol.Part F137816, pp.1393-1395, 2018
5. Cunha, T, Soares, C, de Carvalho, ACPLF, "CF4CF", Proceedings of the 12th ACM Conference on Recommender Systems - RecSys '18, 2018
6. Cunha, T, Soares, C, de Carvalho, ACPLF, "CF4CF: Recommending Collaborative Filtering algorithms using Collaborative Filtering", CoRR, vol.abs/1803.02250, 2018
7. Cunha, T, Soares, C, de Carvalho, ACPLF, "CF4CF-META: Hybrid Collaborative Filtering Algorithm Selection Framework", Discovery Science - Lecture Notes in Computer Science, pp.114-128, 2018
8. Das Dores, SCN, Soares, C, Ruiz, D, "Bandit-Based Automated Machine Learning", 7th Brazilian Conference on Intelligent Systems, BRACIS 2018, São Paulo, Brazil, October 22-25, 2018, pp.121-126, 2018
9. Felix, C, Soares, C, Jorge, A, Ferreira, H, "Using metalearning for parameter tuning in neural networks", Lecture Notes in Computational Vision and Biomechanics, vol.27, pp.1081-1090, 2018
10. Freitas, R, Sousaa, C, Sousa, C, "Industry 4.0 in Tamega e Sousa's region in a twofold perspective: industry vs IT enterprise", 2018 13th Iberian Conference on Information Systems and Technologies (CISTI), 2018
11. Martinho, A, Alves, E, Rodrigues, AM, Ferreira, JS, "Multicriteria location-routing problems with sectorization", Springer Proceedings in Mathematics and Statistics, vol.223, pp.215-234, 2018
12. Mercier, M, Santos, MS, Abreu, PH, Soares, C, Soares, JP, Santos, J, "Analysing the Footprint of Classifiers in Overlapped and Imbalanced Contexts", Advances in Intelligent Data Analysis XVII - 17th International Symposium, IDA 2018, 's-Hertogenbosch, The Netherlands, October 24-26, 2018, Proceedings, vol.11191, pp.200-212, 2018
13. Monjardino, J, Barros, N, Ferreira, F, Tente, H, Fontes, T, Pereira, P, Manso, C, "Improving Air Quality in Lisbon: modelling emission abatement scenarios", Ifac Papersonline, vol.51, pp.61-66, 2018
14. Neuenfeldt Junior, A, Silva, E, Miguel Gomes, AM, Oliveira, JF, "The two-dimensional strip packing problem: What matters?", Springer Proceedings in Mathematics and Statistics, vol.223, pp.151-164, 2018
15. Ribeiro, SP, Santos, VR, Pereira, CS, "eCommerce Business-to-Business platform for the footwear sector: The cluster of Felgueiras", 2018 13th Iberian Conference on Information Systems and Technologies (CISTI), 2018
16. Rivolli, A, Soares, C, de Carvalho, ACPLF, "Label Expansion for Multi-label Classification", 7th Brazilian Conference on Intelligent Systems, BRACIS 2018, São Paulo, Brazil, October 22-25, 2018, pp.414-419, 2018
17. Sato, AK, Setter Bauab, GES, Martins, TD, Guerra Tsuzuki, MDG, Gomes, AM, "A Study in Pairwise Clustering for Bi-dimensional Irregular Strip Packing Using the Dotted Board Model", IFAC-PapersOnline, vol.51, pp.284-289, 2018
18. Silva, P, Rivolli, A, Rocha, P, Correia, F, Soares, C, "Machine Learning for Drugs Prescription", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.11314 LNCS, pp.548-555, 2018
19. Simoes, AC, Barros, AC, Soares, AL, "Conceptual framework for the identification of influential contexts of the adoption decision", Proceedings - IEEE 16th International Conference on Industrial Informatics, INDIN 2018, pp.1059-1064, 2018

20. Strecht, P, Moreira, JM, Soares, C, "A Framework for Analytical Approaches to Combine Interpretable Models", Information Management and Big Data - Communications in Computer and Information Science, pp.182-197, 2018
21. Toscano, C, Arrais, R, Veiga, G, "Enhancement of Industrial Logistic Systems with Semantic 3D Representations for Mobile Manipulators", Advances in Intelligent Systems and Computing, vol.694, pp.617-628, 2018
22. Vieira, M, Barbosa Póvoa, AP, Moniz, S, Pinto Varela, T, "Simulation-optimization approach for the decision-support on the planning and scheduling of automated assembly lines", 13th APCA International Conference on Control and Soft Computing, CONTROLO 2018 - Proceedings, pp.265-269, 2018

Books

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Chapter/Paper in Books

1. Costa, E, Soares, AL, Pinho de Sousa, J, "On the Use of Digital Platforms to Support SME Internationalization in the Context of Industrial Business Associations", Advances in Business Information Systems and Analytics - Handbook of Research on Expanding Business Opportunities With Information Systems and Analytics, pp.66-94, 2018
2. Messina, D, Santos, C, Soares, AL, Barros, AC, "Risk and visibility in supply chains: An information management perspective", Global Business Expansion: Concepts, Methodologies, Tools, and Appl., pp.1501-1524, 2018

Publications (Eitor)

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Dissertations (PhD)

1. Schlickmann, M., "A Decision Support System for Investments in Public Transport Infrastructure";
2. Salimi, F., "an integrated approach to urban parking modeling and pricing";
3. Sadeghi, P., "Balancing and Sequencing Mixed-Model Assembly Systems in the Footwear Industry";
4. Costa, E., "Collaboration and information management in the internationalisation of SMEs: a case in industrial business associations";
5. Pinto, F., "Leveraging Metalearning for Bagging Classifiers";
6. Barbosa, C., "Multidimensional performance assessment for complex manufacturing environments";
7. Bastos, J., "Understanding Customer-Focused Supply Chain Management: A Set-Based Concept Framework";

5.7 CRIIS - CENTRE FOR ROBOTICS IN INDUSTRY AND INTELLIGENT SYSTEMS

Coordinator: António Paulo Moreira

5.7.1 Presentation of the Centre

The Robotics and Intelligent Systems Centre designs and implements 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 Contribution to the Vision of the Cluster

Customer-centric and production optimisation in real time, as well the decentralisation of decisions will only be possible with highly flexible, re-allocable, adaptable and intelligent automation, control and robotics. The use of industrial collaborative robots (mobile and manipulators); smart sensor networks, Industrial vertical IoT-based information architectures and Human-robot collaboration and interface plays an important role in these processes and are the main contribution of the Centre to the Vision of the Cluster.

Furthermore, our contributions and activities in the Cluster focus on the development and implementation of intelligent systems, automation, management and decision support systems, among other technological solutions in the areas of agriculture, forest and livestock in an integrated approach, fostering - the resilience, efficiency, competitiveness and sustainability of these areas towards an effective bio-economy.

5.7.3 Research and Innovation Progress in 2018

Strategic Objectives, Main initiatives / actions planned

- The alignment between basic research, applied research and consultancy was improved through a continuous discussion at the Centre Council Board with results in the chosen and contents in calls and proposals.
- The impact of the Centre's activity in the companies, and promote the valorisation of results was one of the main goals of the iiLab - Industry and Innovation Laboratory started in 2018.
- Strategic partnerships with international research key players, industries and stakeholders, allowing the alignment of the research activities with future industrial projects was improved through new H2020 proposals with new partners.
- Motivation of human resources and creating conditions for attracting high-level national and international researchers was also one of the main objectives of the iiLab - Industry and Innovation Laboratory started in 2018.
- The improvement of the Centre's external visibility was also one of the main objectives of the iiLab - Industry and Innovation Laboratory started in 2018. Also the organization of the IEEE 16th International Conference of Industrial Informatics Indin2018 and participation in the EMAF - International Fair on Machinery, Equipment and Services for Industry adds contributes to the external visibility of the Centre.
- 2018 continued to be a consolidation and confirmation year for the new application area Agriculture Robotics. With several projects already running, this year was focused on the growth of the team dedicated to the area, with special emphasis on the increase of the available equipment infrastructure, and finally the diversification of funding, namely European Projects and direct contracts;
- Consolidation of the strategic communication that included the establishment of Centre's dedicated website, youtube channel in articulation with the communication strategy of INESC TEC;

- Consolidation of a tight national network of partners in the scientific areas Vertical Integration, IoT, Industry 4.0 (CEG-IST, UC, IPB), Human Robot Interfacing and Future Industrial Robotics (UC, UA), Navigation and Localization of Mobile Robots (LarSys and DEMEC both from IST). Contacts and new proposals for projects are ongoing.
- Team - The objective was the maintenance of the permanent staff (6 research contracts) the maintenance of the number of scholarships to 10-12.
- Significant development of the activities under the new iiLab umbrella, including new research project proposals, advanced formation and technology transfer;
- New partnerships with national and international research organizations, leaders in fields near or complementary to the Centre's activity; New contacts and better cooperation with INEGI and FEUP research groups.
- The Centre participation and the visibility in European projects was maintained.
- Partnerships with PBA at Singapore in the area of industrial mobile robots was started.
- Internal regular discussion on research opportunities and project organization. In particular, organization of the robotics LabMeetings, held together with the CRAS Centre;
- New plans defined for the valorisation of the intellectual property of the Centre, and work performed in new patents.
- New industrial laboratory (iiLab - Industry and Innovation Laboratory), large enough to accommodate industrial robots (manipulators and AGVs) and the activities related with Industry 4.0 was created.

Research

- Control of mobile manipulators for non-logistic processes. The focus is on the integrated kinematics development, safety and process control; a new Omnidirectional mobile manipulator was developed.
- Multi robot coordination methodologies for automatic generation of mission plans; supervision of autonomous platform operations; cooperative operation of multiple platforms; new coordination software for multiple robots was developed.
- In vision based real time sensors: perception systems as a sensor for on board sensing; real time stereo, and 3D point-cloud sensing for mapping, self-localization and objects detection; low latency and robust feature extraction in semi controlled environments; Tests with new sensors and new software were performed with good results.
- In the field robotics area: modelling and control of mobile robots; navigation and localization in out-door semi-structured environments (using natural and artificial landmarks); improved the robustness of the already developed algorithms. New algorithms with supervision, coordination and simultaneous usage of natural and artificial landmarks are under development.
- Industrial robotic manipulators: vision and manipulator coordination; advanced sensing: measurements and testing of features; rapid teaching and programming interfaces; New algorithms and tests, namely at the ColRobot project, were implemented.
- Intelligent control and smart sensors: control algorithms for complex dynamic systems. New sensing strategies. Sensors networks and Industrial IoT based on LoRaWAN were implemented and tested.

5.7.4 Main Achievements in 2018

Augmented reality for Human-Robot collaborative workstations

In 2018, improvements on the augmented reality for collaborative robots have been made with the participation in the ScalABLE4.0 project. In this project, CRIIS already has developed an augmented

reality Human Machine Interface (HMI) for cooperative assembly operations, providing information to the operator about the task to perform, its work areas and of the robot. Although the ScalABLE4.0 project is still ongoing, these developments have already been presented in visits to our facilities and in EMAF 2018 with positive feedback, including the interest of companies in implementing this system in their shop floor.

2D/3D Industrial Vision and Advanced Sensing

Considering the 2D/3D Industrial Vision and Advances Sensing topic, CRIIS, during 2018, has been actively involved in several machine vision and advanced sensing projects, reflecting the increasing demand by the companies of this type of technological solutions. P2020 PRECISIONcork project is one of these examples. In this project, CRIIS provided both a 2D industrial vision system for measuring the dimensions of cork stoppers in real-time and an advanced sensing system based on ultrasounds to measure the moisture content of the stoppers. In the area of 3D industrial vision systems, CRIIS has been trailing its path, and during the year 2018 developed a 3D object detection pipeline, specially designed for enhancing the perception of robotic manipulators during pick and place operations. This important result is now being used as a basis for further research in several European projects as ScalABLE4.0, FASTEN and FlexCoating.

Mobile manipulator for the automotive sector

Currently, automobile industrial sector is pushing for more advanced robotic-based production solutions. These requirements come in the inline with the shifting of production paradigm, moving from mass production strategies to client-oriented. Furthermore, in automobile production lines workers' have much time involved in the execution of several non-ergonomic assembly operations, that can cause injuries, affecting the workers' health, morale and productivity. To address these needs, and in the context of the H2020 ColRobot project, CRIIS developed in 2018 a collaborative mobile manipulator that it is capable of autonomously navigate to the inside of a vehicle, where it performs several non-ergonomic fastening operations, and sharing both its working space and task with a human operator. The final solution achieved integrates several advanced methodologies that were developed in CRIIS, as a result of several years of research, such as, autonomous navigation and localization of mobile robots, advanced perception systems for robotic arms, safety, and robot skill-based programming, that were organized in an unified software architecture, allowing to enhance the robot robustness and operational efficiency.

An adaptive framework for automated cells modeling, simulation, and offline robot programming

The brisk and dynamic environment that factories are facing, both at an internal and an external level, requires a collection of dexterous tools to solve emerging issues in the industry 4.0 context. Part of the common challenges that appear is related to the increasing demand for high adaptability in the organizations' production lines, allowing companies to stay competitive and profitable. Having the previous concerns in focus, and in line with the AdaptPack project objectives, CRIIS developed a fast and adaptive framework for automated cells modelling, simulation and a manufacturer-independent offline robot programming, focused on palletization operations. This framework was established as an add-on for the Visual Components 3D manufacturing simulation software and will be evaluated during 2019, in real use case scenarios.

Internal logistics based on AGV

In the context of internal logistics based on AGV, CRIIS developed a partnership with Gertal, a meals company, in order to assist the daily operator's routine in the hospital. Throughout time, it has been shown that the continuous carry of high loads by an operator compromises its health state, due to inadequate ergonomics. To address this undesirable scenario in the hospital environment, CRIIS designed and developed a robotic platform, which incorporated an innovative robotic arm acting as a "hand" for grasping and pulling the trolleys. Furthermore, a logistic planner of a fleet of autonomous and mobile industrial robots was developed, where the robots are able to navigate autonomously in the hospital environment, to identify and to dock a specific trolley. Additionally, the robots are capable of driving to a docking station in order to charge their batteries. CRIIS also developed a simple and user-friendly human-machine interface to give the opportunity to humans to interact with the system and to

receive feedback about the tasks and robot state. Our system has been demonstrated at Braga's hospital facilities, transporting meals trolleys, and received positive feedback.

Robotics for Agriculture and Forestry

In the Robotics for Agriculture and Forestry application field, CRIIS was involved in nine projects (4 international and 5 national) RoMoVi, SmartFarming, BioTecFor, FDControlo, GoTecFor, SistemaDPA, DroneTool, Water4Ever and Agrinupes. In the same year, CRIIS has won three more new projects (2 national and 1 international) MetBots, Safer and agROBOfood. INESC TEC through CRIIS is a member of agROBOfood consortium, which is a network of Digital Innovation Hubs in Robotics for Agrifood Sector (very relevant for this R&D line internationalization). Two projects were closed (SmartFarming and Sistema DPA) with two main achievements: AgIoT and SenseNPK. AgIoT is open source IoT solution that can be applied to the domain of Agrifood that is interoperable with ISOBUS and FIWARE standards and portable solution for different contexts application. SenseNPK is a sensing system for macronutrients estimation over ISOBUS system applied to HERCULANO slurry tanker, which was presented on AgroGlobal 2018 and FIMA 2018 fair as a commercial product. These two results, will allow to move forward the development and research of advanced solutions for agricultural and forestry monitoring systems, reinforces INESC TEC has national reference in the field and supports the INESC TEC approach for internationalization in this field. CRIIS was invited to have a keynote speaker in very relevant agricultural conferences and events (AgroIN 2018, AgroGlobal 2018, REFAB-Revolution in Food and Biomass Production 2018, CERVIM 2018) and was referred in more than a dozen of articles on the main national media (referring the Agrob V16 and Agrob V18 robotic platforms). During this year, 6 papers were submitted (and accepted) in relevant ISI conference/journals. Moreover, important advances were achieved with exploratory research, such a advanced method and device for measuring plant water content (which resulted in patent submission) and further developments in path planning aware of robot centre of gravity and robotic localization reliable without GPS signals, which will allow develop further our solutions for agricultural and forestry robots.

Vertical Integration, IoT, Industry 4.0

The integration of Cyber-Physical Systems, such as advanced robots, is a pinnacle in the establishment of truly connected Factories of the Future. To establish effective interoperability between robotic systems, automation equipment, and enterprise systems, CRIIS and CESE pursued in a joint effort, during 2018, the definition of a common, open, scalable, and adaptable reference production system architecture. This reference architecture, entitled Open Scalable Production System (OSPS), empowers advanced robotic systems to flexible, effective and intuitive integration with existing automation equipment and enterprise-level modules. This technological innovation has been tested in a multitude of projects, with different use cases, environments, and robotic platforms. In specific, H2020 ScalABLE4.0 and H2020 FASTEN have been the main motivators of the aforementioned developments.

New industrial laboratory installations

CRIIS was also actively searching for a new industrial laboratory installation, large enough to accommodate industrial robots (manipulators and AGVs) and the activities related to Industry 4.0. A new place was found, and with the help of CESE, a clear definition of the mission of the new laboratory was established, whose infrastructures and the institutional image was upgraded and defined to be in line with the defined vision. This new space will be inaugurated in the beginning of 2019.

5.7.5 Centre Organisational Structure and Research Team

The Centre for Robotics and Intelligent Systems is coordinated by António Paulo Gomes Mendes Moreira and is organised in the following Areas:

- Navigation, Localisation and Coordination of Mobile Robots - Responsible: Paulo Costa / Héber Sobreira
- Intelligent Sensors and Control of Dynamical Systems - Responsible: J. Boaventura / Filipe Santos
- 2D/3D Industrial Vision - Responsible: Manuel Silva / Luís Rocha
- Human Robot Interfacing - Responsible: Germano Veiga / Rafael Arrais
- Future Industrial Robotics and Collaborative Robots - Responsible: Luis Rocha / 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.

Table 5.2 - CRIIS - Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	3	5	6	1
		Academic Staff	21	21	12	-9
		Grant Holders and Trainees	15	19	23	4
		Total Core Researchers	39	45	41	-4
		Total Core PhD	26	25	15	-10
	Affiliated Researchers		0	0	5	5
	Administrative and Technical	Employees	2	3	3	0
		Grant Holders and Trainees	1	2	0	-2
		Total Admin and Tech	3	5	3	-2
	Total Integrated HR		42	50	49	-7
Total Integrated PhD		26	25	20	-5	
Curricular Trainees			1	1	2	1
External Research Collaborators			5	8	18	10
External Administrative and Technical Staff			1	1	1	0
External Students			4	3	3	0
Total			53	63	73	10

5.7.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform and from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CRIIS - Project funding

Funding Source		Total Income (k€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	4	72	169	97
PN-PICT	National R&D Programmes - S&T Integrated Projects	63	62	31	-32
PN-COOP	National Cooperation Programmes with Industry	54	139	133	-6
PUE-FP	EU Framework Programmes	313	274	357	83
PUE-DIV	EU Cooperation Programmes - Other		35	178	143
SERV-NAC	R&D Services and Consulting - National	169	432	291	-142
SERV-INT	R&D Services and Consulting - International			41	41
OP	Other Funding Programmes				
Closed Projects		54	3	5	2
Total Funding		657	1 018	1 205	187

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	27	18	28	10
Indexed Conferences	62	54	41	-13
Books	1			
Book Chapters	6	2	8	6
PhD Theses - Members		1	1	
PhD Theses - Supervised	5	6	4	-2

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

Type of Result	2016	2017	2018
Invention disclosures	1	2	1
Software copyright registrations	1	0	0
Patent applications	0	0	2
Granted patents	0	0	0
Licence agreements	1	0	0
Spin-offs	0	0	0

Table 5.6 - CRIIS - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	0	0	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	2	1	3
International events in which INESC TEC members participate in the program committees	18	2	30
Participation in events such as fairs, exhibitions or similar	6	2	2
Advanced training courses	0	0	1

5.7.7 List of Projects

Table 5.7 - CRIIS – List of Projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DM4Manufacturing	António Paulo Moreira	01/11/2016	31/10/2019
PN-FCT	COBOTIS	António Paulo Moreira	01/06/2018	31/05/2021
PN-FCT	SAFER-1	Filipe Neves Santos	01/07/2018	30/06/2021
PN-FCT	MetBots-1	Filipe Neves Santos	26/07/2018	24/07/2020
PN-COOP	PrecisionCork-1	Hélio Mendonça	15/05/2016	
PN-COOP	AdaptPack-1	Manuel Santos Silva	01/09/2016	31/08/2019
PN-COOP	ROMOVI	Filipe Neves Santos	07/01/2017	31/08/2019
PN-COOP	SmartFarming	Filipe Neves Santos	01/10/2016	
PN-COOP	ATM-1	António Paulo Moreira	01/09/2016	
PN-COOP	PRODUTECH_SIF-1	António Paulo Moreira	01/10/2017	30/09/2020
PN-COOP	FAMEST-1	Héber Miguel Sobreira	01/11/2017	31/10/2020
PN-PICT	iMAN-3	António Paulo Moreira	01/07/2015	30/06/2019
PUE-DIV	Water4Ever	Filipe Neves Santos	01/04/2017	31/03/2020
PUE-DIV	AGRINUPES	José Boaventura	01/04/2017	31/03/2020
PUE-DIV	MANUFACTUR4.0	Luís Freitas Rocha	17/04/2017	31/12/2019
PUE-DIV	BIOTECFOR	Filipe Neves Santos	01/01/2017	31/12/2019
PUE-FP	ColRobot	Germano Veiga	01/02/2016	31/03/2019
PUE-FP	ScalABLE4.0	Germano Veiga	01/01/2017	30/06/2020
PUE-FP	Fasten-1	Rafael Lírio Arrais	01/11/2017	31/10/2020
PUE-FP	DIVA-2	Filipe Neves Santos	01/04/2018	31/03/2021
PUE-FP	HORSE	Rafael Lírio Arrais	01/10/2018	30/06/2019
SERV-INT	AutoClassII	António Paulo Moreira	01/01/2015	
SERV-INT	DroneTool	Filipe Neves Santos	30/11/2017	29/05/2019
SERV-NAC	TEXTILPRINT	Hélio Mendonça	04/01/2016	
SERV-NAC	TRiHo	Germano Veiga	01/07/2016	31/03/2019
SERV-NAC	UnVirtual	Filipe Neves Santos	01/01/2017	
SERV-NAC	RIDDIG-1	Germano Veiga	03/05/2017	31/08/2019
SERV-NAC	SistemaDPA	Filipe Neves Santos	01/05/2017	31/08/2019
SERV-NAC	FED	Luís Freitas Rocha	01/05/2018	28/02/2019
SERV-NAC	COATING4.0-1	António Paulo Moreira	01/05/2018	31/03/2019
SERV-NAC	PBA	Héber Miguel Sobreira	05/11/2018	04/05/2019
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-P2020 National R&D Programmes - Portugal 2020
- PUE-H2020 EU Framework Programme
- SERV-NAC National R&D Services and Consulting
- SERV-INT International R&D Services and Consulting

5.7.8 List of Publications

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Books

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Chapter/Paper in Books

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2. Ferreira, F, Sobreira, H, Veiga, G, Moreira, A, "Landmark detection for docking tasks", Advances in Intelligent Systems and Computing, vol.693, pp.3-13, 2018
3. Lima, J, Costa, P, "Ultra-wideband time of flight based localization system and odometry fusion for a scanning 3 DoF magnetic field autonomous robot", Advances in Intelligent Systems and Computing, vol.693, pp.879-890, 2018
4. Pádua, L, Adão, T, Narciso, D, Cunha, A, Magalhães, L, Peres, E, "Towards modern cost-effective and lightweight Augmented Reality setups", Virtual and Augmented Reality: Concepts, Methodologies, Tools, and Applications, vol.1, pp.396-423, 2018
5. Relvas, P, Costa, P, Moreira, AP, "Object tracking in a moving reference frame", Advances in Intelligent Systems and Computing, vol.693, pp.26-35, 2018
6. Rodrigues, A, Costa, P, Lima, J, "The K-framed quadtrees approach for path planning through a known environment", Advances in Intelligent Systems and Computing, vol.693, pp.49-59, 2018
7. Santos, L, dos Santos, FN, Mendes, J, Ferraz, N, Lima, J, Morais, R, Costa, P, "Path planning for automatic recharging system for steep-slope vineyard robots", Advances in Intelligent Systems and Computing, vol.693, pp.261-272, 2018
8. Tavares, P, Silva, JA, Costa, P, Veiga, G, Moreira, AP, "Flexible work cell simulator using digital twin methodology for highly complex systems in industry 4.0", Advances in Intelligent Systems and Computing, vol.693, pp.541-552, 2018

Publications (Editor)

Blank

Dissertations (PhD)

1. Pinho, T., "Modelos e Sistemas de controlo preditivo aplicados à indústria de base florestal";

5.8 CEGI - CENTRE FOR INDUSTRIAL ENGINEERING AND MANAGEMENT

Coordinators: Ana Viana and Pedro Amorim

5.8.1 Presentation of the Centre

CEGI integrates the Cluster Industry and Innovation (I&I). This Research Group (RG) is an international reference in business analytics through decision support systems for service and operations management, contributing also in service design, performance assessment and asset management. Prescriptive analytics is at the core of CEGI, having several researchers acting as editors of international journals (e.g., European Journal of Operations Research, International Transactions in Operational Research), the coordination of three EURO Working Groups in the fields of Retail Operations, Production Planning and Cutting Problems, and the vice-chairing of a COST Action line. In the Mobility area, CEGI includes the Portuguese delegate to the European Union Horizon 2020 committee on Smart, Green and Integrated Transport. Regarding the service design area, a CEGI member is the executive member of a global and cross-disciplinary team that defined the “Service research priorities 2015”. Recently, a group of CEGI researchers was finalists of the “Wagner Prize award”, for Excellence in Operations Research Practice, by The Institute for Operations Research and the Management Sciences.

Core areas of application of CEGI include Mobility/Transports, Retail/Industry and Healthcare, with significant contributions also in the Energy Sector through a strengthened collaboration with CPES. Main focus of research is Business Intelligence and Prescriptive Analytics. Activity in Business Intelligence includes Data Mining, Data Analysis and Statistical methods (applied to companies’ management). The goal is to conveniently extract knowledge from data that could be leveraged to increase, for example, revenues of a business. To that end, new analytical techniques are required. Currently, the challenges placed by large data sets lead to a redefinition of the processes of data analysis to find patterns and relationships between data elements in large and noisy data sets. Prescriptive analytics have a place of its own at CEGI. The RG is particularly focused on addressing challenges related to optimization under uncertainty.

This RG originated from the area of industrial engineering and its integration in INESC TEC generated powerful synergies with RGs holding expertise in technologies and industrial processes.

The research outputs of CEGI are in the range of TRL 2-9. With this knowledge, CEGI was involved in the launching of a complementary spin-off (LTPlabs), a boutique management consultancy company.

5.8.2 Contribution to the Vision of the Cluster

The Cluster has a vision of an ever integrated supply chain across different industries (e.g., manufacturing and process industries). This vision materialises in a powerful production link that embeds Industry 4.0 concepts and transportation flows that are capable of using sensor information to replan daily activities. The Cluster has been working on the hardware and operating systems that will advance manufacturing technologies with high flexibility, such as robotics. Nevertheless, to achieve the plenitude of this vision the impact in the overall decision making strategies still has to be analysed.

On one hand, focusing on the production link, the main contribution of the Centre will be to evolve decision-making tools that will have to deal with production technologies with high flexibility, capable of performing different tasks with minimum reprogramming, capable of sensing the environment and working in environments designed for human-use. This new paradigm represents a challenge for the traditional production process modelling techniques, where machines are almost static resources and the flexibility is completely provided by the human resources.

On the other hand, focusing on the entire supply chain, main contributions of the Centre will be to explore the developments of the blockchain and to address the new challenges brought up by on-demand external logistics. Recent development turned blockchain into a safe, trustable, decentralised, and immutable chain of encrypted transactions, opening up a whole new realm of applications once deemed unfeasible. Notwithstanding its success in digital (or crypto) currencies, its usefulness is underlined by its potential of application in diverse fields. One such problem is coordinating a flat, global and distributed supply chain. Although market players use prices to signal scarcity and coordinate

themselves, operational diligence is still a necessity. The Centre will contribute with a proof-of-concept of a blockchain tailored to address supply chain coordination, specifically worldwide procurement supported by a decentralized network. Furthermore, the increasing importance of e-commerce, brings up new challenges both in terms of long-haul and lastmile delivery, requesting for more dynamic adaptable distribution networks, for the inclusion of new players in the same network, and for the definition of new policies addressing network sustainability and environment protection.

5.8.3 Main Achievements in 2018

Aligned with the mission and objectives of INESC TEC, CEGI had important achievements in 2018 both in low/medium TRLs research and technology transfer. For lower TRLs activity we highlight the extremely high acceptance rate of project proposals submitted by CEGI to Fundação para a Ciência e a Tecnologia (FCT) on all scientific domains (around 30% success rate). These proposals cover generally the main areas of research of the Center and approach recent paradigms associated to new social realities and technological challenges. In terms of technology transfer, CEGI reinforced its activity in the area of Asset Management, by increasing its collaboration with Portuguese utilities. It also widened its activity by participating in European project proposals with other Centers of INESC TEC. CEGI also continued to pursue an international leadership positioning, through participation in the editorial boards of renowned international journals, participation in the scientific committee of well-known conferences, and leadership of European working groups and European projects within its area of activity.

Focusing on the online retail segment, CEGI studied numerous behavioral changes of clients in response to management policies and natural events that conditioned their purchasing experience. Namely, CEGI analysed how clients changed purchasing habits upon faster product delivery, in the sequence of failures in their grocery requests and upon the purchase of a subscription free deliveries for a certain time period. Results allow to conclude that, more than a cost reduction or a short-term increase in sales, different policies condition the purchasing behavior of clients, with consequences at the sales and operational levels, that most of the times are not taken into account in strategy design. For instance, avoiding a failure or using defensive marketing cannot only prevent a momentary sales decline but also to retain a client that would churn due to such failure otherwise and increase her trust in the company. By identifying such biases and behavioral changes, it is possible to reinforce algorithms for operational optimization, thus increasing their efficacy and making them more realistic.

Considering the staggering quantity of data being produced on a daily basis by health care institutions, there is an enormous potential for models based on AI and machine learning to exploit some of this potential at all levels, ranging from hospital logistics to clinical decision-making. During the year of 2018, CEGI worked on uncapping some of this potential in two fronts. More specifically, we advanced health care management and healthcare logistics by developing an intelligent dashboard that identifies operational inefficiencies in areas such as inventory management or hospital planning, giving alerts as well as detailed action plans on how to address the problems found. At a clinical level, CEGI started working with a major oncological hospital, using data from patients to build predictive and prescriptive machine learning models that help physicians in clinical decision-making.

One of the main achievements in Performance Management concerns an empirical test of the Theory of Performance Frontiers (TPF) from Operations Management. The new wave of developments in Advanced Manufacturing Technologies (AMT) captured by labels such as industry 4.0 has posed questions and challenges to the established theory including its premises and propositions. Following those developments, our study employed Data Envelopment Analysis to examine whether the TPF is equally valid in high and low adopters of AMT in this new environment. Using advanced analytical and empirical modelling, we tested the theory main propositions based on a large sample of 931 manufacturers from 22 countries. We find compelling empirical support for the TPF in both high and low adopters of AMT. Our findings provide relevant implications for manufacturing strategy research and practice in the current industrial environment. This work opens the possibility of evaluating firms' Corporate Social Responsibility (CSR) using quantitative methods. It has developed new benchmarking models that allow the identification of firms' potential for improvement. These include a directional distance function model, computed with a directional distance function with weight restrictions, and models for the construction of sectoral rankings based on Goal Programming. This work has also been

innovative in relation to the indicators that should be considered in the assessment of CSR of mining companies, opening up new possibilities for performance management in the mining industry.

Advances were also made on the use of frontier techniques (Data Envelopment Analysis and Free Disposal Hull models) to compare the performances of alternative specifications of the parameters of some metaheuristic algorithms and to identify efficient solutions.

In Service Science, Management, Engineering and Design CEGI closed successfully the Marie Curie European Training Network in Service Design for Innovation. The project was coordinated by CEGI's team. This Marie Curie Project involved 9 PhD students, 3 of them being supervised by the service engineering team at CEGI.

Two projects involved a survey with the service research community and multiple case studies to understand how service design can foster service innovation in technology companies. Two other projects focused on identifying smart service trends in the energy and mobility sector, studying the customer experience of different smart energy and mobility segments, and envisioning new smart service concepts for the energy ecosystem.

In terms of publications, CEGI continues to pursue publication in top journals. Noteworthy is that, although the indicators (see table 5.4) show a decrease when compared to the previous years, the number of submissions did not decrease and several papers that will be published at the beginning of 2019, therefore not mentioned in this report, were accepted in 2018.

CEGI maintains its core members. A slight decrease is reflected in the Academic staff, in terms of number of elements. The impact is not however relevant as it refers to researchers who already had a reduced activity level in the Center.

5.8.4 Centre Organisational Structure and Research Team

The evolution of the Centre research team from 2015 to 2017 is presented in Table 5.2.

Table 5.2 - CEGI - Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	0	0	4	4
		Academic Staff	19	19	13	-6
		Grant Holders and Trainees	34	37	30	-7
		Total Core Researchers	53	56	47	-9
		Total Core PhD	29	28	27	-1
	Affiliated Researchers		3	5	7	2
	Administrative and Technical	Employees	0	1	1	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	0	1	1	0
	Total Integrated HR		56	62	55	1
	Total Integrated PhD		32	33	33	0
	Curricular Trainees		5	3	3	0
External Research Collaborators		8	10	19	9	
External Administrative and Technical Staff		2	2	2	0	
External Students		3	5	5	0	
Total		74	82	84	2	

5.8.5 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform and from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CEGI - Project funding

Funding Source		Total Income (k€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	24	115	148	34
PN-PICT	National R&D Programmes - S&T Integrated Projects	65	162	210	47
PN-COOP	National Cooperation Programmes with Industry		10	23	12
PUE-FP	EU Framework Programmes	43	11		-11
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	181	150	109	-41
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes		22	12	-10
Closed Projects		55		2	2
Total Funding		367	471	504	33

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	32	34	29	-5
Indexed Conferences	16	14	12	-2
Books		1		-1
Book Chapters	5	2	3	1
PhD Theses - Members	3	4	8	4
PhD Theses - Supervised	4	7	7	

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

Type of Result	2016	2017	2018
Invention disclosures	0	0	1
Software copyright registrations	0	0	0
Patent applications	0	0	0
Granted patents	0	0	0
Licence agreements	0	1	1
Spin-offs	0	0	0

Table 5.6-CEGI - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	4	7	8
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	2	7	8
International events in which INESC TEC members participate in the program committees	14	18	11
Participation in events such as fairs, exhibitions or similar	0	0	0
Advanced training courses	0	1	2

5.8.6 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	
PN-FCT	mKEP	Ana Viana	01/04/2016	30/09/2019
PN-FCT	EasyFlow-1	Pedro Amorim	01/06/2016	31/05/2019
PN-FCT	DM4Manufacturing-2	Pedro Amorim	01/11/2016	31/10/2019
PN-FCT	DoubleChain	Pedro Amorim	01/09/2018	31/08/2019
PN-FCT	ASAP	Maria Antónia Carravilla	01/06/2018	31/05/2021
PN-FCT	SiuSMS	Maria Antónia Carravilla	26/07/2018	25/07/2021
PN-FCT	DeltaC&P	José Fernando Oliveira	26/07/2018	25/07/2021
PN-FCT	Tec-FEL	Pedro Amorim	04/04/2018	03/04/2021
PN-COOP	KnowLOGIS	Ana Viana	01/04/2017	27/09/2019
PN-PICT	iMAN-2	Luís Guimarães	01/07/2015	30/06/2019
PN-PICT	SMILES-8	João Pedro Pedroso	01/07/2015	30/06/2019
PN-PICT	CORAL-TOOLS-6	João Pedro Pedroso	01/01/2016	
SERV-NAC	PricingSdL	Maria Antónia Carravilla	28/01/2017	30/04/2019
SERV-NAC	UPGASII	Luís Guimarães	26/06/2017	
SERV-NAC	HEAD	Luís Guimarães	01/01/2018	30/04/2019
SERV-NAC	HIP	Luís Guimarães	10/01/2018	
SERV-NAC	BEEF	Pedro Amorim	30/05/2018	12/02/2019
SERV-NAC	Consultoria	Bernardo Almada-Lobo	01/01/2014	
OP	Atena	Maria Antónia Carravilla	14/10/2016	13/10/2019

Type of Project:

- PN-FCT National R&D Programmes - FCT
- PN-PICT National R&D Programmes - S&T Integrated Projects
- PN-P2020 National R&D Programmes - Portugal 2020
- PUE-H2020 EU Framework Programme
- SERV-NAC National R&D Services and Consulting
- SERV-INT International R&D Services and Consulting

5.8.7 List of Publications

International Journals with Scientific Referees

1. Alem, D, Curcio, E, Amorim, P, Almada Lobo, B, "A computational study of the general lot-sizing and scheduling model under demand uncertainty via robust and stochastic approaches", *Computers & Operations Research*, vol.90, pp.125-141, FEB, 2018
2. Antoncic, JA, Antoncic, B, Gantar, M, Hisrich, RD, Marks, LJ, Bachkurov, AA, Li, ZY, Polzin, P, Borges, JL, Coelho, A, Kakkonen, ML, "Risk-Taking Propensity and Entrepreneurship: The Role of Power Distance", *Journal of Enterprising Culture*, vol.26, pp.1-26, MAR, 2018
3. Bianchi Aguiar, T, Silva, E, Guimardes, L, Carravilla, MA, Oliveira, JF, "Allocating products on shelves under merchandising rules: Multi-level product families with display directions", *Omega (United Kingdom)*, vol.76, pp.47-62, 2018
4. Calabria, FA, Camanho, AS, Zanella, A, "The use of composite indicators to evaluate the performance of Brazilian hydropower plants", *International Transactions in Operational Research*, pp.n/a-n/a, 2018
5. Carvalho, M, Klimentova, X, Viana, A, "Observability of power systems with optimal PMU placement", *Computers & Operations Research*, 2018
6. Carvalho, M, Pedroso, JP, Telha, C, Van Vyve, M, "Competitive uncapacitated lot-sizing game", *International Journal of Production Economics*, vol.204, pp.148-159, OCT, 2018
7. Cherri, LH, Cherri, AC, Carravilla, MA, Oliveira, JF, Bragion Toledo, FMB, Goncalves Vianna, ACG, "An innovative data structure to handle the geometry of nesting problems", *International Journal of Production Research*, pp.1-18, 2018
8. Costa, N, Patricio, L, Morelli, N, Magee, CL, "Bringing Service Design to manufacturing companies: Integrating PSS and Service Design approaches", *Design Studies*, 2018
9. Cruz Gomes, S, Amorim Lopes, M, Almada Lobo, B, "A labor requirements function for sizing the health workforce", *Human Resources For Health*, vol.16, 2018
10. Curcio, E, Amorim, P, Zhang, Q, Almada Lobo, B, "Adaptation and approximate strategies for solving the lot-sizing and scheduling problem under multistage demand uncertainty", *International Journal of Production Economics*, vol.202, pp.81-96, AUG, 2018
11. Gomes, C, Parente, M, Azenha, M, Lino, JC, "An integrated framework for multi-criteria optimization of thin concrete shells at early design stages", *Advanced Engineering Informatics*, vol.38, pp.330-342, 2018
12. Hein, F, Almeder, C, Figueira, G, Almada Lobo, B, "Designing new heuristics for the capacitated lot sizing problem by genetic programming", *Computers and Operations Research*, vol.96, pp.1-14, 2018
13. Lopes, MA, Almeida, AS, Almada Lobo, B, "Forecasting the medical workforce: a stochastic agent-based simulation approach", *Health Care Management Science*, pp.1-24, 2018
14. Loureiro, ALD, Migueis, VL, da Silva, LFM, "Exploring the use of deep neural networks for sales forecasting in fashion retail", *Decision Support Systems*, vol.114, pp.81-93, OCT, 2018
15. Marques, A, Rasinmaki, J, Soares, R, Amorim, P, "Planning woody biomass supply in hot systems under variable chips energy content", *Biomass and Bioenergy*, vol.108, pp.265-277, 2018
16. Martins, C, Patricio, L, "Company social networks: customer communities or supplementary services?", *Journal of Services Marketing*, vol.32, pp.443-461, 2018
17. Martins, S, Amorim, P, Almada Lobo, B, "Delivery mode planning for distribution to brick-and-mortar retail stores: discussion and literature review", *Flexible Services and Manufacturing Journal*, pp.1-28, 2018

18. Migueis, VL, Freitas, A, Garcia, PJV, Silva, A, "Early segmentation of students according to their academic performance: A predictive modelling approach", *Decision Support Systems*, vol.115, pp.36-51, NOV, 2018
19. Mundim, LR, Andretta, M, Carravilla, MA, Oliveira, JF, "A general heuristic for two-dimensional nesting problems with limited-size containers", *International Journal of Production Research*, pp.1-24, 2018
20. Neves Moreira, F, da Silva, DP, Guimaraes, L, Amorim, P, Almada Lobo, B, "The time window assignment vehicle routing problem with product dependent deliveries", *Transportation Research Part E: Logistics and Transportation Review*, vol.116, pp.163-183, 2018
21. Oliveira, BB, Carravilla, MA, Oliveira, JF, "Integrating pricing and capacity decisions in car rental: A matheuristic approach", *Operations Research Perspectives*, vol.5, pp.334-356, 2018
22. Ostermeier, M, Martins, S, Amorim, P, Huebner, A, "Loading constraints for a multi-compartment vehicle routing problem", *OR Spectrum*, pp.1-31, 2018
23. Paquay, C, Limbourg, S, Schyns, M, Oliveira, JF, "MIP-based constructive heuristics for the three-dimensional Bin Packing Problem with transportation constraints", *International Journal of Production Research*, pp.1-12, 2018
24. Patricio, L, de Pinho, NF, Teixeira, JG, Fisk, RP, "Service Design for Value Networks: Enabling Value Cocreation Interactions in Healthcare", *Service Science*, vol.10, pp.76-97, 2018
25. Ramos, AG, Silva, E, Oliveira, JF, "A new Load Balance Methodology for Container Loading Problem in Road Transportation", *European Journal of Operational Research*, 2018
26. Real, AC, Borges, J, Oliveira, CB, "Estimation of Daily Mean Temperatures: An Accurate Method for the Douro Valley", *Ciencia E Tecnica Vitivinicola*, vol.33, pp.167-176, 2018
27. Silva, E, Ramos, AG, Oliveira, JF, "Load balance recovery for multi-drop distribution problems: A mixed integer linear programming approach", *Transportation Research Part B: Methodological*, vol.116, pp.62-75, 2018
28. Teles, MD, de Sousa, JF, "Linking fields with GMA: Sustainability, companies, people and Operational Research", *Technological Forecasting and Social Change*, 2018
29. Ushakov, AV, Klimentova, X, Vasilyev, I, "Bi-level and Bi-objective p-Median Type Problems for Integrative Clustering: Application to Analysis of Cancer Gene-Expression and Drug-Response Data", *IEEE/ACM Transactions on Computational Biology and Bioinformatics*, pp.1-1, 2018

International Conference Proceedings with Scientific Referees

1. Beirão, G, Costa, H, "Exploring Customers' Internal Response to the Service Experience: An Empirical Study in Healthcare", *Exploring Service Science - Lecture Notes in Business Information Processing*, pp.303-315, 2018
2. Carvalho, M, Lodi, A, Pedroso, JP, "Existence of Nash Equilibria on Integer Programming Games", *Operational Research*, vol.223, pp.11-23, 2018
3. de Souza Amorim, FMD, Arantes, MD, Motta Toledo, CFM, Frisch, PE, Almada Lobo, B, "Hybrid Genetic Algorithms Applied to the Glass Container Industry Problem", *2018 IEEE Congress on Evolutionary Computation (CEC)*, pp.879-886, 2018
4. Gdowska, K, Viana, A, Pedroso, JP, "Stochastic last-mile delivery with crowdshipping", *Transportation Research Procedia*, vol.30, pp.90-100, 2018
5. Martins, MPG, Migueis, VL, Fonseca, DSB, "A Data Mining Approach to Predict Undergraduate Students' Performance", *2018 13th Iberian Conference on Information Systems and Technologies (CISTI)*, vol.2018-June, pp.1-7, 2018

6. Martins, MPG, Migueis, VL, Fonseca, DSB, "Educational Data Mining: A Literature Review", 2018 13TH Iberian Conference on Information Systems and Technologies (CISTI), vol.2018-June, pp.1-6, 2018
7. Neuenfeldt Junior, A, Silva, E, Miguel Gomes, AM, Oliveira, JF, "The two-dimensional strip packing problem: What matters?", Springer Proceedings in Mathematics and Statistics, vol.223, pp.151-164, 2018
8. Oliveira, BB, Carravilla, MA, "Understanding complexity in a practical combinatorial problem using mathematical programming and constraint programming", Springer Proceedings in Mathematics and Statistics, vol.223, pp.269-295, 2018
9. Oliveira, BB, Carravilla, MA, Oliveira, JF, "A dynamic programming approach for integrating dynamic pricing and capacity decisions in a rental context", Springer Proceedings in Mathematics and Statistics, vol.223, pp.297-311, 2018
10. Ramos, AG, Oliveira, JF, "Cargo stability in the container loading problem - State-of-the-art and future research directions", Springer Proceedings in Mathematics and Statistics, vol.223, pp.339-350, 2018
11. Silva, E, Ramos, AG, Lopes, M, Magalhaes, P, Oliveira, JF, "An intercontinental replenishment problem: A hybrid approach", Springer Proceedings in Mathematics and Statistics, vol.223, pp.351-363, 2018
12. Teixeira, JG, Patrício, L, Tuunanen, T, "Bringing Design Science Research to Service Design", Exploring Service Science - Lecture Notes in Business Information Processing, pp.373-384, 2018

Books

Blank

Chapter/Paper in Books

1. Alvarez Valdes, R, Carravilla, MA, Oliveira, JF, "Cutting and packing", Handbook of Heuristics, vol.2-2, pp.931-977, 2018
2. Carravilla, MA, Oliveira, JF, "Resources for the Education in Operations Research: Past, Present and Future", Advances in Operations Research Education - Lecture Notes in Logistics, pp.49-57, 2018
3. Correia, AG, Parente, M, "Coupled ICT and Dynamic Optimization Tools Toward an Integrated Earthwork Management System", Proceedings of GeoShanghai 2018 International Conference: Transportation Geotechnics and Pavement Engineering, pp.136-143, 2018

Publications (Editor)

Blank

Dissertations (PhD)

1. Ferreira, M., "A Methodology for Designing Mobile Ticketing Services: from Ideas to Deployment";
2. Pires, M., "Effective design of backroom storage facilities in grocery stores";
3. Oliveira, M., "Fleet and revenue management in car rental: quantitative approaches for optimization under uncertainty";
4. Lima, J., "O Impacto da Produtividade na Gestão Industrial - Uma análise aplicada ao sector do móvel e do mobiliário de madeira e derivados em Portugal";
5. Moreira, F., "On Improving Supply Chain Performance Through Integrated Vehicle Routing Problems";
6. Martins, S., "Retail Distribution Planning to Brick-and-Mortar Stores";



7. Silva, T., "Semantic Integration of Urban Mobility Data through Ontologies for Supporting Data Visualization";
8. Oliveira, R., "The assessment of Corporate Social Responsibility in the mining sector using Data Envelopment Analysis";

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 Innovation & Technology Management and Technology Entrepreneurship fostering a cross-cutting approach to all INESC TEC's Clusters, and for Private and Public organisations.

CITE aims to accelerate the transition for a circular management of R&D and innovation activities, contributing for “eliminating unused” and “extending the use” of the R&D results, through collaboration and by empowering researchers and external organisations in the process of innovation management and technology valorisation in a climate of collaboration, transparency and openness.

CITE provides insights, conceptual frameworks, methodologies, tools and resources to support R&D circular mindset and the systemic thinking required to accelerate a transition from a linear to a circular management of R&D and innovation activities.

CITE operates the LET-in (Laboratory for Technological Entrepreneurship of INESC TEC) and is in the front line of support to the launching of new INESC TEC spin-offs as well as aims to contribute for the embrace of an innovation, entrepreneurship & intrapreneurship culture by ensuring that innovation and R&D valorisation culture will be embed across the research activities.

5.9.2 Contribution to the Vision of the Cluster

CITE aims to intensify the cooperation with all Clusters, Centres and supporting services in order to:

- Leverage research outputs for marketplace & society benefit;
- Implement agile cycles of technologies maturity levels;
- Foster adoption of new innovative solutions within industrial partnerships;

Acting as Let in Coordinator, CITE also aims to:

- Develop entrepreneurial skills among research community and organisations;
- Support technology entrepreneurship initiatives.

By continuing research on the topics of Innovation and Technology Management and Technology Entrepreneurship, CITE provides methodologies and tools to better manage innovation with a circular perspective in all types of projects.

Technological innovation does not guarantee business success – new product development effort open new approaches for the entire business model, the design of the strategies to 'go to market' and 'capturing value' is a key factor for value creation. Business models often act as the bridge between technology and the ability to deliver a compelling customer value proposition.

CITE aims to contribute with “user centered and problem solving design” approaches and “new business model development” that complement the technological developments of INESC TEC Centres and Clusters. Therefore, CITE aims to act as a transversal Centre for all Clusters acting in the areas of:

- Innovation and technology management
- Technology adoption and exploitation
- User centered design
- Business model innovation

5.9.3 Research and Innovation Progress in 2018

In 2018, CITE developed its activity according to the activity plan for this year and two new PhD Theses have been initialized during 2018.

Technology Entrepreneurship:

CITE continued developing training programmes focused on technology entrepreneurship:

- 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. The 3rd edition of the program was carried out; 10 technologies have been validated.
- LET IN Catalyst – A set of activities aiming to create awareness and support the vaporization of R&D results and entrepreneurship was presented and discussed with INESC TEC Board of Directors. The program is under development;
- Cite organised CEE'2018, Conference on Entrepreneurship Education. The conference took place on 13 of September in INESC TEC. The conference allowed sharing a set of educational initiatives of entrepreneurship at different levels of education.
- Cite will go on the Implementation of DIVA, a H2020 INNOSUP funded project aiming at bringing the digital change to the agrofood value chain. CITE will bring its expertise in innovation and technology management to the project. Under this project CITE develop a Digital Trend Map for agrofood sector.

Host of Enterprise Europe Network:

CITE will go on acting as a host organization of Enterprise Europe Network, providing advisory, partnering and tailored innovation services for SMEs, including startups and scaleups. Four projects are included here: EEN-Portugal, EEN-Innovative PT, Scale Up Portugal and TouriSMEShare. Under these projects:

- 12 Innovation Management Systems have been implemented in SME's during 2018;
- 5 SME benefits with SME Instrument projects approved, received specialised support under EEN Innovation project;
- 28 SME received business, technological and partnering support under EEN Project.

Innovation Management Systems:

CITE will go on participating in the main national and international working groups dedicated to the standardization of innovation management (ISO/TC 279 – Innovation Management initiative and Portuguese technical Committee - CT 169). CITE actively participates in the international technical working group dedicated to the Innovation Management ISO/TC 279 – WG4-Innovation Management Assessment.

Two new PhD have been initialized in the topics of Fuzzy Front end of Innovation:

- Managing the Front-end of Innovation in the context of the Circular Economy"
- R&D Opportunity Generation & Management through Portfolio Value Proposition"

Technology Management

During 2018, 6 researchers were working on Technology Management & Policy research group of CITE. The group had 7 participations in conferences, submitted 6 papers to international journals, 2 of which were published still in 2018 (and a third was published in 2019). the group participated in 5 proposals to FCT research projects, although none was approved, and also in 1 proposal for an european project (still waiting for response).

Regarding the ongoing research projects during 2018, Safecloud was duly and successfully closed, with the particular result of promoting the launching of a new startup that uses some of the results of the project; iMan, FourEyes, SMILES and CORAL were also closed with several pieces of work contributing

for innovation and technology management of the results of such projects; and Screen-DR proceeded with intense work on a business model to support the commercialization of the result of the project, with one person allocated fully to that project and aiming to contribute with a similar result to the one provided to Safecloud.

5.9.4 Main Achievements in 2018

Building long-term experience through systematic collaboration, LET-in was involved in the following activities in 2018:

- Business Ignition Programme: a ERDF co-funded project from U.Porto Inovação, CIIMAR and INESC TEC, developed a state-of-the-art programme for build and test alternative business models for the exploitation of technologies developed in academia. Twenty technologies have been submitted and evaluate during two editions of the programme.
- Start-up Porto Accelerator boosted start-ups with disruptive and technological profile (Web & Mobile). Two editions have been runned, with 20 new start-ups launched since 2017.

The launching of the Conference on Entrepreneurship Education. The CEE'2017 was the 1st step towards its internationalization, by opening the conference to the Spain and the Iberian American community. This is to be further expanded in the coming years.

The launching of the Journal of Innovation Management. This journal encourages the submission of papers addressing the multidisciplinary nature of the innovation process combining principles and concepts originating from a myriad of scientific areas, from social sciences to technology research and development. This Journal is indexed by ProQuest as Scholarly Journal at ABI/Inform, under the Subject Business and Economics (Pub ID: 2046363).

Enterprise Europe Network projects places INESC TEC as a national provider of a range of services, on behalf of the Executive Agency for SMEs, to support innovative SMEs, including start-ups, going abroad through tailored advisory, partnering and coaching services. INESC TEC is a host organization of the Network in four co-funded projects: EEN-Portugal, EEN-Innovative PT, Scale UP Portugal and TouriSMEshare.

In the area of “Fuzzy Front End Of Innovation” (FFE), the research focused on the multidisciplinary nature of the FFE. The development of the “The Front End of Innovation Integrative Ontology” (FEI2O) was a major achievement of this period (2017 PhD). This new Ontology provides a formal model that allows the in-depth understanding of the whole New Concept Development process, both within organizations, and in a pure entrepreneurial setting, with the leadership of individual entrepreneur.

CITE has been developing instruments as part of project FIRE-ENGINE (Designing flexible management systems for forest fires) that will help authorities prevent and suppress fires. Because Portugal is the European country that suffers the most with forest fires each year, the aim with this project is to help define solutions suited to the needs of every region, combining actions that usually function independently. FIRE-ENGINE has been funded by FCT through the MIT Portugal Program.

5.9.5 Centre Organisational Structure and Research Team

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			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	2	3	3	0
		Academic Staff	1	1	1	0
		Grant Holders and Trainees	4	5	4	-1
		Total Core Researchers	7	9	8	-1
		Total Core PhD	2	4	3	-1
	Affiliated Researchers		6	7	1	-6
	Administrative and Technical	Employees	0	0	0	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	0	0	0	0
	Total Integrated HR		13	16	9	-7
Total Integrated PhD		6	10	4	-6	
Curricular Trainees		1	3	2	-1	
External Research Collaborators		6	6	12	6	
External Administrative and Technical Staff		0	0	0	0	
External Students		6	1	3	2	
Total		26	26	26	0	

5.9.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform and from CORE (Computing Research and Education Association of Australasia).

Table 5.3-CITE - Project funding

Funding Source		Total Income (k€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT			15	14
PN-PICT	National R&D Programmes - S&T Integrated Projects	12	33	53	20
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	46	54	95	40
PUE-DIV	EU Cooperation Programmes - Other	34	36	77	41
SERV-NAC	R&D Services and Consulting - National	3	37	46	9
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	17	126	18	-108
Closed Projects		12			
Total Funding		123	286	303	17

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	8	19	8	-11
Indexed Conferences		2	2	
Books			1	1
Book Chapters	2	2	5	3
PhD Theses - Members	2	3	2	-1
PhD Theses - Supervised	2	3	2	-1

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

Type of Result	2016	2017	2018
Invention disclosures	0	0	0
Software copyright registrations	0	0	0
Patent applications	0	0	0
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs	0	0	0

Table 5.6-CITE - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	2	1	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1	0	1
International events in which INESC TEC members participate in the program committees	2	1	0
Participation in events such as fairs, exhibitions or similar	8	2	2
Advanced training courses	3	3	1

5.9.7 List of Projects

Table 5.7-CITE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	VR2Market-2	Catarina Maia	15/07/2014	30/06/2019
PN-FCT	SCREEN-DR-1	Catarina Maia	01/04/2016	31/03/2020
PN-PICT	FOUREYES-1	João Claro	01/07/2015	30/06/2019
PN-PICT	iMAN-1	João Claro	01/07/2015	30/06/2019
PN-PICT	SMILES-2	João Claro	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL1-2	João Claro	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL2-1	João Claro	01/07/2015	30/06/2019
PN-PICT	CORAL-SENSORS-2	João Claro	01/01/2016	
PUE-DIV	EEN2017/2018	Alexandra Xavier	01/01/2017	
PUE-DIV	ScaleUp-PORTUGAL	Alexandra Xavier	01/07/2017	
PUE-DIV	TouriSMEShare	Alexandra Xavier	15/12/2017	30/11/2019
PUE-FP	SafeCloud-1	João Claro	01/09/2015	
PUE-FP	EEN-InnovatePT	Alexandra Xavier	01/01/2017	
PUE-FP	DIVA	Alexandra Xavier	01/04/2018	31/03/2021
SERV-NAC	NMP-REG	João Claro	01/08/2018	31/12/2018
SERV-NAC	Consultoria	Alexandra Xavier	01/01/2008	
OP	BIP	Alexandra Xavier	01/02/2016	
OP	CEE'2018	Alexandra Xavier	10/04/2018	31/12/2018

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

5.9.8 List of Publications

International Journals with Scientific Referees

1. Almeida, F, "Canvas Framework for Performing Systematic Reviews Analysis", Multidisciplinary Journal for Education, Social and Technological Sciences, vol.5, pp.65, 2018
2. Almeida, F, "Insights and Perspectives from a Literature Review on University Spin-Offs", Management Research and Practice, vol.10, pp.27-40, JUN, 2018
3. Almeida, F, Carvalho, I, Cruz, F, "Structure and challenges of a security policy on small and medium enterprises", KSII Transactions on Internet and Information Systems, vol.12, pp.747-763, 2018
4. Almeida, FL, Amoedo, N, "Decision Support System For Internship Management in Higher Education", International Journal of Information Systems and Social Change, vol.9, pp.40-57, 2018
5. Loureiro, MV, Schell, KR, Claro, J, Fischbeck, P, "Renewable integration through transmission network expansion planning under uncertainty", Electric Power Systems Research, vol.165, pp.45-52, DEC, 2018

6. Pacheco, AP, Claro, J, "Operational flexibility in forest fire prevention and suppression: a spatially explicit intra-annual optimization analysis, considering prevention, (pre)suppression, and escape costs", European Journal of Forest Research, vol.137, pp.895-916, DEC, 2018
7. Silva, AM, Almeida, MI, Teixeira, JH, Ivan, C, Oliveira, J, Vasconcelos, D, Neves, N, Ribeiro Machado, C, Cunha, C, Barbosa, MA, Calin, GA, Santos, SG, "Profiling the circulating miRNome reveals a temporal regulation of the bone injury response", Theranostics, vol.8, pp.3902-3917, 2018
8. Vasconcelos, DP, Costa, M, Neves, N, Teixeira, JH, Vasconcelos, DM, Santos, SG, Aguas, AP, Barbosa, MA, Barbosa, JN, "The use of chitosan porous 3D scaffolds embedded with resolvin D1 to improve in vivo bone healing", Journal of Biomedical Materials Research Part A, 2018

International Conference Proceedings with Scientific Referees

1. Milczarski, P, O'Reilly, D, Podlaski, K, Almeida, FL, Dowdall, S, Hlobaz, A, Bolaert, H, Lourenço, J, "How Participation in an Intensive Project Can Increase 3rd Level Students' Awareness of Entrepreneurship", Proceedings of the 14th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume I: Main Conference, Kyiv, Ukraine, May 14-17, 2018., vol.2105, pp.394-404, 2018
2. Rodrigues, JC, Freitas, A, Garcia, P, Maia, C, Pierre Favre, M, "Transversal and transferable skills training for engineering PhD/doctoral candidates", 2018 3rd International Conference of the Portuguese Society for Engineering Education (CISPEE), 2018

Books

1. Jamil, GL, Ferreira, JJP, Pinto, MM, Pessoa, CRM, Xavier, A, "Handbook of Research on Strategic Innovation Management for Improved Competitive Advantage", Advances in Business Strategy and Competitive Advantage, 2018

Chapter/Paper in Books

1. Almeida, F, Monteiro, JA, "UX Challenges and Best Practices in Designing Web and Mobile Solutions", Advances in Computer and Electrical Engineering - Handbook of Research on Contemporary Perspectives on Web-Based Systems, pp.68-89, 2018
2. Goncalves, F, Pinto, MMGdA, Xavier, A, "U.InovAcelerator", Advances in Business Information Systems and Analytics - Handbook of Research on Expanding Business Opportunities With Information Systems and Analytics, pp.377-394, 2018
3. Pacheco, AP, et. al., , "Does it pay to invest in better suppression resources?: policy analysis of alternative scenarios with simulation", Advances in forest fire research 2018, pp.14011-1414, 2018
4. Santos, JD, Almeida, FL, "Marketing and Technologies Platforms in Smart F-Store", Advances in Human Resources Management and Organizational Development - Managing Diversity, Innovation, and Infrastructure in Digital Business, pp.139-159, 2018
5. Torres, H, et. al., , "Flexible design of a helipad network for forest firefighting helicopters, applied to the case of Sardinia", Advances in forest fire research 2018, pp.1280-1283, 2018

Publications (Editor)

Blank

Dissertations (PhD)

1. Teles, V., "Planning and exploitation of new production technologies in public-funded R&D";
2. Diogenes, J., "The influence of implementation barriers on the development of onshore wind farms";

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) is integrated in the Computer Science Cluster. Its mission 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 Embedded/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 provide the visual and user interaction components such a solution may require. To this effect, it has 4 transversal application areas: Platforms and Methods for Earth and Ocean Observation Science, Platforms and Methods for Personalised Health Research, Public Administration Business Area, Mobility and Transport Business Area.

Furthermore, the Centre is also strongly committed to the training of young researchers and professionals, regularly graduating more than 10 hosted PhD students per year.

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 Contribution to the Vision of the Cluster

Researchers from the Computer Science Cluster, together with partners from companies and other institutions, cooperate to bring the state-of-the-art in computing methodologies to problems with high social relevance, managing and processing their data in an ethical and responsible manner. CSIG has a central role in this endeavour, leading the Cluster's contribution in the thematic lines TEC4HEALTH, TEC4MEDIA, TEC4SEA and TEC4AGRO.

5.10.3 Research and Innovation Progress in 2018

CSIG fulfilled almost completely its objectives for 2018 and surpassed largely several of them:

2018 objectives	Fulfilment
Achieve a balanced economic operation.	Positive operational and direct margins, but negative total margin, i.e., CSIG could not support completely its INESC TEC's overhead share.
Increase scientific production, especially in terms of top-level international journals and conferences.	The total indexed publication of CSIG increased from a total of 116 to 133 publications. Nevertheless the number of journal publications decreased from 42 to 33.
Obtain at least one new H2020 project.	Three new H2020 projects were obtained.
Obtain at least two FCT projects.	Six FCT projects were obtained, as well as three additional ones managed also by FCT (CMU Portugal, NORTE2020 and DSAIPA).
Increase collaboration with main partners, contracting at least four Technology Transfer contracts	Services contracts were signed with VESTAS, Chaves Municipality, Porto Municipality and Assembleia da República .

Leverage the MASSIVE Lab's unique competencies to diversify collaborations and attract new partners, obtaining at least two Technology Transfer contracts	A Portugal 2020 project with VESTAS was submitted and won in 2018 and a contract was subsequently signed. A collaboration with EMPORDEF TI was established and a collaboration protocol signed.
Increase collaboration with other centres from the CS cluster (especially LIAAD) and other clusters, especially Power Systems, with whom we currently have 2 EU projects and a new one will start in 2018	New FCT PERFECT with CBER (NIS Cluster). New FD-Controlo with CRIIS (II Cluster) GRESBAS, FEEDBACK and new INTEGRID with CPES (PS Cluster) New P2020 RUTE with LIAAD (CS Cluster) Algorithmic Science News with LIAAD (CS Cluster) ATENA services contract with CEGI (II Cluster)

A detailed view per Scientific Area follows:

Computer Graphics and Virtual Environments

In the area of Serious Games, the H2020 BEACONING project entered the last year providing a system to design, develop and manage pervasive games for learning. The major software components are being concluded and large pilots will validate and disseminate its results. Another project in this area is GRESBAS, a gamified platform to reduce the energy costs in buildings, which is leading the focus on games for behaviour change. The results of this project has led to the approval of a new H2020 project called Feedback, focused on how energy savings can be gamified but maintaining the levels of confort of the users, with large scale pilots across Europe. The link of Serious Games and e-Learning platforms for Health will be continued in projects like RECAP and E-COMPARED, but also will be pushed forward as the results of recent applications on serious games in medical training, with project SIMPROVE.

In the area of Virtual Environments, the MASSIVE project is undergoing its second phase, starting in 2017 with the inauguration of the Vila Real Research Lab. Research in Usability and User Experience will be taken to a new level of quality and impact. AV360 Google DNI will also explore how immersive environments can improve the impact of the media in the audience and will develop new tools for journalists. The Tele-Media-Art project is complete and data analysis will yield new insights on the accessibility affordances for the blind of audio rendering of motion for dance and theatre classes.

The project FOUREYES entered the integration phase, merging CSIG's results with other INESC TEC centres. This integration will provide opportunities to new applications at both national and international scopes.

Information Management and Information Systems

In the area of Information Management and Information Systems, several objectives were obtained in 2018. In Research Data Management (RDM), the work in the context of project TAIL continued with the publication of datasets, described according to domain-dependent models. The Dendro platform, used experimentally in INESC TEC and the University of Porto, was promoted as the support for data organisation and description within projects in research groups. The international collaboration with the EUDAT European infrastructure progressed with the proposal of INESC TEC as a member of the EUDAT Common Data Infrastructure. Collaboration in the national Open Science Working Group provided the continuation of the work on national RDM policy.

Work on the windscanner.pt e-infrastructure progressed, with the completion of an e-Science platform for supporting field experiments, together with the collaboration in the New European Wind Atlas.

We continued our work on the development of tools that help laypeople search the web for health information. Most of the work was associated with the NanoSTIMA project. We proceeded with the development of a Portuguese version of a consumer health vocabulary through HealthTranslations; worked towards a method to assess the readability of Portuguese health contents; proceeded with the

development of HealthTalks and evaluated it in a naturalistic environment; advanced previous work on the influence of health literacy on health search behaviours; explored the Wikipedia as a source of health information; worked on the classification of queries on the health domain; compared automatic methods to classify messages shared in online health communities and progressed with the development of HealthSuggestions. In addition, we also explored techniques to provide useful information to clinicians treating patients through the retrieval of existing knowledge.

The focus on Digital Media, and News Media in particular, continued during 2018. The FourEyes project was on its last year and, within CSIG's context, the focus was on characterizing and exploring information publication patterns to improve news access and news filtering. The Stop PropagHate project started in 2018. This is a Google DNI funded project focused on the automatic detection of hate speech text messages in news media. The Algorithmic Science News project, another Google DNI funded project where CSIG and LIAAD collaborated, reached its end. This project was focused on information extraction and natural language generation to build tools to help journalists explore science repositories. In the area of Information Retrieval, there was work in entity-oriented search integrating text and knowledge bases using graphs.

Software Engineering

In the scope of the NanoSTIMA project, we continued the work on automated scenario-based testing of distributed and heterogeneous systems, initiated in 2016, with an increasing focus on real-time and IoT scenarios. After the development of controllability and observability checking algorithms in 2017, the next steps were focused on the development of decentralized algorithms for model-based test generation and execution, with application examples in the e-health and IoT domains. In the same line, in 2018, we were be involved in a new workshop we promoted in the scope of the 11th IEEE Conference on Software Testing, Validation and Verification (ICST 2018): the First International Workshop on Verification and Validation of Internet of Things (VVIoT).

Based on the partnerships set forth in the preparation of the Software560 project of the TICE.PT cluster on the "Productization and Internationalization of Portuguese Software" (not approved), we prepared a new project proposal with Critical Software, in which we expect to take advantage of prior research on automated pattern-based testing of mobile applications (iMPACT tool).

We also consolidated and extended the work on automated software process performance analysis and improvement recommendation (ProcessPAIR), in order to support the automated assessment of adherence to agile practices and take further advantage of data mining, crowdsourcing and gamification techniques.

We were also involved in the FOUREYES project and our goal was to develop and apply techniques for ensuring the quality of the multimedia software applications developed inside this project.

Accessibility and Assistive Technologies

In the area of Accessibility and Assistive Technologies, we continued the work developing and integrating technologies to help blind people in their daily life and for enhancing their autonomy. Based on the previous experience we developed an accessible game engine under the BEACONING project and integrate it with the existing blind navigation system in order to allow blind people to play serious geo-location games.

Under the scope of sports, health and wellbeing, several solutions were developed in cooperation with CIDESD under the NanoSTIMA project. The solutions integrate Research Line 2 (RL2) aiming the development of smart interfaces for data acquisition of the elderly physics activity. An innovative monitoring platform for arterial peripheral disease patients was tested with a group of users, that had participated in a rehabilitation program promoted by CIDESD. Moreover, a monitoring pervasive platform for the elderly was also developed under NanoSTIMA RL2 that will provide data about the health condition of the elderly in their everyday life. In the field of sport, the Swish application for the processing and visualization of player location data was developed that allows analysing variables of collective tactical performance in an easy and intuitive way.

The Natural Interfaces for the Elderly project -NIE - explored new ways of interaction for the elderly using mobile devices and robots. This project is being developed in cooperation with UTAD nursery school.

In cooperation with Human Computer Interaction Institute of Carnegie Mellon University and the Instituto Dom Luiz we explored the usage of expert crowdsourcing for semantic annotation of atmospheric phenomena under the project eCSAAP.

We prepared 3 proposals for the Horizon 2020 in this area of Accessibility and Assistive Technologies.

We disseminated and promoted the AAT area organizing special sessions and publishing in scientific conferences of this area, namely in the HCII 2018, DSAI 2018, TISHW 2018 and publishing as well as in scientific journals.

The work of the Web Accessibility Barometer of the web sites of private companies continued as well.

Special Purpose Computing Systems/Embedded Systems

In 2018, the Special Purpose Computing Systems (SPeCS) area continued to address compiler transformations and the efficient mapping of computations to hardware accelerators using GPGPUs and FPGAs. The mapping methods and approaches took into account performance, energy and power consumption figures. The area also provided custom solutions for data-intensive algorithms, mainly considering classification and recommendation systems, such as the ones developed in the context of the projects CONTEXTWA and SMILES.

The SPeCS area continued to research new techniques to map efficiently (in terms of performance and energy consumption) matrix-oriented computations. This mapping process focused on the translation of matrix-based models (e.g., MATLAB) to C/OpenCL both targeting multi-core architectures and hardware accelerators (GPGPUs and FPGAs). The new techniques were integrated in the MATISSE compiler and an extensive evaluation with well know benchmarks was accomplished. In the context of an interdisciplinary work between members of SMILES and FOUREYES, there was a preliminary evaluation of the MATISSE compiler and techniques in the context of a recommender system.

In the context of the CONTEXTWA project, the SPeCS area addressed runtime adaptivity and autotuning schemes for algorithms to classify user's activities based on sensing from, e.g., accelerometers and gyroscopes. The intention was to provide the required accuracy levels with respect to activities of the user while saving energy and satisfying real-time requirements.

In 2018, the SPeCS area participated in three H2020 proposals, which unfortunately were not selected for funding.

Regarding the mature Application Areas, the progress in 2018 was as follows:

Personalized Health Research (PHR)

This area focuses in empowering researchers in the health domain to achieve evidence-driven science towards personalized health care. Presently, it branches into two sub-areas:

1. Personalized Internet-based treatments;
2. Human data storage, harmonization and controlled sharing.

The first sub-area encompasses the generalization of Internet-based treatments and accessory evaluation tools to support clinical trials in a multi-site environment. It includes the development of flexible platforms that have been used to support large scale randomized controlled trials mainly in the mental health domain. The tools provide an aseptic environment to collecting and further analyse data towards the delivery of treatments that are tailored to individuals. Projects such as ICT4Depression (FP7 IST), E-COMPARED (FP7 HEALTH), STOP DEPRESSION (EEA Grant, Public Health) and iCare4Depression (FCT) have contributed to and benefited from these tools.

In the second sub-area, the focus is rather different although the goal is also personalized health research. It aims at storing duly curated human data, across the life span of individuals, support harmonization across different repositories and performing distributed analysis, thus fostering cooperative hypothesis-driven research. This approach is mainly applicable in cohort studies, given the diverse and sensitive nature of collected data, the need to compare results from multiple cohorts and the very large temporal extent of the studies. It is currently used in RECAP Preterm (H2020 SC1, 2017-2021) to support harmonisation among 20 European cohorts of children and adults born premature.

During 2018 two new projects have been approved in this sub-area: EUCAN-connect (H2020 SC1, 2019-2023) and iReceptor Plus (H2020 SC1, 2019-2022). Besides adaptiveness, other important trends in this area result from the dichotomy in implementing FAIR Data principles, while protecting the privacy of individuals (GDPR, ELSI), thus creating in new paradigms for collaborative analyses and the tools/methods to support them.

Earth and Ocean Observation Science (EOOS)

This area focuses in empowering researchers in the EOOS domain in achieving evidence-driven science by providing generalizable tools and methods to manage streams of observation data either from sensors or collected by humans. Challenges are the generalization of observation data models, the adaptation of these tools to integrate and process data, thus producing value-added outputs (so-called “products”) and support services based on analysis and forecasts.

Given that data in this area is mostly of geospatial nature, all the methods and standards to ensure interoperability apply, namely the ones addressed by the Open Geospatial Consortium (OGC). The area is also related to the broader scope initiative designated as Linked Open Data.

Tendency is that EOOS relies now more on continuously acquired data, rather than in “snapshots” taken periodically in the scope of scientific campaigns. Nevertheless, both are relevant and pose challenges in organizing, exploring, combining and drawing value from data in due time. Given the real time traits of data streams acquired by sensors, standards and methods associated to the Internet of Things (IoT) became of utter importance. Semantic interoperability, real time data stream processing and big data analysis are but a few examples of the undergoing trends and challenges.

Following the trend of projects such as RAIA, RAIA.co and RAIA TEC (Interreg) and also SeaBioData (EEA Grant), in 2018 several research projects were active in this research line, namely: MarRISK (Interreg), Coral Tools RL3 (Norte 2020), C4G (FCT Infra), EPOS (H2020 ESFRI) and MELOA (H2020 SC5).

5.10.4 Main Achievements in 2018

Multisensory VR and AR, including 360° video, are reaching maturity, mainly due to an effort in creating intuitive authoring tools. This has been successfully implemented in distinct projects, from private contracts with the industry, for learning, training and communication, to scientific projects in areas like perception, science communication and museums.

In European projects like BEACONING and Feedback we have also created authoring tools and platforms to enhance learning and behaviour change with games and gamification. This effort has also been leveraging on innovative procedural content generation techniques.

In 2018, the main achievements for the area of Information Management and Information Systems were: in the context of the TAIL project, launch of the first national research data repositories, including INESC TEC’s repository, which supports DOI issuing (<https://rdm.inesctec.pt>); continued participation and contribution to the activities of the Research Data Alliance (RDA), INESC TEC led a group of 8 Portuguese institutions in the successful application for a national RDA node; successful organization of 22nd edition of the International Conference on Theory and Practice of Digital Libraries (TPDL) in Porto; successful application of the EPISA project, funded in the context of FCT’s program of data science and artificial intelligence in public administration; conclusion of the Google DNI funded project Algorithmic Science News (ASN), and start of the project Stop PropagHate, another Google DNI funded project.

The Software Engineering group was involved in organizing (General Chair, Co-Chair, Local Chair) various events such as XP, QUATIC, INTUITESTBEDS, ANT and ICST.

Mushtaq Raza successfully completed PhDs with the subject "Automated Software Process Performance Analysis and Improvement Recommendation", which also resulted in an innovative prototype (ProcessPAIR), in collaboration with the Software Engineering Institute (USA) and the Technological Institute of Monterrey (Mexico).

FCT funded research was reinforced by seven new projects: MoST, PERFECT, PAINTER, M2S, PromoTourVR, SCReLProg and Wex-Atlantic (CMU-Portugal).

European research was also reinforced with three new projects: iReceptor+, EUCAN CONNECT and TIPES. The first two are part of a more than a decade-long stream of EU-funded projects in e-health.

Consultancy services activities was diversified with several new projects in the virtual environments area.

5.10.5 Centre Organisational Structure and Research Team

The Centre for Information Systems and Computer Graphics is coordinated by António Gaspar and Ângelo Martins and is organised in 5 research areas and 4 multidisciplinary application areas, each one lead by an area coordinator:

- **Research areas**
 - Computer Graphics and Virtual Environments – António Coelho
 - Software Engineering – Ana Paiva
 - Accessibility and Assistive Technologies – João Barroso
 - Information Management and Information Systems – Cristina Ribeiro
 - Embedded/Special-Purpose Computing Systems – João Paiva Cardoso
- **Application areas**
 - Platforms and Methods for Personalized Health Research – Artur Rocha
 - Platforms and Methods for Earth and Ocean Observation Science – Artur Rocha
 - Public Administration Business Area – Lino Oliveira
 - Mobility and Transport Business Area – José Correia

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

Table 5.2 - CSIG - Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017- 18
Integrated HR	Core Research Team	Employees	7	10	13	3
		Academic Staff	26	30	24	-6
		Grant Holders and Trainees	35	56	50	-6
		Total Core Researchers	68	96	87	-9
		Total Core PhD	32	42	31	-11
	Affiliated Researchers		15	16	18	2
	Administrative and Technical	Employees	1	1	1	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	1	1	1	0
	Total Integrated HR		84	113	106	-9
	Total Integrated PhD		45	56	49	-7
Curricular Trainees		4	4	1	-3	
External Research Collaborators		10	8	11	3	
External Administrative and Technical Staff		0	0	1	1	
External Students		4	5	8	3	
Total		102	130	127	-3	

5.10.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	46	117	183	66
PN-PICT	National R&D Programmes - S&T Integrated Projects	189	294	230	-64
PN-COOP	National Cooperation Programmes with Industry		80	126	46
PUE-FP	EU Framework Programmes	226	262	350	88
PUE-DIV	EU Cooperation Programmes - Other	178	64	55	-9
SERV-NAC	R&D Services and Consulting - National	541	214	148	-66
SERV-INT	R&D Services and Consulting - International			32	32
OP	Other Funding Programmes	16	111	123	12
Closed Projects		71	38	64	27
Total Funding		1 267	1 180	1 311	131

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

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	33	42	33	-9
Indexed Conferences	87	74	101	27
Books			1	1
Book Chapters	5	5	6	1
PhD Theses - Members	9	7	2	-5
PhD Theses - Supervised	16	13	19	6

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

Type of Result	2016	2017	2018
Invention disclosures	0	0	2
Software copyright registrations	0	0	0
Patent applications	0	0	1
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs	0	0	1

Table 5.6 - CSIG - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	14	9	6
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	16	15	15
International events in which INESC TEC members participate in the program committees	29	86	63
Participation in events such as fairs, exhibitions or similar	8	11	32
Advanced training courses	4	4	1

5.10.7 List of Projects

Table 5.7 - CSIG – List of Projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	TAIL	Cristina Ribeiro	30/05/2016	30/09/2019
PN-FCT	CONTEXTWA	João Paiva Cardoso	01/06/2016	31/05/2019
PN-FCT	Icarefordepression	Artur Rocha	01/06/2016	31/05/2019
PN-FCT	C4G	Artur Rocha	15/06/2017	13/06/2020
PN-FCT	WindScanner	João Correia Lopes	23/10/2017	21/10/2020
PN-FCT	NIE	João Barroso	10/08/2017	18/04/2019
PN-FCT	eCSAAP	Hugo Paredes	01/09/2018	31/08/2019
PN-FCT	PERFECT	Maximino Bessa	01/07/2018	29/06/2020
PN-FCT	PAINTER	Rui Silva Nóbrega	01/07/2018	30/06/2021
PN-FCT	M2S	António Coelho	01/07/2018	30/06/2021
PN-FCT	PromoTourVR	Maximino Bessa	26/07/2018	25/07/2021
PN-FCT	SCReLProg	Leonel Morgado	01/10/2018	30/09/2021
PN-COOP	Simprove	António Gaspar	15/03/2017	14/09/2019
PN-COOP	FDControlo-1	Lino Oliveira	02/01/2018	01/01/2022
PN-PICT	FOUREYES-2	Sérgio Nunes	01/07/2015	30/06/2019
PN-PICT	SMILES-5	João Paiva Cardoso	01/07/2015	30/06/2019
PN-PICT	CORAL-SENSORS-3	Susana Alexandra Barbosa	01/01/2016	
PN-PICT	CORAL-TOOLS-3	Artur Rocha	01/01/2016	
PN-PICT	NanoStima-RL2	João Barroso	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL3-2	Ângelo Martins	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL4-3	Carla Lopes	01/07/2015	30/06/2019
PUE-DIV	GReSBAS-1	António Coelho	01/04/2016	30/09/2019
PUE-DIV	MarRisk	Artur Rocha	01/07/2017	30/06/2020
PUE-FP	BEACONING	António Coelho	01/01/2016	30/04/2019
PUE-FP	RECAP	Artur Rocha	01/01/2017	31/03/2021
PUE-FP	MELOA	Artur Rocha	01/12/2017	28/02/2021
PUE-FP	FEEdBACK-1	António Coelho	01/11/2017	31/10/2020
PUE-FP	InteGrid-2	António Gaspar	01/01/2017	30/06/2020
SERV-NAC	IMOPORTAL	José Correia	01/07/2016	31/07/2019

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	ARQNET	José Correia	26/10/2016	31/01/2020
SERV-NAC	RCD	Gabriel David	01/06/2017	
SERV-NAC	AUTOTESTSW	João Pascoal Faria	01/07/2017	31/07/2019
SERV-NAC	SIGMAIA	Lígia Silva	01/07/2017	30/06/2019
SERV-NAC	EYEFYPLUS	José Correia	15/01/2018	30/04/2018
SERV-NAC	GEOCONSULT	Lino Oliveira	29/12/2017	30/09/2018
SERV-NAC	TRICONSULT	Lino Oliveira	27/12/2017	28/06/2018
SERV-NAC	PalacioDaAgua	António Gaspar	01/06/2018	31/05/2020
SERV-NAC	RUTE-1	Ana Cristina Paiva	01/10/2018	29/02/2020
SERV-NAC	PPD-Parlamento	Gabriel David	03/10/2018	31/12/2018
SERV-NAC	MuseuPorto	Rui Silva Nóbrega	15/11/2018	14/07/2019
SERV-INT	PilotoEUDAT	Cristina Ribeiro	01/07/2017	
SERV-INT	MBSupport	José Pedro Ornelas	18/10/2018	17/12/2020
SERV-INT	MBIntervention	José Pedro Ornelas	20/12/2018	19/07/2019
OP	Atena-1	Carla Lopes	14/10/2016	13/10/2019
OP	HDR4RTT	Maximino Bessa	30/09/2016	29/09/2019
OP	AV360-DNI	Rui Pedro Rodrigues	01/03/2017	
OP	StopPropagHate	Sérgio Nunes	06/02/2018	28/02/2019
OP	TPDL/DublinCore	Cristina Ribeiro	23/10/2017	16/09/2018
	Lab_massive	António Gaspar	02/01/2018	

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

5.10.8 List of Publications

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- Antoncic, JA, Antoncic, B, Gantar, M, Hisrich, RD, Marks, LJ, Bachkirov, AA, Li, ZY, Polzin, P, Borges, JL, Coelho, A, Kakkonen, ML, "Risk-Taking Propensity and Entrepreneurship: The Role of Power Distance", Journal of Enterprising Culture, vol.26, pp.1-26, MAR, 2018
- Au Yong Oliveira, M, Goncalves, R, Martins, J, Branco, F, "The social impact of technology on millennials and consequences for higher education and leadership", Telematics and Informatics, 2018
- Barbosa, S, Huisman, JA, Azevedo, EB, "Meteorological and soil surface effects in gamma radiation time series - Implications for assessment of earthquake precursors", Journal of Environmental Radioactivity, vol.195, pp.72-78, 2018
- Barreira, J, Bessa, M, Barbosa, L, Magalhaes, L, "A Context-Aware Method for Authentically Simulating Outdoors Shadows for Mobile Augmented Reality", IEEE Transactions on Visualization and Computer Graphics, pp.1-1, 2018

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3. Méndez, E, Crestani, F, Ribeiro, C, David, G, Lopes, JC, "Digital Libraries for Open Knowledge, 22nd International Conference on Theory and Practice of Digital Libraries, TPDL 2018, Porto, Portugal, September 10-13, 2018, Proceedings", TPDL, vol.11057, 2018

Dissertations (PhD)

1. Silva, H., "Applying Real-time Strategy Game Principles to Emergency Management";
2. Jesus, D., "Sketch based interaction for procedural modelling";

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 started as a Machine Learning Research Group in 1991 and has since been in the area of Data Science, which 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, optimisation and mathematics.

5.11.2 Contribution to the Vision of the Cluster

Computing is becoming ubiquitous, decentralised and mobile, reaching all devices, appliances and beings, in real time, producing enormous amounts of data, which can produce a wealth of information if properly mined, challenging individual privacy and society fundamentals. More intelligent and autonomous systems will change the way we live and work. New interfaces will enable more immersive and inclusive interactions among humans and machines, blurring real and virtual environments.

Machine learning and decision support are at the centre of the vision of the Cluster. LIAAD adds skills in these central areas that are related to data processing, pervasive intelligence, autonomous systems and intelligent interfaces.

- The processing of big and small data, from storage to analytics, is an important vector of the Cluster. LIAAD concentrates on the analytics layer. Machine learning and statistics are important to automatically produce operational abstractions of data (models). Optimisation, Mathematical modelling and simulation complement the use of models for effective and balanced action deployment. Many algorithmic challenges lie here, from data stream processing to complex and varied data analysis, ubiquitous and situation-aware machine learning. Meta learning / AutoML have a growing importance in this areas.
- The Cluster has a strong strategy in cyber-privacy and security, where machine learning and decision support are playing a fundamental role. Additionally cyber-security concerns apply to machine learning/artificial intelligence installations.
- Intelligent interfaces and immersive environments require real time user interaction with a strong demand on human-machine collaboration.

5.11.3 Research and Innovation Progress in 2018

- The Keyword extractor Yake! made a difference, winning Best Short Paper Award at ECIR 2018 and leading to a victory in the Arquivo.pt prize with project “Conta-me histórias”.
- We managed to successfully model the time of onset for the rare disease Transthyretin Familial Amyloid Polyneuropathy by exploring genealogical features.
- With Text2Story2018, the first workshop on Narrative Extraction from Texts at the ECIR 2018 Conference, we objectively started the research line on Narrative Extraction and Representation.
- LIAAD is actively involved in the launching of the Data Science Hub.

- Runner up for the best student data mining paper award, ECMLPKDD 2018 with a work on Clustering in the Presence of Concept Drift.
- Best Paper award at I Workshop en Deep Learning (DeepL 2018) at XVIII Conferencia da Asociacion Española para la Inteligencia Artificial (CAEPIA).

5.11.4 Main Achievements in 2018

- Arquivo.pt prize: a team of LIAAD researchers has won the first Arquivo.pt prize organized by FCCN with the web portal “Conta-me histórias”, which, given a topical query, has the capability of going through the Portuguese web archive and produce a proto-narrative in the form of a chronological sequence of relevant statements extracted from the news.
- Best short paper award at ECIR 2018, the European Conference on Information Retrieval, with the title “A Text Feature Based Automatic Keyword Extraction Method for Single Documents”.
- The Yake! library and online tool for keyword extraction has been released.
- We secured one of the 15 projects awarded by open competition in the first wave of “Artificial Intelligence applied to the Public Administration”. The project is “FailStopper - Early failure detection of public transport vehicles in operational context”.
- LIAAD continued the high publication activity with a large number of journal and conference papers referenced in WOS or Scopus.
- Three books were published by members of LIAAD.
- Organization of several journal special issues, conference tracks and workshops in main conferences such as WWW and ECIR.
- Organization of the Advanced School on Data Science for Big Data, EAIA 2018 in Porto, which attracted more than 150 participants.

5.11.5 Centre Organisational Structure and Research Team

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			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	0	0	3	3
		Academic Staff	29	28	22	-6
		Grant Holders and Trainees	38	50	24	-26
		Total Core Researchers	67	78	49	-29
		Total Core PhD	36	41	30	-11
	Affiliated Researchers		5	6	4	-2
	Administrative and Technical	Employees	0	0	0	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	0	0	0	0
	Total Integrated HR		72	84	53	-13
	Total Integrated PhD		41	47	34	-13
Curricular Trainees		5	3	1	-2	
External Research Collaborators		15	20	42	22	
External Administrative and Technical Staff		0	0	0	0	
External Students		10	13	20	7	
Total		102	120	116	-4	

5.11.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	24	46	64	18
PN-PICT	National R&D Programmes - S&T Integrated Projects	127	355	242	-113
PN-COOP	National Cooperation Programmes with Industry	1	41	41	
PUE-FP	EU Framework Programmes	100	74	107	33
PUE-DIV	EU Cooperation Programmes - Other	16			
SERV-NAC	R&D Services and Consulting - National	20	19	93	75
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	41	4	13	10
Closed Projects				6	6
Total Funding		329	539	567	28

Table 5.4 - LIAAD - Summary of publications by members of the Centre

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	36	36	44	8
Indexed Conferences	48	44	53	9
Books		1	2	1
Book Chapters	5	7	6	-1
PhD Theses - Members	2	2		-2
PhD Theses - Supervised	3	6		-6

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

Type of Result	2016	2017	2018
Invention disclosures	0	0	1
Software copyright registrations	0	0	0
Patent applications	0	0	1
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs	0	0	0

Table 5.6 - LIAAD - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	5	4	20
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	12	14	24
International events in which INESC TEC members participate in the program committees	15	12	36
Participation in events such as fairs, exhibitions or similar	1	0	6
Advanced training courses	3	0	10

5.11.7 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
PN-FCT	FOTOCATGRAF-1	Luís Torgo	01/06/2015	
PN-FCT	FAST-manufacturing	Dalila Fontes	01/07/2018	30/06/2021
PN-FCT	MDG	Alberto Pinto	01/10/2018	30/09/2021
PN-FCT	MaLPIS	Paula Brito	01/10/2018	30/09/2021
PN-COOP	SmartFarming-1	Carlos Ferreira	01/10/2016	
PN-PICT	FOUREYES-3	Alípio Jorge	01/07/2015	30/06/2019
PN-PICT	iMAN-4	Dalila Fontes	01/07/2015	30/06/2019
PN-PICT	SMILES-7	João Gama	01/07/2015	30/06/2019
PN-PICT	CORAL-TOOLS-5	Luís Torgo	01/01/2016	
PN-PICT	NanoStima-RL3-3	Rui Camacho	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL4-2	Rui Camacho	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL5-2	Carlos Ferreira	01/07/2015	30/06/2019
PUE-FP	RECAP-1	Rui Camacho	01/01/2017	31/03/2021
PUE-FP	NEXT-NET-1	Pedro Campos	01/10/2017	30/09/2019
SERV-NAC	FLOWTEE	Alípio Jorge	01/01/2018	31/12/2019
SERV-NAC	MDIGIREC-1	Alípio Jorge	01/12/2017	
SERV-NAC	RUTE	Alípio Jorge	01/10/2018	29/02/2020
SERV-NAC	Consultoria	Alípio Jorge	01/01/2017	
OP	Coop_India	João Gama	01/01/2018	31/12/2019
OP	EAIA2018	João Gama	01/02/2018	31/12/2018

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

5.11.8 List of Publications

International Journals with Scientific Referees

1. Abdulrahman, SM, Brazdil, P, van Rijn, JN, Vanschoren, J, "Speeding up algorithm selection using average ranking and active testing by introducing runtime", Machine Learning, vol.107, pp.79-108, 2018
2. Bini, A, Amaral, TF, Oliveira, BMPM, Carvalho, P, Teixeira, VH, "Skinfolds compressibility and calliper's time response in male athletes", Progress In Nutrition, vol.20, pp.273-278, JUN, 2018
3. Branco, P, Torgo, L, Ribeiro, RP, "Resampling with neighbourhood bias on imbalanced domains", Expert Systems, vol.35, AUG, 2018
4. Brito, PQ, Stoyanova, J, "Marker versus Markerless Augmented Reality. Which Has More Impact on Users?", International Journal of Human-Computer Interaction, pp.1-15, 2018
5. Brito, PQ, Stoyanova, J, Coelho, A, "Augmented reality versus conventional interface: Is there any difference in effectiveness?", Multimedia Tools and Applications, pp.1-30, 2018
6. Brito, PQ, Vale, VT, "Toward an integrated model of visitor's food Nostalgia and gender difference: A festival context", Event Management, vol.22, pp.609-628, 2018
7. Cerqueira, V, Moreira Matias, L, Khiari, J, van Lint, H, "On Evaluating Floating Car Data Quality for Knowledge Discovery", IEEE Transactions On Intelligent Transportation Systems, vol.19, pp.3749-3760, NOV, 2018
8. Chaves, AA, Goncalves, JF, Nogueira Lorena, LAN, "Adaptive biased random-key genetic algorithm with local search for the capacitated centered clustering problem", Computers & Industrial EngineerinG, vol.124, pp.331-346, OCT, 2018
9. Colonna, JG, Gama, J, Nakamura, EF, "A comparison of hierarchical multi-output recognition approaches for anuran classification", Machine Learning, vol.107, pp.1651-1671, NOV, 2018
10. de Matos, AN, Sousa, CN, Almeida, P, Teles, P, Rego, D, Teixeira, G, Loureiro, L, Teixeira, S, Antunes, I, "Radiocephalic Fistula Recovery Using the Brachial Vein and Forearm Basilic Vein: A Case Series and Literature Review", Therapeutic Apheresis and Dialysis, vol.22, pp.570-574, DEC, 2018
11. de Sa, CR, Azevedo, P, Soares, C, Jorge, AM, Knobbe, A, "Preference rules for label ranking: Mining patterns in multi-target relations", Information Fusion, vol.40, pp.112-125, MAR, 2018
12. de Sa, CR, Duivesteijn, W, Azevedo, P, Jorge, AM, Soares, C, Knobbe, A, "Discovering a taste for the unusual: exceptional models for preference mining", Machine Learning, vol.107, pp.1775-1807, 2018
13. Duarte Silva, APD, Filzmoser, P, Brito, P, "Outlier detection in interval data", Advances in Data Analysis and Classification, pp.1-38, 2018
14. Fathi, M, Machado Martins Fontes, DBMM, Moris, MU, Ghobakhloo, M, "Assembly line balancing problem", Journal of Modelling in Management, vol.13, pp.455-474, 2018
15. Fernandes, S, Fanaee T, H, Gama, J, "Dynamic graph summarization: a tensor decomposition approach", Data Mining and Knowledge Discovery, vol.32, pp.1397-1420, SEP, 2018
16. Fernandez Viagas, V, Valente, JMS, Framinan, JM, "Iterated-greedy-based algorithms with beam search initialization for the permutation flowshop to minimise total tardiness", Expert Systems with Applications, vol.94, pp.58-69, 2018
17. Fontes, DBMM, Goncalves, JF, Fontes, FACC, "An evolutionary approach to the maximum edge weight clique problem", Recent Advances in Electrical and Electronic Engineering, vol.11, pp.260-266, 2018

18. Ghobakhloo, M, Fathi, M, Fontes, DBMM, Ching, NT, "Modeling lean manufacturing success", *Journal of Modelling in Management*, 2018
19. Hosseinian, S, Fontes, DBMM, Butenko, S, "A nonconvex quadratic optimization approach to the maximum edge weight clique problem", *J. Global Optimization*, vol.72, pp.219-240, 2018
20. Jorge, A, Campos, R, Jatowt, A, Nunes, S, Rocha, C, Cordeiro, JP, Pasquali, A, Mangaravite, V, "ECIR 2018: Text2Story Workshop - Narrative Extraction from Texts", *SIGIR Forum*, vol.52, pp.150-152, 2018
21. Lopes, RL, Jorge, AM, "Assessment of predictive learning methods for the completion of gaps in well log data", *Journal of Petroleum Science and Engineering*, 2018
22. Matuszyk, P, Vinagre, J, Spiliopoulou, M, Jorge, AM, Gama, J, "Forgetting techniques for stream-based matrix factorization in recommender systems", *Knowl. Inf. Syst.*, vol.55, pp.275-304, 2018
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24. Mozetic, I, Torgo, L, Cerqueira, V, Smailovic, J, "How to evaluate sentiment classifiers for Twitter time-ordered data?", *PLoS ONE*, vol.13, pp.e0194317, 2018
25. Nogueira, AR, Ferreira, CA, Gama, J, "Improving acute kidney injury detection with conditional probabilities", *Intell. Data Anal.*, vol.22, pp.1355-1374, 2018
26. Norton de Matos, AN, Sousa, CN, Almeida, P, Teles, P, Rego, D, Teixeira, G, Loureiro, L, Teixeira, S, "Radio-cephalic arteriovenous fistula recovered with drainage through the brachial vein", *Hemodialysis International*, vol.22, pp.E53-E56, OCT, 2018
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31. Ribeiro, H, de Sousa, T, Santos, JP, Sousa, AGG, Teixeira, C, Monteiro, MR, Salgado, P, Mucha, AP, Almeida, CMR, Torgo, L, Magalhaes, C, "Potential of dissimilatory nitrate reduction pathways in polycyclic aromatic hydrocarbon degradation", *Chemosphere*, vol.199, pp.54-67, 2018
32. Rocha, A, Camacho, R, Ruwaard, J, Riper, H, "Using multi-relational data mining to discriminate blended therapy efficiency on patients based on log data", *Internet Interventions*, 2018
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34. Rodrigues, PP, Araujo, J, Gama, J, Lopes, L, "A local algorithm to approximate the global clustering of streams generated in ubiquitous sensor networks", *International Journal of Distributed Sensor Networks*, vol.14, pp.155014771880823, 2018
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43. Veloso, B, Leal, F, Gonzalez Velez, H, Malheiro, B, Carlos Burguillo, JC, "Scalable data analytics using crowdsourced repositories and streams", Journal of Parallel and Distributed Computing, vol.122, pp.1-10, 2018
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14. Cerqueira, V, Pinto, F, Torgo, L, Soares, C, Moniz, N, "Constructive Aggregation and Its Application to Forecasting with Dynamic Ensembles", Machine Learning and Knowledge Discovery in Databases - European Conference, ECML PKDD 2018, Dublin, Ireland, September 10-14, 2018, Proceedings, Part I, vol.11051, pp.620-636, 2018
15. Cherkani, N, Brito, PQ, "Tourists' Precautions in an Unsafe Destination: The Case of Agadir, Morocco", Innovative Approaches to Tourism And Leisure, pp.573-581, 2018
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5.12 CRACS - CENTRE FOR RESEARCH IN ADVANCED COMPUTING SYSTEMS

Coordinator: Luís Antunes and Ricardo Rocha

5.12.1 Presentation of the Centre

CRACS integrates the Computer Science Cluster with the mission of pursuing scientific excellence in the areas of programming languages, parallel and distributed computing, information mining, security and privacy, with a focus on scalable software systems for challenging multidisciplinary applications in Engineering, Life Sciences, Social Networks and the Internet of Things (IoT). The core research team is currently composed by 52 members, of which 21 are senior researchers, mostly faculty members at the CS department at FCUP. The research environment is enriched with junior talented researchers that together with senior researchers build the necessary critical mass and scientific competences to fulfill our mission.

5.12.2 Contribution to the Vision of the Cluster

CRACS activity is in line with some of the major challenges for Europe2030, namely high performing computing, data science and cybersecurity and privacy. We expect to contribute from new sensors, data gathering by the sensors in some platform where we can contribute in the development of its middleware in particular focus on security and privacy of the data and, finally, data science techniques to transform the data in useful knowledge. Given our past research and collaborations in health sciences and smart cities, CRACS can leverage some societal challenges in real world scenarios, thus contributing to the vision of the CS Cluster, namely in the research areas of:

- 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, 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.
- Data science: computing is becoming ubiquitous, decentralised and mobile, generating never-ending amounts of data daily. Developing methods, systems and applications that better understand the process of transforming raw data into knowledge is a competitive advantage that most organisations have identified as the key to being successful and competitive in today's world.
- Cybersecurity and privacy: the ever-increasing volume of data produced by the internet-of-Things (IoT) undermines some of the fundamentals privacy principles: informative self-determination, data minimization, consent and the rights to individual access. Nowadays, large sets of data are collected and used without respect for these international rights for privacy. Therefore, it is mandatory to find mechanisms to ensure an adequate level of privacy protection, user empowerment, through new applications and services based on access to personal information. In particular, techniques allowing online preprocessing of data streams as close as possible to the source (e.g., smartphones) in order to significantly avoid information linkage.

Addressing these challenges is a key factor in the development of the Digital Single Market, and the large scale data economy envisioned by the EU.

5.12.3 Research and Innovation Progress in 2018

As planned for 2018, CRACS was successful in at least 2 new projects, namely, two national projects (projects Angerona and CRADLE) and one EU cooperation programme (project FGPE). However, as expected, in 2018 there was a small decrease in the income from national programmes (from 443k€ in

2017 to 376k€ in 2018) and R&D services and consulting (from 78k€ in 2017 to 45k€ in 2018), for a total decrease of around 15% on the centre's funding mix.

Nevertheless, the core research team of CRACS remained stable (around 50 members) as well as the number of PhD researchers (around 20 members). Regarding the dissemination indicators, there was a significant increase in the number of international events in which CRACS members participate in the program committees (from 16 in 2017 to 27 in 2018), which somehow consolidates and strengthens the international visibility and notoriety of CRACS members. In terms of technology transfer outputs, in 2018, CRACS registered 1 patent application and 1 invention disclosure (compared with none in 2016 and 2017). On the other hand, the publication output in indexed journals and conferences reduced slightly compared to the previous year (10 publications in indexed journals and 38 in indexed conferences in 2018), as a side-effect of the funding decreased.

Regarding the core areas of CRACS, we would like to highlight the amount of work done in the research line 'Languages and Distributed Computing', with particular emphasis on the goals and deliverables accomplished by projects HYRAX, SMILES and ELVEN, and also the new Portugal-CMU project named Angerona, which leverages the work done in the HYRAX project to address the challenges put forward by the security and privacy of the Internet-of-Things (IoT). These are good examples of the research and progress being done as strategic for INESC TEC, particularly for the Computer Science cluster, namely on mobile edge computing and security.

5.12.4 Main Achievements in 2018

Logic-based systems: (i) implementation of a prediction-based pruning strategy for Probabilistic Inductive Logic Programming (PILP) systems aimed to reduce the search space based on the probabilistic evaluation of previously evaluated theories; (ii) application of a PILP predictive model to breast cancer data; (iii) progress in the development of type systems for Logic Programming (LP); (iv) integration of LP in foreign programming environments; (v) advances in the integration of Inductive Logic Programming and Deep Neural Networks; (vi) evaluation of error prediction in temporal, spatial systems.

Logtalk: language extended with: (i) support for parameter variables and new error throwing methods; (ii) runtime performance improvements, hot patching improvements, and embedding support improvements; (iii) updated tools (linter, code metrics, documenting, diagrams, unit testing, and make) and new and improved libraries (notably, "optional" terms, "expected" terms, EDCGs, and type-checking libraries); (iv) sample implementations of industry standard design patterns (notably, object-oriented behavioral, creational, and structural design patterns); (v) extended test suites and new and improved examples.

HYRAX: continued development of the Hyrax middleware for programming crowd-sourcing applications leading to the completion of one PhD. The following prototypes have been implemented on top of the Hyrax middleware: (i) Panoptic - an edge-cloud system that enables the search for missing people, similar to the commonly known Amber alert system; (ii) Ramble - an application that allows geo-referenced content sharing in environments that have limited infrastructural communications, motivated by applications such as rescue operations in disaster scenarios or citizen-science data collection in areas with low communication coverage; (iii) User Generated Replays - a video streaming application for large venues that uses information locality to improve latency and bandwidth and that provides caching of contents when used in conjunction with built-in wireless infrastructure.

SMILES: work on mobile data sensing led to the development of: (i) Flux - a streaming service that allows users to gather information from devices according to regions, defined by constraints in certain attributes, usually values from sensors, that in sequence led to an ongoing project with Museu da Biodiversidade for the development of a mobile app for museum visits; (ii) Dolphin - a task orchestration language for networks of autonomous vehicles in cooperation with LSTS/FEUP.

Lock-freedom: (i) design and implementation of LRMalloc, a novel lock-free memory allocator that leverages lessons of modern memory allocators and combines them with a lock-free scheme; (ii) extension of a lock-free hash trie design based on fixed size data structures and persistent memory references to support sorting of keys (concurrently with the search, insert, remove and expand operations) and to support memory reclamation based on the concept of hazard pointers.

Computational power of parsing expression grammars (PEGs): we have constructed a computational model for PEGs, and used it to show that PEGs are much more expressive, and their computational complexity is much more difficult to contain, than what was previously thought. In particular we have constructed a PEG language for a P-complete problem, and shown that there can be no pumping lemma for PEGs.

Vector-matrix-vector product: there are no fast randomized data structures for vector-matrix-vector product. We have shown that if one wishes to store an $n \times n$ matrix M in n -large registers, and compute $x M y$ when given two vectors x and y , then one must query $\Omega(n)$ registers, even if one only wishes to be correct with non-negligible probability.

Type-inhabitation: following the definition of the notion of pre-grammars, we defined a unifying framework to deal with type-inhabitation related problems for simple types. Furthermore, we define a scheme for a decision algorithm that, for particular instantiations of the parameters, can be used to show different inhabitation related problems to be in PSPACE. We started exploring the pre-grammar formalism for richer type-systems, such as systems with finite intersections.

Pattern-based calculi: we have studied finitary matching problems for pattern calculi and defined a framework that solves the (finitary) pattern-matching problems for such calculi. The framework is parametrised by the solving function, which is responsible for computing solutions to the matching problems. A concrete instance of the function gives a concrete version of the pattern calculus. By imposing conditions on the solving function, one can obtain a generic confluence proof for a class of pattern calculi with finitary matching. We have studied relevant particular instances of the solving function.

Angerona: leveraging on the work done in the HYRAX project, we now address the challenges put forward by the security and privacy of the Internet-of-Things (IoT) in a new Portugal-CMU project called Angerona. Here, we aim to find mechanisms that ensure adequate levels of privacy protection and user empowerment through novel applications and services based on access to personal information. Furthermore, proper identity management and authentication in IoT is critical. Given the ubiquity of devices and the complexity of their interconnections, scalable ways to manage their identities must be envisioned.

Enforcing privacy and security in public cloud storage: implementation of a broker, named ARGUS, that acts as a proxy to the existing public cloud infrastructures by performing all the necessary authentication, cryptography and erasure coding. ARGUS uses erasure code as a way to provide efficient redundancy (opposite to standard replication) while adding an extra layer to data protection in which data is broken into fragments, expanded and encoded with redundant data pieces that are stored across a set of different storage providers (public or private). The key characteristics of ARGUS are confidentiality, integrity and availability of data stored in public cloud systems.

Privacy properties of secure VoIP metadata: some governments do not consider metadata as personal data, and so not in the scope of privacy regulations. In voice calls, we are facing a critical situation in terms of privacy, as metadata can identify, for example, who calls to whom and the duration of the call. We have evaluated privacy properties of voice calls metadata, in particular when using secure VoIP, giving evidence of the ability to extract sensitive information from its ("secure") metadata. We find that ZRTP metadata is freely available to any client on the network, and that users can be re-identified by any user with access to the network. In addition, we propose a solution for this problem, suitable for all the ZRTP-based implementations.

Mooshak: new forms of assessment were added to the current version, including game-based and quizzes. Game-based challenges consist of the development of a software agent that actually plays a game, rather than the student. Existing forms of assessment were improved, including the assessment of diagram based exercises. An experimental interface for the Eclipse IDE was also developed as part of MSc thesis.

REMINDS: project that develops systems to automatically crawl and identify information that is potentially relevant to a general audience. The system bases its work in social media by filtering personal, trivial or fake information, and focusing on trendy or controversial topics. In 2018, we started the development of a dynamic mechanism that allows the system to automatically use the best trained

model for predictions, based on the post characteristics. The model library was extended, and the number of available features was also enlarged to include new features based on IA from Azure, IBM and Google.

Fake News Detection: the project formally started, and the main goal during this year was to derive a credibility index based on the history of authors and in authority. The next step will involve transfer learning in what concerns results from emotion recognition.

Graph mining: (i) development of a new accurate method for comparing temporal networks based on graphlet-orbits transitions; (ii) development of a new efficient method for the canonization of small subgraphs on a streaming data of graph changes; (iii) development of a new method for automatically creating hierarchical expert profiles of researchers based on a heterogeneous network containing information from publications.

Habitat mapping: initiated collaboration with LSTS/FEUP for the development of a machine learning method based on convolutional neural networks to automatically classify habitats using information obtained by the sensors of autonomous underwater vehicles.

5.12.5 Centre Organisational Structure and Research Team

The Centre for Research in Advanced Computing Systems is coordinated by Luís Antunes and Ricardo Rocha and is organised in three main research areas:

- Languages and Distributed Computing - Coordinators: Luís Lopes and Ricardo Rocha
- Security and Privacy – Coordinators: Luís Antunes and Rolando Martins
- Knowledge in a World of Data - Coordinators: Álvaro Figueira 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			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	2	1	1	0
		Academic Staff	14	14	14	0
		Grant Holders and Trainees	41	38	37	-1
		Total Core Researchers	57	53	52	-1
		Total Core PhD	22	22	21	-1
	Affiliated Researchers		2	1	0	-1
	Administrative and Technical	Employees	1	1	1	0
		Grant Holders and Trainees	1	1	0	-1
		Total Admin and Tech	2	2	1	-1
	Total Integrated HR		61	56	53	-3
	Total Integrated PhD		23	24	21	-3
Curricular Trainees		1	1	1	0	
External Research Collaborators		11	13	11	-2	
External Administrative and Technical Staff		0	0	0	0	
External Students		1	8	13	5	
Total		74	78	78	0	

5.12.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	141	126	81	-44
PN-PICT	National R&D Programmes - S&T Integrated Projects	172	317	295	-22
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	67	65	77	12
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	114	78	45	-33
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes				
Closed Projects		2			
Total Funding		497	585	499	-87

Table 5.4 - CRACS - Summary of publications by members of the Centre

Publication Type	Total Publications			Δ 2017-2018
	2016	2017	2018	
Indexed Journals	9	14	11	-3
Indexed Conferences	29	45	38	-7
Books				
Book Chapters	3	1	1	
PhD Theses - Members	1	1	2	1
PhD Theses - Supervised	1	1	2	1

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

Type of Result	2016	2017	2018
Invention disclosures	0	0	1
Software copyright registrations	0	0	0
Patent applications	0	0	1
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs	0	0	0

Table 5.6 - CRACS - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	1	3	3
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	4	5	6
International events in which INESC TEC members participate in the program committees	18	16	27
Participation in events such as fairs, exhibitions or similar	1	2	1
Advanced training courses	0	1	3

5.12.7 List of Projects

Table 5.7-CRACS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Hyrax	Fernando Silva	21/04/2014	
PN-FCT	ELVEN	Vítor Santos Costa	01/07/2016	30/06/2019
PN-FCT	Angerona	Luís Filipe Antunes	01/09/2018	31/08/2019
PN-FCT	CRADLE	Vítor Santos Costa	15/06/2018	14/06/2021
PN-PICT	FOUREYES-4	José Paulo Leal	01/07/2015	30/06/2019
PN-PICT	SMILES-3	Fernando Silva	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL3	Luís Filipe Antunes	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL4	Luís Filipe Antunes	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL5-3	Luís Filipe Antunes	01/07/2015	30/06/2019
PUE-FP	Digi-NewB	Luís Filipe Antunes	01/03/2016	29/02/2020
SERV-NAC	vCardID2-1	Fernando Silva	01/12/2016	
SERV-NAC	PGODISSEIA	Manuel Eduardo Correia	24/07/2018	23/01/2019
SERV-NAC	AuthenticusNF	Fernando Silva	01/08/2018	31/01/2019
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

5.12.8 List of Publications

International Journals with Scientific Referees

1. Alves, S, Dundua, B, Florido, M, Kutsia, T, "Pattern-based calculi with finitary matching", Logic Journal of the IGPL, vol.26, pp.203-243, 2018

2. Alves, S, Wasserman, R, "Preface", Electr. Notes Theor. Comput. Sci., vol.338, pp.1-2, 2018
3. Aparicio, D, Ribeiro, P, Silva, F, "Graphlet-orbit Transitions (GoT): A fingerprint for temporal network comparison", PLOS ONE, vol.13, pp.e.0205497, 2018
4. Areias, M, Rocha, R, "Table space designs for implicit and explicit concurrent tabled evaluation", Theory and Practice of Logic Programming, vol.18, pp.950-992, SEP, 2018
5. Buhrman, H, Koucký, M, Loff, B, Speelman, F, "Catalytic Space: Non-determinism and Hierarchy", Theory Comput. Syst., vol.62, pp.116-135, 2018
6. Maia, MI, Leal, JP, "EmoSpell, a morphological and emotional word analyzer", Information (Switzerland), vol.9, pp.1, 2018
7. Queirós, R, "CSS Preprocessing: Tools and Automation Techniques", Information, vol.9, pp.17, 2018
8. Rodrigues, PP, Araujo, J, Gama, J, Lopes, L, "A local algorithm to approximate the global clustering of streams generated in ubiquitous sensor networks", International Journal of Distributed Sensor Networks, vol.14, pp.155014771880823, 2018
9. Silva, J, Aguiar, A, Silva, F, "Parallel Asynchronous Strategies for the Execution of Feature Selection Algorithms", International Journal of Parallel Programming, 2018
10. Silva, N, Marques, ERB, Lopes, LMB, "FLUX: A Platform for Dynamically Reconfigurable Mobile Crowd-Sensing", ACM Transactions on Sensor Networks, vol.14, pp.20:1-20:25, DEC, 2018
11. 11. Teixeira, AS, Fernandes, F, Francisco, AP, "SpliceTAPyR - An Efficient Method for Transcriptome Alignment", International Journal of Foundations of Computer Science, vol.29, pp.1297-1310, DEC, 2018

International Conference Proceedings with Scientific Referees

1. Alves, S, Broda, S, "A Unifying Framework for Type Inhabitation", 3rd International Conference on Formal Structures for Computation and Deduction, FSCD 2018, July 9-12, 2018, Oxford, UK, vol.108, pp.5:1-5:16, 2018
2. Araujo, M, Pinto Ribeiro, PM, Faloutsos, C, "TensorCast: Forecasting Time-Evolving Networks with Contextual Information", Proceedings of the Twenty-Seventh International Joint Conference on Artificial Intelligence, IJCAI 2018, July 13-19, 2018, Stockholm, Sweden., pp.5199-5203, 2018
3. Carvalho, AC, Martins, R, Antunes, L, "How-to Express Explicit and Auditable Consent", 16th Annual Conference on Privacy, Security and Trust, PST 2018, Belfast, Northern Ireland, UK, August 28-30, 2018, pp.1-5, 2018
4. Chattopadhyay, A, Koucky, M, Loff, B, Mukhopadhyay, S, "Simulation Beats Richness: New Data-Structure Lower Bounds", Electronic Colloquium on Computational Complexity (ECCC), vol.24, pp.170, 2018
5. Correia, H, Leal, JP, Paiva, JC, "Improving Diagram Assessment in Mooshak", Technology Enhanced Assessment - Communications in Computer and Information Science, pp.69-82, 2018
6. Correia, H, Leal, JP, Paiva, JC, "Moozz: Assessment of Quizzes in Mooshak 2.0 (Short Paper)", 7th Symposium on Languages, Applications and Technologies, SLATE 2018, June 21-22, 2018, Guimaraes, Portugal, vol.62, pp.3:1-3:8, 2018
7. Costa, J, Silva, C, Antunes, M, Ribeiro, B, "Adaptive Learning Models Evaluation in Twitter's Timelines", 2018 International Joint Conference on Neural Networks (IJCNN), 2018
8. Fernandes, D, Ferreira, LS, Nozari, M, Sebastiao, P, Cercas, F, Dinis, R, "Combining Drive Tests and Automatically Tuned Propagation Models in the Construction of Path Loss Grids", 2018 IEEE 29th Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), vol.2018-September, pp.1161-1162, 2018

9. Figueira, A, "A Three-Step Data-Mining Analysis of Top-Ranked Higher Education Institutions' Communication on Facebook", Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality, Salamanca, Spain, October 24-26, 2018, pp.923-929, 2018
10. Figueira, Á, "Uncovering Social Media Content Strategies for Worldwide Top-Ranked Universities", Procedia Computer Science, vol.138, pp.663-670, 2018
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34. Rodrigues, J, Marques, ERB, Silva, J, Lopes, LMB, Silva, FMA, "Video Dissemination in Untethered Edge-Clouds: A Case Study", Distributed Applications and Interoperable Systems - Lecture Notes in Computer Science, pp.137-152, 2018
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37. Silva, JMB, Ribeiro, P, Silva, FMA, "Hierarchical Expert Profiling Using Heterogeneous Information Networks", Discovery Science - Lecture Notes in Computer Science, pp.344-360, 2018
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Books

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Chapter/Paper in Books

1. Choobdar, S, Pinto Ribeiro, PM, Silva, FMA, "Querying Volatile and Dynamic Networks", Encyclopedia of Social Network Analysis and Mining, 2nd Edition, 2018

Publications (Editor)

1. Henriques, PR, Leal, JP, Leitão, AM, Guinovart, XG, "7th Symposium on Languages, Applications and Technologies, SLATE 2018, June 21-22, 2018, Guimaraes, Portugal", SLATE, vol.62, 2018
2. Rocha, R, Son, TC, Mears, C, Saeedloei, N, "Technical Communications of the 33rd International Conference on Logic Programming, ICLP 2017, August 28 to September 1, 2017, Melbourne, Australia", ICLP (Technical Communications), vol.58, 2018

Dissertations (PhD)

1. Cruz, F., "Linear Logic and Coordination for Parallel Programming";
2. Oliveira, L., "Social Media Governance in the Public Portuguese Polytechnical";

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 Contribution to the Vision of the Cluster

Prominent application areas of HASLab research include the development of safety- and security-critical software systems, the operation and security of Cloud infrastructures, and the privacy-preserving management and processing of Big Data. These are key enablers for pervasive intelligence, and will continue to be the focus of the group for the period 2019-2024.

5.13.3 Research and Innovation Progress in 2018

As planned, there was a substantial increase in the income from consultancy and R&D services (more than double the income of the previous year). Two of these contracts were with high-profile international ICT companies, namely Amazon and Redis Labs, which, also as planned, will enable us to consolidate stable long-term technology transfer collaborations with high-impact in real-world applications.

Another goal for 2018 was to reinforce the stability of the research team, namely increase the number of hired researchers. During 2019, 5 postdocs previously with grants were hired with regular contracts, meaning that, at the end of 2018, half of HASLab's postdocs already had a medium term contract providing them some stability. The number of senior researchers in the core team was reduced to 15 and we roughly maintained the number of PhD students (unfortunately, still less than the desired number).

The final goal for 2018 was to move some of the software development tools in HASLab from prototype-level to production-level. Unfortunately, although some of the tools had a significant increase in the maturity level, they are still not at the planned level, and still have a reduced user-base and lack of high-profile real-world applications. As such, this goal was reiterated in the plan for 2019.

5.13.4 Main Achievements in 2018

Throughout 2018, HASLab has continued to produce fundamental and applied research that met the quality requirements of the top-rated journals and conferences. In particular, the centre published five and eight papers at conferences that received A* and A ratings, respectively, from the popular computer science CORE ranking. HASLab has also published 15 journal articles, of which eight were Q1 and four were Q2. Among these publications, we highlight a paper published at the CRYPTO Conference, entitled "Indifferentiable Authenticated Encryption", where the theoretical foundations for analysing and constructing strong forms of encryption schemes were launched, and an article published at the Journal of Parallel and Distributed Computing, entitled "Delta State Replicated Data Types", that establishes the foundations for efficient synchronization of state in global systems, and that has already led to several industrial implementations.

The quality of the research developed by HASLab's members was recognised in 2018 by several prizes at relevant events and distinctions. José Creissac Campos, senior researcher at HASLab, was appointed a member of the College of Assessors of New Zealand Ministry of Business, Innovation and Employment (MBIE); Carlos Baquero, senior researcher at HASLab, joined Redis Labs' Technical Advisory Board; and

João Paulo, postdoctoral researcher at HASLab, was nominated for the Cor Baayen Young Researcher Award of the ERCIM. Two other researchers have also received the Best Paper Award in the XXI Ibero-American Conference on Software Engineering with the article entitled “Using Automatic Refactoring to Improve Energy Efficiency of Android Apps”.

In terms of projects, 2018 was marked by a strong effort to establish new services and consultancy projects with key national and international companies. In fact, the team has started three different consultancy projects. One of these consultancy project is with Amazon, an international giant in the market of Cloud-based solutions, and its goal is to leverage HASLab’s expertise in machine-checked security proofs for cryptographic protocols. Another services agreement was established with Redis Labs, the company supporting the Redis memory cache and database, to support consultancy in the area of multi-master replication and distributed systems.

HASLab has also started four new projects that were approved by the Foundation for Science and Technology (FCT), namely, DaVinci, KLEE, SAFER, and HADES.

Finally, 2018 was also characterised by the organisation of the 13th European Conference on Computer Systems (EuroSys 2018), one of the world’s largest conferences on computer systems, and that has become a premier forum for discussing systems software research and development, including their hardware dependency. This edition of the conference was organised by INESC TEC and by the University of Minho, with Rui Oliveira from HASLab being the general chair, and took place at Palácio do Freixo, Porto, Portugal, between 23 and 26 April. Around 300 participants from all over the world attended.

5.13.5 Centre Organisational Structure and Research Team

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			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	0	1	6	5
		Academic Staff	21	21	14	-7
		Grant Holders and Trainees	46	41	49	8
		Total Core Researchers	67	63	69	6
		Total Core PhD	31	34	30	-4
	Affiliated Researchers		1	1	7	6
	Administrative and Technical	Employees	0	0	0	0
		Grant Holders and Trainees	1	2	3	1
		Total Admin and Tech	1	2	3	1
	Total Integrated HR		69	66	79	3
	Total Integrated PhD		32	35	37	2
Curricular Trainees		2	0	0	0	
External Research Collaborators		10	10	10	0	
External Administrative and Technical Staff		4	4	3	-1	
External Students		17	19	18	-1	
Total		102	99	110	11	

5.13.6 Activity indicators in 2018

The following tables present the main indicators of the activity carried out in 2018 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2018 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€)			
		2016	2017	2018	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT		11	68	57
PN-PICT	National R&D Programmes - S&T Integrated Projects	132	189	195	7
PN-COOP	National Cooperation Programmes with Industry		16	34	18
PUE-FP	EU Framework Programmes	340	554	566	12
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	99	60	79	18
SERV-INT	R&D Services and Consulting - International			61	61
OP	Other Funding Programmes		19	91	73
Closed Projects			19	-1	-19
Total Funding		571	869	1 094	226

Table 5.4 - HASLab - Summary of publications by members of the Centre

Publication Type	Total Publications			Δ
	2016	2017	2018	2017-2018
Indexed Journals	43	15	15	
Indexed Conferences	55	56	36	-20
Books				
Book Chapters	2	1		-1
PhD Theses - Members	3	3	6	3
PhD Theses - Supervised	3	3	11	8

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

Type of Result	2016	2017	2018
Invention disclosures	0	1	0
Software copyright registrations	0	0	1
Patent applications	0	1	0
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs	0	0	0

Table 5.6 - HASLab - Summary of dissemination activities

Type of Activity	2016	2017	2018
Participation as principal editor, editor or associated editor in journals	6	2	2
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	16	7	11
International events in which INESC TEC members participate in the program committees	61	26	21
Participation in events such as fairs, exhibitions or similar	17	3	12
Advanced training courses	2	16	13

5.13.7 List of Projects

Table 5.7-HASLab – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	GSL	Rui Maranhão	01/07/2016	30/06/2019
PN-FCT	KLEE	Luís Soares Barbosa	01/06/2018	31/05/2021
PN-FCT	SAFER	Alcino Cunha	01/07/2018	30/06/2021
PN-FCT	DaVinci	José Paiva Proença	26/07/2018	25/07/2021
PN-FCT	HADES	Manuel Barbosa	01/10/2018	30/09/2021
PN-COOP	Cloud-Setup-1	Manuel Barbosa	01/07/2016	
PN-PICT	SMILES	Carlos Baquero	01/07/2015	30/06/2019
PN-PICT	CORAL-TOOLS-7	Alcino cunha	01/01/2016	
PN-PICT	NanoStima-RL1-4	José Creissac Campos	01/07/2015	30/06/2019
PN-PICT	NanoStima-RL3-4	Manuel Barbosa	01/07/2015	30/06/2019
PUE-FP	SafeCloud	Rui Carlos Oliveira	01/09/2015	
PUE-FP	Lightkone	Carlos Baquero	01/01/2017	31/12/2019
PUE-FP	CloudDBAppliance	Rui Carlos Oliveira	01/12/2016	30/11/2019
PUE-FP	InteGrid-1	Manuel Barbosa	01/01/2017	30/06/2020
SERV-INT	CRDB	Carlos Baquero	21/01/2018	20/01/2020
SERV-INT	KMSEC	Manuel Barbosa	01/04/2018	30/06/2019
SERV-NAC	DSGrid	Vítor Francisco Fonte	01/06/2016	
SERV-NAC	RCS	Fábio André Coelho	01/03/2018	29/02/2020
SERV-NAC	OLM	José Creissac Campos	10/08/2018	09/02/2019
SERV-INT	EMRPrototype	Paolo Masci	18/01/2018	07/03/2018
OP	PTCRIS	Alcino cunha	01/07/2016	30/06/2019
OP	EUROSYS'2018	Rui Carlos Oliveira	01/10/2017	31/12/2019

Type of Project:

- PN-FCT National R&D Programmes - FCT
- PN-PICT National R&D Programmes - S&T Integrated Projects
- PN-P2020 National R&D Programmes - Portugal 2020
- PUE-H2020 EU Framework Programme
- SERV-NAC National R&D Services and Consulting
- SERV-INT International R&D Services and Consulting

5.13.8 List of Publications

International Journals with Scientific Referees

1. Almeida, PS, Shoker, A, Baquero, C, "Delta State Replicated Data Types", Journal of Parallel and Distributed Computing, vol.abs/1603.01529, 2018
2. Barbosa, LS, Madeira, A, "A Research Agenda on Quantum Algorithmics", ERCIM News, vol.2018, pp.44-45, APR, 2018
3. Benevides, MRF, Madeira, A, Martins, MA, "A Family of Graded Epistemic Logics", Electronic Notes in Theoretical Computer Science, vol.338, pp.45-59, 2018
4. Bernardeschi, C, Domenici, A, Masci, P, "A PVS-Simulink Integrated Environment for Model-Based Analysis of Cyber-Physical Systems", IEEE Transactions on Software Engineering, pp.1-1, 2018
5. Cledou, G, Estevez, E, Barbosa, LS, "A taxonomy for planning and designing smart mobility services", Government Information Quarterly, 2018
6. de Sa, CR, Azevedo, P, Soares, C, Jorge, AM, Knobbe, A, "Preference rules for label ranking: Mining patterns in multi-target relations", Information Fusion, vol.40, pp.112-125, MAR, 2018
7. de Sa, CR, Duivesteyn, W, Azevedo, P, Jorge, AM, Soares, C, Knobbe, A, "Discovering a taste for the unusual: exceptional models for preference mining", Machine Learning, vol.107, pp.1775-1807, 2018
8. Hennicker, R, Madeira, A, Wirsing, M, "Behavioural and abstractor specifications revisited", Theoretical Computer Science, 2018
9. Hofmann, D, Neves, R, Nora, P, "Generating the algebraic theory of C(X): The case of partially ordered compact spaces", Theory and Applications of Categories, vol.33, pp.276-295, 2018
10. Machado, N, Romano, P, Rodrigues, L, "CoopREP: Cooperative record and replay of concurrency bugs", Software Testing, Verification and Reliability, pp.e1645, 2018
11. Madeira, A, Barbosa, LS, Hennicker, R, Martins, MA, "A logic for the stepwise development of reactive systems", Theoretical Computer Science, 2018
12. Madeira, A, Neves, R, Martins, MA, Barbosa, LS, "Hierarchical Hybrid Logic", Electronic Notes In Theoretical Computer Science, vol.338, pp.167-184, 2018
13. Neves, R, Barbosa, LS, "Languages and models for hybrid automata: A coalgebraic perspective", Theoretical Computer Science, vol.744, pp.113-142, 2018
14. Oliveira, JN, "Programming from metaphors", Journal of Logical and Algebraic Methods in Programming, vol.94, pp.15-44, JAN, 2018
15. Pedro, AD, Pinto, JS, Pereira, D, Pinho, LM, "Runtime verification of autopilot systems using a fragment of MTL-?", International Journal on Software Tools for Technology Transfer, pp.1-17, 2018

International Conference Proceedings with Scientific Referees

1. Akkoorath, DD, Brandão, J, Bieniusa, A, Baquero, C, "Global-Local View: Scalable Consistency for Concurrent Data Types", Euro-Par 2018: Parallel Processing - 24th International Conference on Parallel and Distributed Computing, Turin, Italy, August 27-31, 2018, Proceedings, vol.11014, pp.492-504, 2018
2. Alam, MI, Halder, R, Goswami, H, Pinto, JS, "K-Taint: An Executable Rewriting Logic Semantics for Taint Analysis in the K Framework", Proceedings of the 13th International Conference on Evaluation of Novel Approaches to Software Engineering, ENASE 2018, Funchal, Madeira, Portugal, March 23-24, 2018., pp.359-366, 2018

3. Almeida, JB, Barbosa, M, Barthe, G, Pacheco, H, Pereira, V, Portela, B, "Enforcing ideal-world leakage bounds in real-world secret sharing MPC frameworks", Proceedings - IEEE Computer Security Foundations Symposium, vol.2018-July, pp.132-146, 2018
4. Almeida, JB, Cunha, A, Macedo, N, Pacheco, H, Proenca, J, "Teaching how to program using automated assessment and functional glossy games (experience report)", Proceedings of the ACM on Programming Languages, vol.2, pp.1-17, 2018
5. Barbosa, LS, "Layered logics, coalgebraically", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.10669 LNCS, pp.55-63, 2018
6. Barbosa, M, Farshim, P, "Indifferentiable Authenticated Encryption", Advances in Cryptology - CRYPTO 2018 - 38th Annual International Cryptology Conference, Santa Barbara, CA, USA, August 19-23, 2018, Proceedings, Part I, vol.10991, pp.187-220, 2018
7. Bernardeschi, C, Masci, P, Santone, A, "Data Leakage in Java Applets with Exception Mechanism", Proceedings of the Second Italian Conference on Cyber Security, Milan, Italy, February 6th - to - 9th, vol.2058, 2018
8. Broccia, G, Masci, P, Milazzo, P, "Modeling and Analysis of Human Memory Load in Multitasking Scenarios: Late-Breaking Results", Proceedings of the ACM SIGCHI Symposium on Engineering Interactive Computing Systems, EICS 2018, Paris, France, June 19-22, 2018, pp.9:1-9:7, 2018
9. Brunel, J, Chemouil, D, Cunha, A, Hujsa, T, Macedo, N, Tawa, J, "Proposition of an Action Layer for Electrum", Abstract State Machines, Alloy, B, TLA, VDM, and Z - 6th International Conference, ABZ 2018, Southampton, UK, June 5-8, 2018, Proceedings, vol.10817, pp.397-402, 2018
10. Brunel, J, Chemouil, D, Cunha, A, Macedo, N, "The electrum analyzer: model checking relational first-order temporal specifications", Proceedings of the 33rd ACM/IEEE International Conference on Automated Software Engineering, ASE 2018, Montpellier, France, September 3-7, 2018, pp.884-887, 2018
11. Carvalho, NR, Barbosa, LS, "Transforming Legal Documents for Visualization and Analysis", Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance, ICEGOV 2018, Galway, Ireland, April 04-06, 2018, pp.23-26, 2018
12. Couto, R, Campos, JC, Macedo, N, Cunha, A, "Improving the Visualization of Alloy Instances", Proceedings 4th Workshop on Formal Integrated Development Environment, F-IDE@FLoC 2018, Oxford, England, 14 July 2018., vol.284, pp.37-52, 2018
13. Cruz, L, Abreu, R, "Using Automatic Refactoring to Improve Energy Efficiency of Android Apps", CoRR, vol.abs/1803.05889, 2018
14. Cruz, R, Proença, J, "ReoLive: Analysing Connectors in Your Browser", Software Technologies: Applications and Foundations - STAF 2018 Collocated Workshops, Toulouse, France, June 25-29, 2018, Revised Selected Papers, vol.11176, pp.336-350, 2018
15. Cunha, A, Macedo, N, "Validating the Hybrid ERTMS/ETCS Level 3 Concept with Electrum", Abstract State Machines, Alloy, B, TLA, VDM, and Z - 6th International Conference, ABZ 2018, Southampton, UK, June 5-8, 2018, Proceedings, vol.10817, pp.307-321, 2018
16. Figueiredo, D, Martins, MA, Barbosa, LS, "A Note on Reactive Transitions and Reo Connectors", It's All About Coordination - Essays to Celebrate the Lifelong Scientific Achievements of Farhad Arbab, vol.10865, pp.57-67, 2018
17. Goncharov, S, Jakob, J, Neves, R, "A Semantics for Hybrid Iteration", 29th International Conference on Concurrency Theory, CONCUR 2018, September 4-7, 2018, Beijing, China, vol.118, pp.22:1-22:17, 2018
18. Harrison, MD, Masci, P, Campos, JC, "Formal Modelling as a Component of User Centred Design", Software Technologies: Applications and Foundations - Lecture Notes in Computer Science, pp.274-289, 2018

19. Lourenço, CB, Frade, MJ, Nakajima, S, Pinto, JS, "A Generalized Approach to Verification Condition Generation", 2018 IEEE 42nd Annual Computer Software and Applications Conference, COMPSAC 2018, Tokyo, Japan, 23-27 July 2018, Volume 1, pp.194-203, 2018
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27. Rei, J, Brito, C, Sousa, A, "Assessment of an IoT platform for data collection and analysis for medical sensors", Proceedings - 4th IEEE International Conference on Collaboration and Internet Computing, CIC 2018, pp.405-411, 2018
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1. Mendes, J., "Design, Implementation and Evaluation of Model-Driven Spreadsheets";
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3. Neves, R., "Hybrid Programs";
4. Gonçalves, R., "Multi-Value Distributed Key-Value Stores";
5. Lourenço, C., "Single-assignment Program Verification";
6. Perez, A., "Spectrum-based Diagnosis: Measurements, Improvements and Applications";

6 TEC4 INITIATIVES

6.1 Overview

A TEC4 (“TECHnologies FOR ...”) is an initiative aiming at structuring the market-pull innovation process, as opposed to the science-push that occurs naturally in the Research Centres. This supports the establishment of the adequate balance between the two opposing motivations and supports the full knowledge-to-value chain.

Each TEC4 targets a specific market and induces cross-cluster multidisciplinary projects, promoting collaboration with industry and producing solutions to be transferred to companies. Each TEC4 is pushed by an Agent (contracted, linked to SAPE), working in close contact with a Champion (Senior Researcher linked to a Cluster). SAPE is the support service that provides active interaction with markets and innovation managers in companies.

The performance of each TEC4 is measured by the volume of direct contracts with the industry and the number of inter-Centre and Inter-Cluster projects motivated. The TEC4 are not involved in project development: once an opportunity is detected, negotiations occur with the relevant Research Centres and it is under these that the project is then managed and completed.

The TEC4 initiatives address regional and national challenges by mapping the short- and medium-term domain needs with INESC TEC scientific roadmaps. Typically, each TEC4 is composed by:

- 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 provides added value services to businesses that cannot be found in the market.

Each TEC4 has its own strategic agenda, according to their market domain, addressing three pillars: the stakeholders 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 short-term objectives of the TEC4 initiatives are the creation of innovative solutions 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 specialities, 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.

Sections 1.2 to 1.7 present a short description of the scope and objectives of the current TEC4 initiatives.

6.1.1 Current Initiatives

Currently, INESC TEC is leading six TEC4 initiatives devoted to the following domains:

- TEC4SEA – solutions for the Blue Economy
- TEC4MEDIA – solutions for the Creative Industries Economy
- TEC4AGRO – solutions for the Agro-Industrial, Forest and Green Economy
- TEC4INDUSTRY – solutions for the Retail and Manufacturing Economy
- TEC4ENERGY – solutions for the Energy Economy
- TEC4HEALTH – solutions for the Health Economy

The application domains addressed by the TEC4 are aligned with regional and national priority domains, developing and consolidating internal R&D competencies around socio-economic pillars, well understood by businesses. Furthermore, the attraction of international partners to the TEC4 initiatives, supports INESC TEC internationalisation strategy, facilitates the national companies an easy access to

international partners and enables the attraction of foreign direct investment into the Region and the country.

easy access to international partners and enables the attraction of foreign direct investment into the Region and the country.

6.1.2 Methodology

Each TEC4 follows an implementation plan covering the following maturity states:

- Identification of market segments where INESC TEC competencies can create value;
- Identification of internal research lines with highest potential impact in business – 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 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 TEC4 and the creation of its advisory board;
- Establishment of collaboration plans with other institutions.

6.2 TEC4SEA

Coordinator: Carlos Pinho

6.2.1 Mission and Positioning

The MISSION of TEC4SEA is to induce a market pull drive into R&D activities targeting sea and deep-sea challenges towards a sustainable Sea Economy.

TEC4SEA is the INESC TEC initiative that brings together R&D Institutions, businesses and associations, increasing synergies and critical mass to address real world challenges related with the Sea Economy. TEC4SEA monitors results in the range TRL 1-9 and focuses on applied research leading to products, processes and services (TRL 5-9) that can be transferred to companies.

6.2.2 Market

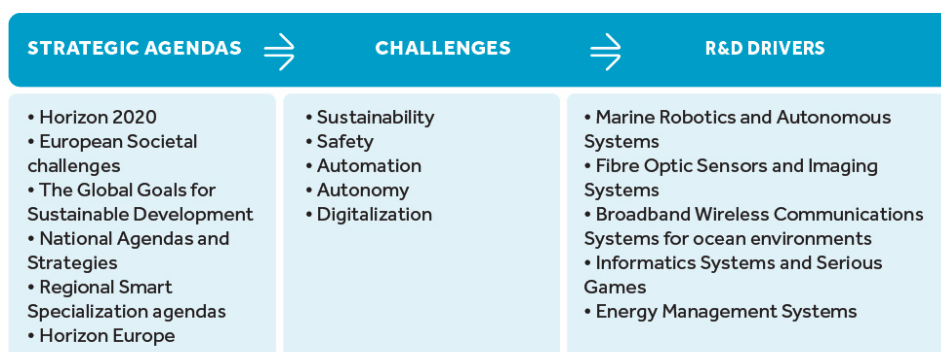
The multidisciplinary application-oriented solutions addressed by TEC4SEA cover a wide range of both established and emerging industries:

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	

6.2.3 Driving Forces

TEC4SEA addresses some of the main societal challenges for the next years identified by INESC TEC Clusters, such as NIS, and is completely aligned with the trends that influence its future research activities: “Smaller, smarter, long endurance, collaborative autonomous systems”.

The Societal Challenges, European, National and Regional agendas and specialisation strategies, and, more recently, the Global Goals for Sustainable Development were considered in the identification of the main challenges for the Sea Economy as well as the main R&D driver’s for INESC TEC.



CLUSTERS RESEARCH LINES	R&D DRIVERS	MARINE ROBOTICS AND AUTONOMOUS SYSTEMS	FIBRE OPTICS SENSORS AND IMAGING SYSTEMS	BROADBAND WIRELESS COMMUNICATIONS SYSTEMS FOR OCEAN ENVIRONMENTS	INFORMATICS SYSTEMS AND SERIOUS GAMES	ENERGY MANAGEMENT SYSTEMS
	Energy Conversion	●		●		●
	Network Planning and Operation	●	●	●	●	●
	Computer vision	●	●		●	
	Sensing	●	●	●	●	
	Autonomous systems	●	●	●	●	●
	Big data	●	●	●	●	
	Privacy-preserving computing	●	●		●	
	Virtual environments	●			●	
	Sustainable production systems	●	●	●	●	●
	Digital transformation of industry	●	●	●	●	●
	Industrial robotics	●	●	●	●	●

6.2.4 Innovation Services

The following services and solutions are provided by INESC TEC in the scope of TEC4SEA:

- 3D Mapping and data fusion in unstructured environments - the services can involve several complementary technologies for 3D mapping and data fusion from heterogeneous sensors for air, ground and underwater environments;
- Development of optical and bio-sensors - the services include the conception, development and test of sensors for physical and chemical parameters monitoring;
- Broadband communications solutions for marine environments - the services provided cover the simulation, development test and validation of broadband communications solutions to be deployed above or underwater;
- Data collection, processing and management - conception, development and test of technological frameworks that ensure the integrity, organisation, long-term preservation and accessibility of data as well as efficient data processing and visualization.

6.2.5 External Competencies and Partners

The external competencies leveraged by TEC4SEA include the following:

- **Marine and environmental knowledge** – knowledge and information about biological, physical and chemical dynamics in the marine environments as well as the impact of natural and human activities are fundamental in the technological development for these environments - CIIMAR, IPMA;

New materials - new materials, information about their characteristics and behaviour in different environments and under different conditions is fundamental for new solutions - INEGI;

6.2.6 Associated Centres

The main Centres involved in TEC4SEA are the following:

- CRAS - Robotics and Autonomous Systems

- CTM - Telecommunications and Multimedia
- CAP - Applied Photonics
- CSIG - Information Systems and Computer Graphics
- CPES - Power and Energy Systems

6.2.7 Main Achievements in 2018

6.2.7.1 Promotion and Dissemination

BUSINESS 2 SEA

A set of results of the TEC4SEA initiative were presented to national and international entities. INESC TEC also had a relevant participation in this event, promoting several seminars and workshops.

OCEANS MEETINGS

The results of the TEC4SEA initiative were exhibited to national and international entities that were present in this international event. The focus of the event were the debate and networking regarding sustainable solutions for the ocean.

VIDA ECONÓMICA

In partnership with the Publishing Group Vida Económica, INESC TEC organised the conference “O Cluster do Mar” held at the Aveiro Exhibition Park. INESC TEC also presented the relevant technological trends for the Sea Economy and how INESC TEC is addressing them.

REP’2018

INESC TEC participated in the 2018 Rapid Environmental Picture (REP), organized by the Portuguese Navy, to test, evaluate and validate unmanned autonomous vehicles working in cooperation.

6.2.7.2 Relevant Activities

MODULMAR

This project, which was developed with a strategic partner, supports INESC TEC’s goals of developing technologies for the Deep Sea (up to 4km of depth). The goals of the project include the development of a modular system and several components to facilitate the customisation of autonomous platforms for the Deep Sea.

“PORTO DE PESCA SUSTENTÁVEL”

The consulting activities to be developed by INESC TEC for Docapesca aim at defining the transformation process of the fishing ports to become sustainable in terms of the environmental and social perspectives. The integrated intervention includes water consumption, waste produced/collected, energy consumed/produced as well as the communities and the stakeholders of the port.

STRONGMAR

This project, led by INESC TEC, had its final workshop at the end of 2018. Supported by the experience and the best practices of partners such as the University of Aberdeen, Universitat de Girona and CMRE, the project successfully achieved the expected impacts of strengthening the cooperation with these recognised institutions, increased the R&DI capacity of INESC TEC whilst extending the innovation potential of the northern region of Portugal, among others.

CORAL

INESC TEC, in partnership with CIIMAR, successfully completed the results of this project and publicly presented them. A video with the project results was also created. The aim of the project was to investigate and to develop technology-driven solutions to tackle deep-sea resource exploitation under a sustainable environmental framework, in addition to developing a sensor-based technology for marine or marine-related activities.

6.2.7.3 Structural Relevant Initiatives

TEC4SEA Infraestructure

INESC TEC pursued its ambition to set up an infrastructure dedicated to support the research, development and test of marine robotics, telecommunications, and sensing technologies for monitoring and operating in the ocean environment. The investments in this infrastructure continued throughout 2018.

IN THE BLACK

«In the Black - Deep Sea Mining Challenges» was the name of the workshop organised by INESC TEC for the second consecutive year. This workshop had several worldwide relevant entities involved in mining exploration at sea. The entities present in the event ranged from pilot ones to commercial (diamond) ones.

OCEANS 2018

INESC TEC had a significant attendance in OCEANS 2018, which was held in Kobe (Japan) and Charleston (USA), preparing the researchers in advance for OCEANS 2021, which will be co-organised by INESC TEC and taking place in Porto.

EMRA 2018

For the fourth consecutive time, INESC TEC was invited for the Workshop on EU-funded Marine Robotics and Applications (EMRA), held at Limerick, Ireland. INESC TEC presented several ongoing projects related to aquatic robotics. The presence in this restricted workshop, which could only be made by means of an invitation, enabled valuable networking.

6.3 TEC4INDUSTRY

Coordinator: José Nina de Andrade

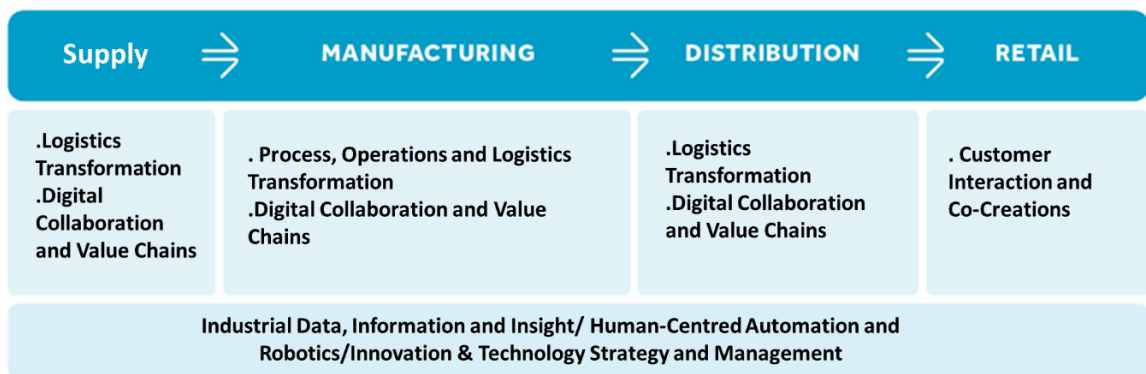
6.3.1 Mission and Positioning

The MISSION of TEC4INDUSTRY is to foster transformation for an innovative, collaborative, human-centred and sustainable industry.

TEC4INDUSTRY is INESC TEC initiative to induce a market pull drive into R&D and generate a convergence of knowledge and competences into solutions for the Retail and Manufacturing Industries, covering end-to-end supply chain actors, anchored in a history of successes and impact in technology transfer to companies. TEC4INDUSTRY monitors results in the range TRL 1-9 and focuses on applied research leading to products, processes and services (TRL 5-9) that can be transferred to companies.

6.3.2 Market

TEC4INDUSTRY covers all the value chain actors and processes, and is committed to bringing unique knowledge and solutions to logistics, manufacturing industry, distribution, and retail.



6.3.3 Driving forces

The European and national strategic agendas were considered in the definition of the challenges of manufacturing, logistics and retail economic sectors.

Considering those challenges, the driving R&D lines were identified in order to accomplish them.

The focus on clients and the need to have quick response increases the value of personalising manufacturing and services offered by companies. Digital process transformation and collaboration in the value chain are main requirement for operational efficiency increase. A better knowledge of the customer by business analytics techniques will induce new business models.



The Centres R&D research lines, together with TEC4INDUSTRY driving R&D lines, respond to the challenge of creating a high impact research program towards a sustainable production paradigm, beyond productivity improvement, assuring the digital transformation of industry enterprise sector.

CLUSTERS RESEARCH LINES	R&D DRIVERS	PERSONALISATION OF MANUFACTURING	AUTOMATISE AND ROBOTISE	DIGITISE PROCESSES	COLLABORATION	BUSINESS ANALYTICS
	Sustainable production systems	●	●	●	●	
	Digital transformation of industry	●	●	●	●	
	Industrial robotics	●	●		●	
	Innovation & technology management	●	●	●	●	
	Computer vision		●	●		●
	Sensing		●			
	Big data, machine learning and data science			●	●	●
	Privacy-preserving computing			●	●	●
	Virtual environments		●	●		●

The mapping highlights the multiple cross participation of R&D research lines to TEC4INDUSTRY R&D drivers.

Personalisation of manufacturing and process digitise are addressed by the defined R&D lines, such as digital transformation and sustainable production systems, assuring agile and real-time decision-making process, while incorporating conditions and constraints generated by the use of technology and, finally, by developing models that represent reality and exploit the digital twin/shadow concept, accelerating the creation of smart decision-support systems. Research lines of Industry and Computer Science Clusters address collaboration activities, including all players in the supply chain. Business Analytics drivers are developed in the objectives of research lines, addressing Big data, machine learning, computer science and privacy-preserving computing. The challenges of automatization and robotisation are considered in research lines of industrial robotics, addressing navigation, localization and coordination of mobile robots, intelligent sensors and control of dynamic systems, Human Robot Interfacing and Augmented Reality.

6.3.4 Innovation Services

The following innovation services are provided by INESC TEC in the scope of TEC4INDUSTRY:

- **Factory Design and Operational Planning.** The work addresses simulation and optimisation of the production lines through mathematical and simulation models to design facilities and to plan and operate operations;
- **Future industrial robotics and Collaborative robotics.** 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, close collaboration with humans and continuous process learning;
- **Logistics and Retail.** Development of intra and inter-organisational logistics systems. Services to enable companies to integrate IoT components and orchestrate manufacturing modules, such as planning, scheduling. New models and algorithms for optimising the delivery of products purchased by online customers.
- **Predictive Maintenance and Consumer Forecasting.** Prediction of anomalous events and machine learning techniques to increase maintenance optimisation and consumer forecast.

6.3.5 External Competencies and Partners

The external competencies leveraged by TEC4INDUSTRY include the following:

- **Product development** - Design of mechanical, pneumatic and hydraulic systems - INEGI;
- **Material technics** - New materials integrated in solutions - INEGI and INL Laboratório Ibérico Internacional de Nanotecnologia.

6.3.6 Associated Centres

The Centres involved in TEC4INDUSTRY are the following:

- CESE – Centre for Enterprise Systems Engineering, Industry and Innovation
- CEGI – Centre for Management and Industrial Engineering, Industry and Innovation
- CRIIS – Centre for Industrial Robotics and Intelligent Systems, Industry and Innovation
- CITE – Centre for Innovation, Technology and Entrepreneurship, Industry and Innovation
- LIAAD – Laboratory of Artificial Intelligence and Decision Support, Computer Science
- HASLab – High Assurance Laboratory, Computer Science
- CSIG – Centre for Information Systems and Computer Graphics, Computer Science
- CTM – Centre for Telecommunications and Multimedia, Networked Intelligent Systems
- CAP – Centre for Applied Photonics, Networked Intelligent Systems

6.3.7 Main Achievements in 2018

6.3.7.1 Promotion and Dissemination

EMAF

Within this fair, a set of TEC4INDUSTRY initiatives were presented to national and international entities. Projects based on 360º video with dynamic annotations, advanced plant model, digital twin technique, asset management, predictive maintenance, collaborative automation and robotics were exhibited.

HANNOVER MESSE

INESC TEC was present under the BEinCPPS – Business Experiments in Cyber-Physical Production Systems of the I4MS - ICT Innovation for Manufacturing SMEs - an initiative of the European Commission. On display, there was the installation of a cyber-physical system (Internet of Things) at the Kyaia footwear company and the presentation of the iMan Norte Hub.

TECHDAYS 2018

Results of the TEC4INDUSTRY initiative were presented to national entities in this event, which was held in Aveiro.

6.3.7.2 Relevant Activities

MANU-SQUARE

This H2020 project creates a European platform-enabled responsible ecosystem, making it performing as a virtual marketplace. The project pursues a paradigm shift that disrupts the traditional static supply chain model and establishes dynamic value networks that can be arranged on-demand in order to couple the needs of buyers and the availability of sellers of manufacturing capacity.

HORSE

HORSE (Smart integrated Robotics system for SMEs controlled by IoT based on dynamic manufacturing processes) aims at promoting a step forward in the manufacturing industry, by proposing a new flexible model of a smart factory involving collaboration of humans, robots, Autonomous Guided Vehicles (AGV's) and machinery to accomplish industrial tasks in an efficient manner.

NewShoeFactory

Study and design of an organisational and operational model of a new industrial unit for the production of footwear.

TEC FEL Logística 4.0

Development of intelligent logistics systems aimed at improving the sustainability of supply chains in the circular economy. The project intends to investigate advanced and intelligent optimisation methods for flexible planning of the transport at lower costs, the models of which include uncertainty and dynamic adaptation to “just-in-time” information.

6.3.7.3 Structural Initiatives

EIT MANUFACTURING

EIT Manufacturing’s mission is to bring together important agents in the European manufacturing industry in innovation ecosystems who can add unique value to the corresponding products, processes and services. The main goal of this project is to improve the competitiveness of the European companies, by creating jobs and protecting the environment.

iMAN NORTE HUB

INESC TEC is part of the Digital Innovation Network for the industry in the north of Portugal, aiming to foster the digital transformation of manufacturing companies and to nurture their respective innovation ecosystem of the region.

FUTURE 4.0

INESC TEC headed the technical coordination of the FOOTURE 4.0, known as the Roadmap of the Footwear Sector for the Digital Economy. This is a strategic document that defines an action plan and the required conditions so the sector can benefit from the opportunities of the digital revolution.

6.4 TEC4MEDIA

Coordinator: Cristina Machado Guimarães

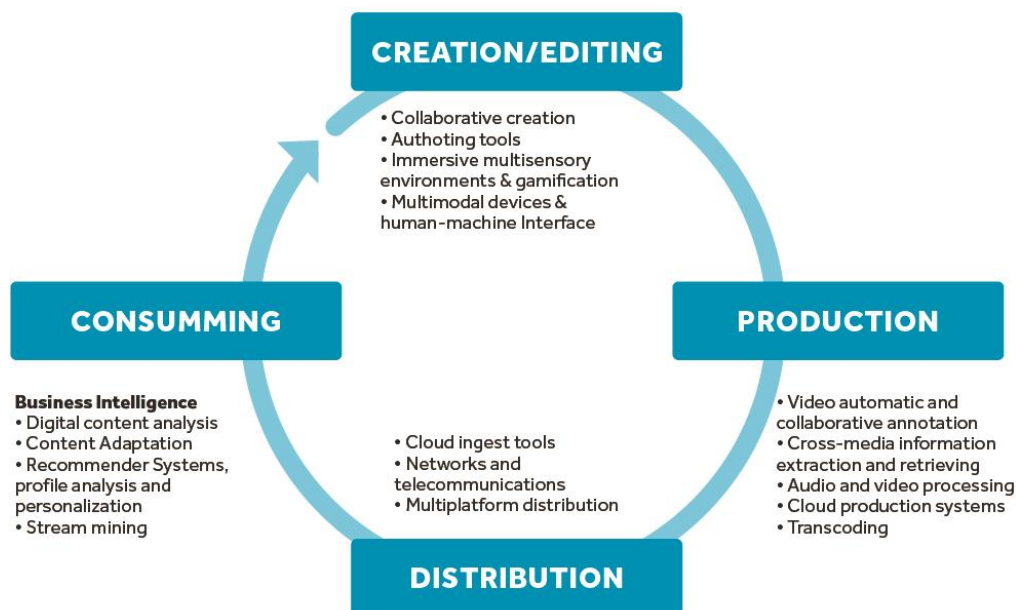
6.4.1 Mission and Positioning

The mission of TEC4MEDIA is to improve the content value chain in cultural organisations, creative industries and digital media communities with digital technologies and solutions centred in user experience.

TEC4MEDIA monitors results in the range TRL 1-9, focuses on applied research leading to products, processes and services (TRL 5-9) that can be transferred to: technological companies (multimedia, software, video games, streaming, content storage, digital marketing, digitalization); content producers (educational content producers, editors, audiovisual, film, digital arts, advertising); distributors (on-line media, traditional media, social media, broadcasters, libraries, cultural archives, entertainment, telecoms, museums and cultural organisations).

6.4.2 Market

TEC4MEDIA, covering all the value chain actors and processes, is strongly committed to bringing unique knowledge and technologies to solve challenges and provide technologies and solutions in the cultural, creative industries and digital media sectors.



6.4.3 Driving forces

The European and national strategic agendas were considered in the definition of the challenges of the new media and content sectors. Driving R&D lines were identified to accomplish them.



Mapping R&D research lines defined in the Clusters with the TEC4MEDIA vision and objectives, enables identifying several relevant topics in three main areas: (i) Networked Intelligent Systems: multimodal information processing; (ii) Computer Science: distributed computing and information security; and (iii) Industry and Innovation: business analytics and innovation and technology management.

In the Networked Intelligent Systems group, one can highlight: (i) Computer vision – image and video processing, machine learning and pattern recognition techniques for media industries; (ii) Sound and Music Computing – human computer interaction, signal processing and music analytics, content creation; (iii) Multimedia Technologies – context aware personalized multimedia management, distribution and consumption; semantic visualisation and navigation into content.

In the Computer Science group, one can highlight: (i) Big data - management, analytics and novel visualisation techniques for stationary and streamed data; mobile marketing applications; privacy preserving computation, data mining; (ii) Virtual environments - AR/VR tools for immersive virtual environments; HCI and multi-sensorial immersion.

In the Industry and Innovation group, one can highlight: (i) Sustainable operation systems – Improving business intelligence and decision support; (ii) Digital transformation - IoT-based information architectures supporting risk and asset management, collaborative networks design, multi- dimensional performance management and crowd-servicing based services; (iii) Innovation & technology management - new business concepts and models for the new media ecosystem, accelerator programs for technology exploitation. This figure presents the Centres R&D research lines' intersections with TEC4MEDIA R&D lines drivers:

CLUSTERS RESEARCH LINES	R&D DRIVERS	NEW TECHNIQUES AND TOOLS FOR STORYTELLING	IMMERSIVE ENVIRONMENTS/ EXPERIENCES CREATION	RECOMMENDER SYSTEMS AND PROFILE ANALYSIS	METADATA (CREATION AND MANAGEMENT)	CONTENT AGILE MANAGEMENT AND DISTRIBUTION	CRYPTOGRAPHY IN IOT
	Computer Vision	●	●				
	Sensing		●				●
	Autonomous Systems		●				●
	Big Data	●	●	●	●		●
	Privacy-preserving computing		●	●	●		●
	Virtual environments			●		●	
	Digital transformation		●	●		●	●
	Innovation & technology management	●	●	●	●	●	●

The mapping highlights the multiple cross participation of R&D research lines to TEC4MEDIA R&D drives.

6.4.4 Innovation Services

The following innovation services are provided by INESC TEC in the scope of TEC4MEDIA:

- Digital marketing efficacy;
- Multidimensional recommendation;
- Multimodal Content Analysis;
- Story discovery from unstructured text;
- Context aware Multimedia Services and Applications;
- Personalised Multimedia environments;
- Machine Learning for Multimedia Environments;
- Ubiquitous data stream mining.

6.4.5 External Competencies and Partners

The external competencies leveraged by TEC4MEDIA include the following:

- Facility for Large scale Adaptive Media Experimentation – FLAME;
- Endo-to-end multi-content, management, distribution and production workflow, control – MOG.

6.4.6 Associated Centres

The Centres involved in TEC4MEDIA are the following:

- CITE- Innovation, Technology and Entrepreneurship, Cluster Industry and Innovation
- CTM - Telecommunications and Multimedia, Cluster Networked Intelligent Systems
- LIAAD - Artificial Intelligence and Decision Support, Cluster Computer Science
- CSIG - Information Systems and Computer Graphics, Cluster Computer Science

6.4.7 Main Achievements in 2018

6.4.7.1 Promotion and Dissemination Activities

SYNCTALKS IN EXPOSYNK CONFERENCE

Within this international conference, several debates were held such as: Technology, Workflows and

“mindsets” of “Mobile Journalism”; monetisation of online content; data protection and press freedom; 360º audio in augmented reality, to name the most relevant activities to TEC4MEDIA.

SUNSET HACKATON ROADSHOW

INESC TEC hosted once again the SUNSET HACKATON roadshow, presenting an opportunity for the whole research community to participate in a 72-hour technological marathon in an open innovation context. The participants were presented with challenging problems proposed by the companies within the media sector.

WORKSHOP- CINEMA & AUDIOVISUAL

As a member and office of NEM Portugal, INESC TEC organised several thematic workshops, specially focusing on the workshop dedicated to the Cinema and Audiovisual subsectors. These workshops took place in an iconic room at Cinemateca. Several speakers such as David Pontes (Global Media Group); Elsa Mendes (Portuguese National Reading Plan); Susana Gato (APIT); Luís Ismael (Lightbox); Alcides Vieira (SIC) and Mário Augusto (RTP) discussed the important challenges of this sector. It was also a moment to vote for the new board of NEM Portugal.

6.4.7.2 Relevant Activities

NEW MUSEUM OF PORTO HISTORY

INESC TEC is the technological and multimedia partner in the new Museum of History of the city of Porto. A EUR 73, 590 contract will allow the development and the implementation (alongside the technology partner, GEMA Digital) of five innovative solutions in order to present several historical topics and episodes using augmented and virtual reality competences, interactive 3D content, and procedural generation.

FOTO IN MOTION

This H2020 project, which is promoted by INESC TEC's Centre for Telecommunications and Multimedia (CTM), focuses on reusing and enriching images for immersive video storytelling. The project will allow content creators to build multimedia stories in a simple way, by developing automatic tools for context identification, recognition of objects and people with visual information and creation of semantic descriptions, whether from an original photo or from visual content available online. This project includes at least three areas of application: photojournalism, fashion and festivals.

CLOUD SETUP

This project developed tools for post-production of high quality audiovisual content for the television industry that allow the automation in inserting and/or replacing content in TV programming and that can work both inside a radio broadcast station as well as in a cloud-based environment. The results of this project are extremely important for the television and audiovisual content industries as it allows a cost-effective automation of processes. It proved to facilitate and speed up the content formatting that must be displayed in multiple distribution platforms.

6.4.7.3 Structural Initiatives

PROJECT CHIC

INESC TEC is a member of the Cooperative Holistic view on Internet and Content (CHIC), a project that was approved for funding the call “Mobilizers programs”, supported by Portugal 2020 fund. With an approved budget of nearly EUR 10 million, CHIC was submitted by a consortium of 24 entities headed by MOG Technologies, S.A. The consortium incorporates different entities, ranging from SME to medium/large companies, and from institutions to the Portuguese Scientific and Technological System. The CHIC project aims to develop, test and demonstrate a wide range of new processes, products and services that have a significant impact on the audiovisual and multimedia sectors. By their nature, these projects will have a clear mobilising effect on other important sectors of the culture such as the cultural

heritage, archives, books and publications or the performing arts. This project already delivered its second technical and scientific report and started to disseminate the results.

NEM PORTUGAL

INESC TEC organised all the workshops and brokerage activities within NEM Portugal. In 2018, four events were held and two more companies joined this initiative, which is now composed of 51 entities and, counting on individual participations from relevant players of the Media and Content value chain industry.

NEM PORTUGAL also disseminates the strategic research agenda, which has recently been updated. It also promotes the cooperation among industrial players and research institutions, with CHIC project being an illustrative example.

NEM INITIATIVE

The NEM community expressed its willingness to consider the content sector as a strategic European sector to invest on, more so when there is a need for investment on infrastructures. We need to avoid having the most powerful digital infrastructure in Europe in order to transmit only the content derived from other regions of the world. The NEM community has high expectations from the next Research Framework Programme, hoping to have specific slots dedicated to the development of new technologies for future proof content.

In 2018, NEM INITIATIVE updated its vision, by working on a revised Strategic and Research agenda, disseminating position and white papers, sharing and promoting our actions during our General Assemblies and the NEM summit. Teresa Andrade was INESC TEC's contact person in this summit.

6.5 TEC4AGRO-FOOD

Coordinator: André Sá

6.5.1 Mission and Positioning

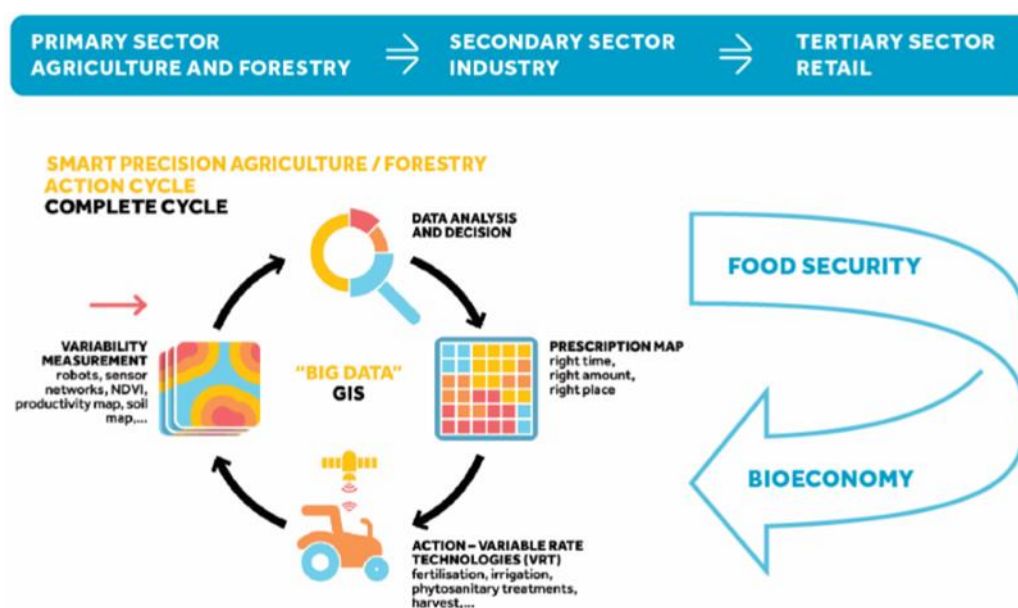
TEC4AGRO-FOOD is the INESC TEC innovation area to induce a market pull drive into RTD and generate a convergence of knowledge and competencies into producing solutions for Agro-Food and Forestry. TEC4AGRO-FOOD has competencies in the main technologies involved in the digital (r)evolution of Agro-Food and Forestry, i.e. IoT, Artificial Intelligence, Robotics and Big Data.

TEC4AGRO-FOOD follows-up results in the range TRL 1-7 and focuses on applied research leading to products and services (TRL 5-7).

The Mission of TEC4AGRO-FOOD is co-shaping the digital (r)evolution in Agro-Food and Forestry to tackle the productivity and sustainability societal challenges towards an effective bioeconomy.

6.5.2 Market

TEC4AGRO-FOOD may and will act in all phases of the Smart Precision Agriculture/Forestry cycle, from Variability Measurement to Action with VRT, encompassing Data Analysis and Decision and Prescription, as well as in what concerns Food Security and Bioeconomy.



6.5.3 Driving forces

TEC4AGRO-FOOD may and will act in all phases of the Smart Precision Agriculture/Forestry cycle, from Variability Measurement to Action with VRT, encompassing Data Analysis and Decision and Prescription, as well as in what concerns Food Security and Bioeconomy.

Considering those challenges R&D lines' drivers were identified.



Analysing the Clusters Research Lines and mapping it with TEC4AGRO-FOOD R&D Drivers, one can verify that they respond to the challenge of creating a high impact research program towards a Smart Precision Agriculture/Forestry, assuring the digital (r)evolution of Agro-Food and Forestry.

	R&D DRIVERS	INTERNET OF THINGS (IOT)	ARTIFICIAL INTELLIGENCE	ROBOTICS AND AUTOMATION	BIG DATA
CLUSTERS RESEARCH LINES	Sensing	●	●	●	●
	Big data	●	●		●
	Digital Transformation of Industry	●	●		●
	Industrial robotics	●	●	●	

The mapping shows the multiple cross participation of Clusters Research Lines regarding TEC4AGRO-FOOD R&D Drivers.

6.5.4 Innovation Services

INESC TEC in the scope of TEC4AGRO-FOOD provides the following innovation services:

- **Research and Technological Development in Smart Precision Agriculture/Forestry.** This service comprises all phases of the Smart (IoT, Artificial Intelligence, Robotics and Big Data) Precision (“right time, right amount, right place”) Agriculture/Forestry cycle: Variability Measurement, Data Analysis and Decision, Prescription Map and Action with Variable Rate Technologies (VRT);
- **Research and Technological Development in Food Security.** This service deals with Food Security issues along the agriculture and forestry supply chains;
- **Research and Technological Development in Bioeconomy.** This service deals with Bioeconomy issues along the agriculture and forestry supply chains.

6.5.5 External Competencies and Partners

The external competencies leveraged by TEC4AGRO-FOOD include the following:

- **Research in Agriculture and Forestry:**
 - Precision (“right time, right amount, right place”) Agriculture/Forestry;
 - INIAV - National Institute for Agrarian and Veterinarian Research;
 - CITAB - Centre for the Research and Technology of Agro-Environmental and Biological Sciences.
- **Trailers and Machinery for Agriculture Manufacturer:**
 - Trailers and Machinery for Smart (IoT, Artificial Intelligence, Robotics and Big Data) Precision (“right time, right amount, right place”) Agriculture/Forestry manufacturer;
 - HERCULANO.

6.5.6 Associated Centres

Although most of the activity related with TEC4AGRO-FOOD is pursued by the R&D Centres belonging to the Cluster Industry and Innovation, there are others R&D Centres that have a relevant participation in projects related to the digital (r)evolution of Agro-Food and Forestry.

The Centres involved in TEC4AGRO-FOOD are the following:

- CPES - Power and Energy Systems, Cluster Power and Energy
- CAP - Applied Photonics, Cluster Networked Intelligent Systems
- CTM - Telecommunications and Multimedia, Cluster Networked Intelligent Systems
- CESE - Enterprise Systems Engineering, Cluster Industry and Innovation
- CEGI - Industrial Engineering and Management, Cluster Industry and Innovation
- CRIIS - Robotics in Industry and Intelligent Systems, Cluster Industry and Innovation
- CITE - Innovation, Technology and Entrepreneurship, Cluster Industry and Innovation
- LIAAD - Artificial Intelligence and Decision Support, Cluster Computer Science
- CSIG - Information Systems and Computer Graphics, Cluster Computer Science
- HASLab - High Assurance Software, Cluster Computer Science
- C-BER - Biomedical Engineering Research, Cluster Networked Intelligent Systems

6.5.7 Main Achievements in 2018

6.5.7.1 Promotion and Dissemination

FIMA

Participation in one of the most important European fairs of agriculture machinery, FIMA - International Fair of Agricultural Machinery, in Zaragoza, Spain, with exhibition of the tanker developed in collaboration with HERCULANO (*"Made by HERCULANO, powered by INESC TEC"*).

AGROIN

Participation in one of the most relevant Portuguese agriculture and forestry events, AgroIN, organised by the magazine Vida Rural, with Filipe Santos (CRIIS) as a key note speaker with the presentation "How to use technology to foster sustainable agriculture?".

AGROGLOBAL

Participation in the most important Portuguese professional agriculture and forestry fair, Agroglobal, with an exhibition at the Technology Pavilion, presentations at the Tech Stage and the demonstration of the tanker developed in collaboration with HERCULANO (*"Made by HERCULANO, powered by INESC TEC"*). A collaboration protocol was signed with HERCULANO, in the presence of the Portuguese Minister of Agriculture, Forestry and Rural Development.

AGRO INOVAÇÃO

Participation in one of the most relevant Portuguese agriculture and forestry events, Agro Inovação - National Summit of Innovation in Agriculture, Forestry and Rural Development, organised by the Portuguese Ministry of Agriculture, Forestry and Rural Development, with CoLABs ForestWISE and Vines&Wines, among others.

Forestry 4.0 UNAC Seminar

Participation in the seminar "Forestry 4.0 - Digitalisation in value and competitive advantages creation for the forestry management and production", organised by UNAC - Mediterranean Forest Union, with Alexandra Marques (CESE) as a key note speaker with the presentation "Digitalisation in the Forestry Value Chain: Facts and Trends".

Forestry Inventory SPCFlorestais Seminar

Participation in the seminar "Occupation and Land Usage and Forestry Inventory: Decision Support Tools", organised by the Portuguese Society of Forest Science (SPCFlorestais), with Alexandra Marques (CESE) as a key note speaker with the presentation "Decision Support Tools".

6.5.7.2 Relevant Activities

SMARTFARMING

End of project SmartFarming - Advanced tool for precision agriculture operationalisation, a PT2020 Co-promotion Project, with ProdFarmer, INIAV, Esporão and Herdade Maria da Guarda. The systems prototypes of the technologies developed by INESC TEC were successfully demonstrated in operational environment.

AGROBOFOOD

Submitted application for agROBOfood: Business-Oriented Support to the European Robotics and Agri-food Sector, towards a network of Digital Innovation Hubs in Robotics, a strategic H2020 European project regarding Digital Innovation Hubs for the agri-food sector, coordinated by the Wageningen University & Research. The project was approved in January 2019.

DEMETER

Submitted application for DEMETER - Building an Interoperable, Data-Driven, Innovative and Sustainable European Agri-Food Sector, a strategic H2020 European project regarding digital integration platforms for the agri-food sector, coordinated by the Wageningen University & Research. The project was approved in March 2019.

SMART FERTILIZERS

Approval (with a distinctive evaluation) and kick-off of the project SMART FERTILIZERS - Tankers for Precision Fertilising in an agriculture 4.0 context, a direct contract with HERCULANO (under a PT2020 Individual R&D Project).

CERVIM

Acceptance to join the Network between the Centres and Institutes of Research of CERVIM - Centre for Research, Environmental Sustainability and Advancement of Mountain Viticulture.

6.5.7.3 Structural Initiatives

COLLABORATION PROTOCOL WITH HERCULANO

Signing of a collaboration protocol with HERCULANO at Agroglobal, in the presence of the Portuguese Minister of Agriculture, Forestry and Rural Development, for joint research and innovation activities in Smart Precision Agriculture and Forestry.

COLAB VINES&WINES

Signing of the protocol for the creation of the CoLAB Vines&Wines - Portuguese vines and wines, competitiveness and sustainability and membership of ADVID.

COLAB FORESTWISE

Legal constitution of the CoLAB ForestWISE - Collaborative Laboratory for Integrated Forest & Fire Wise Management, with INESC TEC being the promoter of the initiative.

6.6 TEC4ENERGY

Coordinator: João Peças Lopes

6.6.1 Mission and Positioning

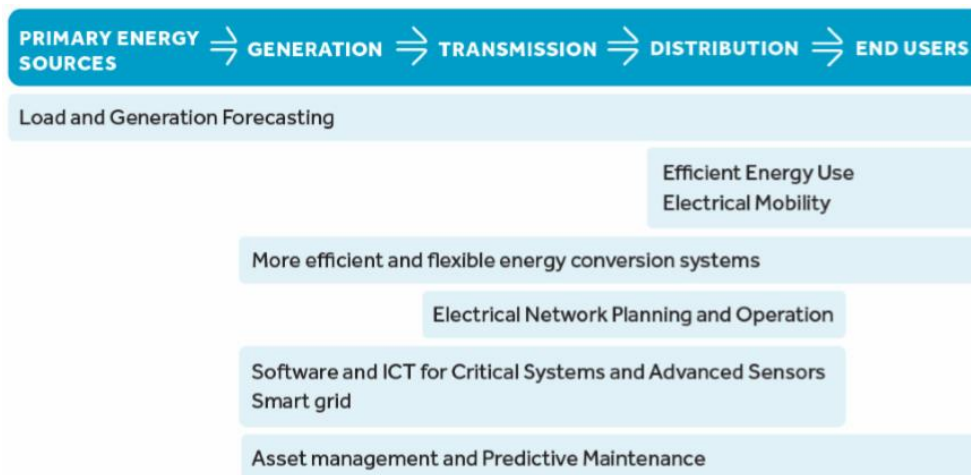
TEC4Energy is the leading innovation initiative that responds to the societal challenge “Secure, clean and efficient energy”, addressing the major challenges of the sector, namely the ongoing digitalization and the large-scale integration of renewable based generation, proposing a multidisciplinary scientific based approach to overcome the limitations that the different stakeholders find in the existing market solutions.

The INESC TEC competence in IoT, artificial intelligence, power systems, robotics, sensors, communications and big data will leverage a multidisciplinary capacity to generate innovative advancements. The focus will be on the implementation of optimised, intelligent and sustainable solutions, in software and hardware, for all agents (utilities, industry, transportation, retail) that operate in a broadly defined energy-concerned social structure, including water or waste management when intimate connection with energy, keeping in mind climate change and global warming challenges.

INESC TEC is a creator of research and technology transfer targeting this sector, allowing companies to be internationally competitive with innovative products.

6.6.2 Market

The TEC4ENERGY benefits from a strong recognised INESC TEC expertise in Power Systems, with more than 20 years transferring research results to manufacturers, software vendors, electric utilities and large energy users in Portugal, Europe and Brazil. This adds credibility to a broader effort, extended also to the fossil fuel sector, and encompassing from industry to transportation, buildings and energy efficiency.



6.6.3 Driving forces

The main drivers for the TEC4ENERGY initiative are the Societal Challenges and Innovation Strategies for Smart Specialisation defined by EU policies: the energy sector will be heavily digitalized, under user centric and market based approach, requiring the conceptualisation and development of disruptive solutions. At the same time, we are aiming at a very large decarbonization of the society and economy.



Considering the above challenges, the driving R&D lines in order to accomplish this are presented in the next figure.

CLUSTERS RESEARCH LINES	R&D DRIVERS			
	PREDICTIVE MANAGEMENT	DATA-DRIVEN MANAGEMENT	EFFICIENT ENERGY CONVERSION SYSTEMS	NEW BUSINESS AND MARKET ARCHITECTURES
Energy Conversion			●	
Network Planning and Operation	●	●		●
Energy end users			●	●
Sensing	●	●	●	●
Autonomous systems	●	●		●
Big data	●	●		●
Privacy-preserving computing		●		●
Digital transformation of industry	●	●		●

This mapping describes the multiple cross participation of R&D research lines to TEC4ENERGY R&D drivers.

6.6.4 Innovation Services

- **DMS/EMS and network automation:** specification, development and integration of advanced computational tools for network management systems for all voltage levels (transmission, distribution and island systems) and of new solutions for network automation, protection and control of distribution networks
- **System planning and reliability:** tools and models within this area aim at supporting not only the operational planning but also the expansion of power systems. Naturally, this activity appeals to advanced optimization techniques and new stochastic models for the representation of the overall system behaviour
- **RES & DER integration:** 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) and development of grid code requirements to allow the power system to cope with large scale integration of RES. These activities are supported by the laboratorial infrastructure of CPES (SGEVL)
- **Asset Management and predictive maintenance:** implementation of a risk-based maintenance strategy software for the distribution grids by analysing failure modes, consequences and decision maker's risk attitudes; estimation of power transformers condition and remaining useful life (RUL) by combining expert knowledge, engineering models and data analytics; fibre optic sensors to measure vibration and magnetic field for HV lines, and corrosion monitoring in off shore wind parks; drone with rotary wings o monitor electrical assets, such as, medium and high voltage support, substations and wind parks. This latter solution is innovative because it

operates autonomously, making it possible to reduce risks and to optimise the inspection process that leads afterwards to definition of maintenance (and even repair) actions

6.6.5 External Competencies and Partners

The external competencies leveraged by TEC4ENERGY include the following:

- **Renewable Energy Sources:** feasibility studies on wind and solar photovoltaic potential for producing electricity - INEGI
- **Power converter models:** development of transient stability models in PSS/E, provide plant controller modelling, with varied set of functionalities, enabling the performance of grid integration studies of plants with of advanced control for system support- IIT Comillas
- **Power electronics:** Innovative EV Battery Charging Systems for Smart Homes and Smart Grids, Active Power Filters and Power Quality Analysis – GEPE/Uminho
- **Electrochemical devices:** redox flow batteries integration in electrical grids, providing grid support functionalities to building advanced energy management systems – LEPABE/FEUP

6.6.6 Associated Centres

The Centres involved with the TEC4ENERGY initiative are the following:

- CPES - Power and Energy Systems
- CAP - Applied Photonics
- CTM - Telecommunications and Multimedia
- CRAS - Robotics and Autonomous Systems
- CEGI - Management and Industrial Engineering
- LIAAD - Artificial Intelligence and Decision Support
- HASLab - High Assurance Software
- CESE - Enterprise Systems Engineering

6.6.7 Main Achievements in 2018

6.6.7.1 Promotion and Dissemination

Vienna – European Utility Week 2018

INESC TEC participated in the EUW 2018 in Vienna, presenting the most advanced outcomes of INESC TEC in the energy field. The EUW platform is the best forum to meet top-level European energy professionals and to negotiate with them, to create new relationships and to promote new projects

World Energy Day in São Miguel – Azores

INESC TEC participated in the World Energy Day in São Miguel, by participating in several round tables focused on Smart Grids, efficient use of electric energy at consumer level and electric mobility

Grande Conferência Água & Energia

INESC TEC participated in the “Grande Conferência Água & Energia 2018”, where the water-energy nexus was discussed, namely the technologies that can support efficiency in both sectors, the benefits of having an integrated management and the future challenges for both sectors

Conference of the Portuguese association for the PV sector (APESF)

INESC TEC presented the relevant technological trends to exploit solar PV energy, at the household level, via the Home Energy Management Systems (HEMs), which would maximise the usage of electricity when solar PV generation is available

“A Economia Portuguesa e a Indústria 4.0. O Caminho de uma Nova Industrialização”

INESC TEC participated in a panel discussion entitled “Discussion of the challenges for increasing the energy efficiency of industrial processes in a context of industry 4.0 and internet of things”. The business

opportunities and models emerging from local renewable energy generation and flexibility markets (at the wholesale market level) were also discussed

6.6.7.2 Relevant Activities

“Porto de Pesca Sustentável”

The consulting activities to be developed by INESC TEC aim at defining the transformation process of the fishing ports to become sustainable in terms of the environmental and social perspectives. The integrated intervention includes water consumption, waste produced/collected, electrical energy consumption/production (involving local power generation facilities and an increase in the use of energy efficiency) as well as the communities and the stakeholders of the port.

Integrid

This EU funded project, led by INESC TEC, aims at bridging the gap between citizens and the providers of technologies and solutions such as utilities, households, manufacturers and all the other agents who provide energy services, thus expanding from the distribution and access services of the Distribution System Operators (DSOs) to active market facilitation and system optimisation services while ensuring sustainability, security and quality of delivery. In this project, the integration between electric vehicles (EVs), Home Energy Management and distributed resources went one step further. Prototypes for energy storage, Home Energy Management Systems (HEMS) and EV chargers were developed.

CORAL

INESC TEC, in partnership with CIIMAR, successfully completed the results of this project and publicly presented them.

The project developed technology-driven solutions to tackle deep sea resource exploitation under a sustainable environmental framework. A special platform was developed in order to harvest renewable energy sources and to store the electrical energy to feed autonomous submarine robots.

6.6.7.3 Structural Activities

Laboratory of Smart Grids and Electric Vehicles (SGEV)

INESC TEC pursued its ambition to set up an infrastructure dedicated to support research, to develop and to test smart grid architectures and solutions (software and hardware) in order to further foster the smart grids concepts. This laboratory is part of the National Roadmap of Research Infrastructures.

Contract-Programme with EDP

The long-term Contract-Programme with EDP, which was launched in 2014, was continued, allowing to start several new projects involving the different INESC TEC's Centres. In the last five years, about a million Euros from projects have been contacted to INESC TEC.

Long-Term Partnership with EFACEC

The long-term partnership with EFACEC, which started in 1996 and aimed at developing a Distribution Management System (DMS), was celebrated in 2018. A new collaboration protocol was also signed to strengthen the collaboration for the future.

6.7 TEC4HEALTH

Coordinator: Cristina Machado Guimarães

6.7.1 Mission and Positioning

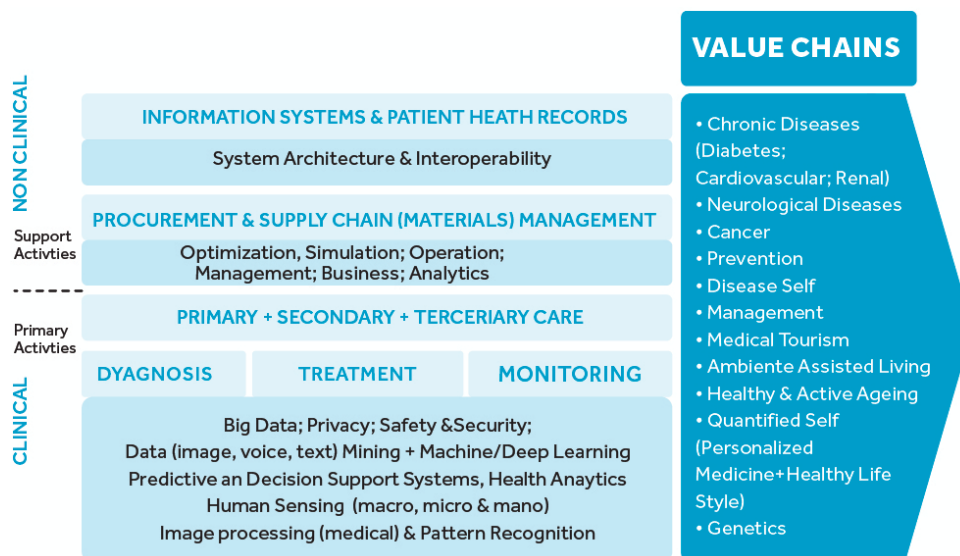
The Mission of TEC4HEALTH is to induce a market pull human centered systems engineering R&D targeting healthcare and personal wellbeing challenges towards personalized medicine, healthier life style and better health systems management.

TEC4HEALTH is the INESC TEC initiative to induce a market pull drive into R&D and generate a convergence of knowledge and competences into producing solutions for the Health Economy.

INESC TEC is already a high producer of research targeting the Health Sector. TEC4HEALTH monitors results in the range TRL 1-9 and focuses on applied research leading to products, processes and services (TRL 5-9) that can be transferred in 3 broad areas of application: healthcare providers (primary, secondary and long-term care); patient monitoring (medical devices, e-health, m-health); pharmaceutical industry.

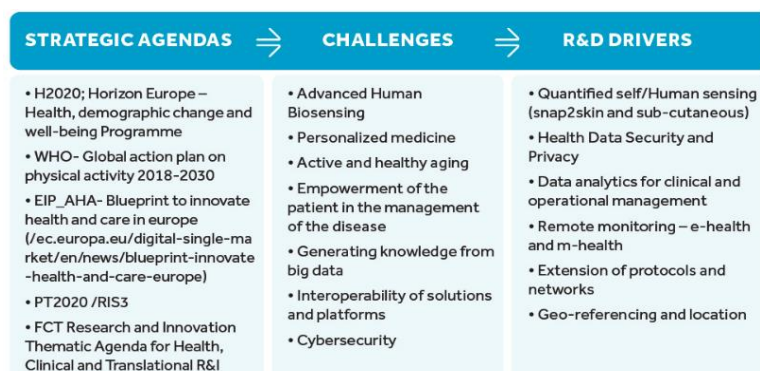
6.7.2 Market

TEC4HEALTH, covering all the value chain actors and processes, is strongly committed to bringing unique knowledge and technologies to solve challenges in: disorders, personalized medicine, healthy life style and health systems management.



6.7.3 Driving forces

The European and national strategic agendas were considered to define challenges and driving R&D lines to accomplish them.



Analysing the Centres R&D research lines and mapping with TEC4HEALTH driving R&D lines topics are grouped in 3 main areas:

(i) Networked Intelligent Systems, gathering and process information from extreme environments. Computer vision: prediction, detection and diagnosis of the lung and breast cancer by using holistic data and epidemiological information, combining computer vision and artificial intelligence. Adopting multimodality big data approaches based on images and biological data, to understand relationships between multi-sensing settings; Sensing: new micro and nano sensors (e.g. miniaturized photonic sensors in fibre and planar platforms) and sensor integration in autonomous systems aligned with quantified self-challenges and hazardous environment monitoring.

(ii) Computer Science, with software engineering, distributed computing, machine learning and information security. Big data: management, analytics and novel visualization techniques for stationary and streamed big health data; Privacy preserving computation: Privacy expertise when addressing the unprecedented volumes of information, and sets of pervasive smart devices; (ii) Virtual environments: methods and tools streamlining the use of intelligent immersive virtual environments, used in serious games for training and simulation. Lab resources (MASSIVE) enable advanced and inclusive HCI with multi-sensorial immersion in augmented and virtual reality.

(iii) Industry and Innovation. Sustainable operation systems: improving business intelligence and lead to a framework to visualise, virtualise, construct, control, maintain and optimise resources in healthcare setting; Digital transformation of healthcare services: development of novel vertical IoT-based information architectures, collaborative networks design, multidimensional performance management and crowd-servicing based services; Innovation & technology management: focus on the conditions and enablers for the adoption of new business concepts and models for silver economy, healthy environments and launch accelerator programs for technologies exploitation.

CLUSTERS RESEARCH LINES	R&D DRIVERS	QUANTIFIED SELF/HUMAN SENSING (ON AND SUB-CUTANEOUS)	HEALTH DATA SECURITY AND PRIVACY	DATA ANALYTICS FOR CLINICAL AND OPERATIONAL MANAGEMENT	REMOTE MONITORING – E-HEALTH AND M-HEALTH	EXTENSION OF PROTOCOLS AND NETWORKS	GEO-REFERENCING AND LOCATION	
		Computer Vision	●			●		
		Sensing	●	●		●	●	●
		Autonomous Systems			●	●		●
		Big Data	●	●	●	●	●	
		Privacy-preserving computing	●	●	●	●		●
		Virtual environments		●		●		●
		Sustainable operation systems		●	●		●	
		Digital transformation		●	●	●	●	●
		Innovation & technology management	●	●	●	●	●	●

The mapping of the figure evidences the multiple cross participation of R&D research lines to TEC4HEALTH R&D drives

6.7.4 Innovation Services

The following innovation services are provided by INESC TEC in the scope of TEC4HEALTH:

- New micro and nano-sensing approaches (based on Nobel-Award Optical Tweezers)
- New chip designs for biodata distributed edge computing architectures
- Advanced methodologies for computer-aided detection and diagnosis

- Multimodal integration of patient data
- Novel approaches for medical information communication and patient empowerment in the decision making process.

6.7.5 External Competencies and Partners

The external competencies leveraged by TEC4HEALTH include the following:

- **Translational research, technology transfer in biomedical engineering. biomaterials, tissue regeneration, nanomedicine, geoepidemiology, câncer and genomics – I3S**
- **AAL living Lab – Fraunhofer Aicos**

6.7.6 Associated Centres

The Centres involved in TEC4HEALTH are the following:

- CAP - Applied Photonics, Cluster Networked Intelligent Systems
- CITE - Innovation, Technology and Entrepreneurship, Cluster Industry and Innovation
- CTM - Telecommunications and Multimedia, Cluster Networked Intelligent Systems
- C-BER - Biomedical Engineering Research, Cluster Networked Intelligent Systems
- CEGI - Management and Industrial Engineering, Cluster Industry and Innovation
- LIAAD - Artificial Intelligence and Decision Support, Cluster Computer Science
- CSIG - Information Systems and Computer Graphics, Cluster Computer Science
- CRACS - Research in Advanced Computing Systems, Cluster Computer Science
- CRIIS - Industrial Robotics and Intelligent Systems, Cluster Industry and Innovation
- HASLab - High Assurance Software, Cluster Computer Science

6.7.7 Main Achievements in 2018

6.7.7.1 Promotion and Dissemination

E-HEALTH SUMMIT

Within this fair, and with an exposition and a conference promoted by the Shared Services Ministry of Health (SPMS), INESC TEC's participation was made through the robotic demonstration in Trivalor's stand, a partner of the institution in the project IGOR.

This event was also an opportunity for B2B meetings and presentations of the competences of the TEC4HEALTH team.

PRAÇA DA SAÚDE

In this showcase, three project demonstrations (WeSENSS, ISEABlind and Passus) of the TEC4HEALTH initiative were presented to national and international entities, namely to EIT-Health.

INNOVATION AFTER HOURS

The institutional participation in the first event of the José de Mello Saúde company, which dedicates itself to innovation, allowed to show three project demonstrations, giving visibility to some members of the TEC4HEALTH team and their skills in the analysis of health data, optimisation and simulation, IoT, inclusive digital interfaces and computer vision.

6.7.7.2 Relevant Activities

NIE PROJECT - NATURAL INTERFACES FOR THE ELDERLY

The prototype of a robotic system that helps the elderly to take medicines was one of the results of the collaboration between INESC TEC's Centre for Information Systems and Computer Graphics (CSIG) and

the Superior School of Health of the University of Trás-os-Montes and Alto Douro (UTAD). The developed laboratory prototype was based on the educational robot NAO, which has a set of motors that control the articulations, and cameras to assess the surrounding environment, as well as the ability to listen and to understand the human speech while also being able to communicate in several languages.

HOVIONE CAPITAL Prize

The project NeuroQ from INESC TEC was the winner of the i3S Hovione Capital Health Innovation Prize award, a joint initiative of i3S and Hovione Capital, which aims at distinguishing innovative ideas in the healthcare area. NeuroQ is a wearable device for wrist rigidity evaluation for supporting surgical procedures.

The project also won an Aescuvest award, totalling EUR 52,500. This award is an example of the recognised forefront in the wearable expertise of the TEC4Health team.

iCARE4DEPRESSION

This project combines face-to-face psychotherapy with digital mobile and internet solutions in order to support the treatment of depression. It also consists in the combination of psychotherapy sessions with mobile applications and web platforms in order to enhance the effects of the treatment and to reduce the costs associated to it. A pilot study is being conducted to test the available digital tools and to improve the assessment and intervention process with them. The goal is to enhance the access to the treatment for depression, to reduce the costs and to increase the clinical effectiveness. This project is enfolded in a set of research projects known as Moodbuster, one of the five projects nominated for the European Health Awards of 2018.

6.7.7.3 Structural Initiatives

EIP ON AHA CONFERENCE

INESC TEC, as a member of the Consortium of Porto4Ageing, a reference website in the European Innovation Partnership (EIP) on Active and Healthy Ageing (AHA), assumed two commitments at the EIP on AHA Conference in two specific action groups: action group C2 - Personal User Experience (PUX) - producing a document with guidelines for manufacturers and developers of Active and Healthy Ageing solutions aiming for a Personal User Experience; and an action group D4 – the age friendly environments.

PORTUGUESE NETWORK HEALTHY, INTELLIGENT AND FRIENDLY ENVIRONMENTS

INESC TEC integrates this network that gathers a wide group of Portuguese organisations committed to promote an united schedule for the implementation of inclusive atmospheres for all ages, prevalent in the Health, Social Support, TICE and Infrastructures areas. It focuses on the quadruple helix participation and actively promotes the cooperation between research/academia, public authorities, companies and civil society/citizens, with the aim of finding common solutions to the national challenges in this area.

SHAFE – THEMATIC NETWORK ON SMART HEALTHY AGE-FRIENDLY ENVIRONMENTS

Following the Blueprint on Digital Transformation of Health and Care, INESC TEC, as a member of this network, supported a joint declaration in 2018. It summed up a common position on smart, healthy and age-friendly environments (AFE), with priorities for the formulation of policies and recommendations for 2020. The priorities are focused on providing a forum for the exchange of political priorities and technical knowledge in AFE and eHealth / mHealth; informing the Commission and the Member States about the available knowledge in the community concerning the needs, solutions and good practices of the partners; taking the best local practices that are already implemented so that they can be doubled while collecting the lessons learned for the drawing of new policies; promoting common beginnings as interventions centred in the person, protection of personal data, standardisation, and interoperability.

7 RESEARCH INFRASTRUCTURES

7.1 Smart Grids and Electric Vehicles Laboratory (SGEVL)

7.1.1 Mission and Positioning

The Smart Grid and Electric Vehicle Laboratory (SGEVL) constitutes a physical space integrating systems and equipment designed to support the development and testing of solutions and pre-industrial prototypes, promoting active and intelligent management of electric grids in scenarios with a progressive integration of microgeneration together with other distributed energy resources including and Electric Vehicles (EV). Proof-of-concept and experimental validation, which includes pre-prototyping processes for physical devices and/or software and equipment modules, are performed to support functional/technical specification of solutions for microgeneration, active demand response solutions and EV integration in distribution grids. It allows individual and in integrated test of control concepts, communication solutions in normal and emergency modes of operation.

This RI has a unique integrated capacity to simulate, prototype and test the electrical system of the future, providing support and services to the scientific and industrial ecosystem, generating revenue through those direct services or indirectly by supporting R&D funded initiatives.

The main benefit of this RI, in comparison with other infrastructures with commercial purposes, is the fact of being neutral in terms of commercial interest, which is also an opportunity. Other main advantage of SGEVL is the staff, which has a professional behavior as it can be expected from certification laboratories, but at the same time is very active in research activities which brings an updated and scientific approach to these works. This can be particularly interesting to companies needing a support in the initial stage of development and not only for advanced prototypes that require testing for pre-certification. It can be also useful to offload some development and research which is not possible to perform in house due to time and human resource limitations.

The laboratory facility has a significant flexibility that are easily configured to a specific project, to provide quick and reliable results. Most of the test laboratories have a very rigid infrastructure which requires for the equipment under test to be adapted to the laboratory, which we believe is a major weakness. Finally, and of great relevance, we can give a detailed analysis and feedback reporting, considering not also the results of the tests, but going deep into the technological solution.

7.1.2 Management Structure and Team

The SGEVL is intended to support research and validation activities for the scientific community and companies that develop products in the energy sector, supporting top-level research and innovation in their respective fields.

Having in mind the range of activities in the referred domains, the infrastructure intends to provide professional support to the research activities, taking also advantage of INESC TEC expertise in these domains. But more than that, these developments are usually supported and supervised by academic staff, namely Professors, which are not fully dedicated to these activities. In SGEVL a new researcher is quickly integrated in an active R&D environment where they can work side-by-side with senior researchers with solid experience on the same topics, which has proven to motivate the new researchers and accelerates the development considerably. This acceleration allows then to go deeper in the topics within the same time frame.

The RI has a professional management team (since November 2018, is an area of CPES and coordinated by Luis Miguel Miranda.), with competences in innovation and research funding management, that guarantees the implementation of an action plan and the accomplishment of the specific aims defined, with an efficient and transparent internal management of resources. This managements structure is also responsible for the implementation of specific procedures to grant access by national and international researchers that are external to the infrastructure.

7.2 TEChnologies for the Sea (TEC4SEA)

7.2.1 Mission and Positioning

The TEChnologies for the Sea (TEC4SEA – www.tec4sea.com) infrastructure, currently under implementation, aims to be a unique and pioneer platform in Europe to support research, development, and test of marine robotics, telecommunications, and sensing technologies for monitoring and operating in the ocean environment.

Its characteristics, geographic location allowing fast access to deep sea, and support of multidisciplinary research, enable full validation and evaluation of technological solutions designed for the ocean environment, allowing researchers to evolve from simulation/lab experiment to field trial. This research infrastructure brings together a set of laboratories, testbeds, equipments, and support facilities for experiments in controlled and real environments, including:

- Laboratories of (a) robotics with test tanks, (b) optical/radio communications with access to an anechoic camera, (c) acoustic submarine signal processing and instrumentation development for submarine exploration, and (d) optical and image sensors, with access to infrastructure for fabrication of fiber optic based devices, microfabrication (clean room), and optoelectronics instrumentation;
- Maritime wireless networks testbed with fixed stations and sea nodes deployed in fishing ships;
- Support facilities at Leixões sea port;
- Robotic platforms capable of supporting different payloads, including buoys and aerial, surface, and underwater vehicles.

The scientific objectives of the TEC4SEA are:

- To become a reference on experimentally-driven, multidisciplinary research on technology for the ocean;
- To support research, development, and testing of new technologies;
- To support the specification and testing of draft standard technologies for the ocean environment;
- To support research in other scientific areas;
- To integrate with international infrastructures;
- To support technical training of human resources as well as advanced education programmes.

TEC4SEA has poles in Porto and Faro, two major coastal cities of Portugal. Additionally, a maritime wireless network composed by two land station and eight sea nodes located offshore the Porto metropolitan area are also available. The TEC4SEA geographic location (North Atlantic Ocean) enables fast deployments in deep sea.

This RI shall provide support and services to the scientific and industrial ecosystems, generating revenue through contracted services or indirectly by supporting R&D funded initiatives.

7.2.2 Management Structure and Team

The TEC4SEA is currently under implementation. This implementation phase is coordinated by Paulo Mónica as Principal Investigator. The implementation management team also includes Agostinho Oliveira, Aníbal Matos, António Silva, Eduardo Silva, Manuel Ricardo, Maria Barbosa, Marta Barbas, Pedro Jorge, Diana Viegas, and Sérgio Jesus.

7.3 European Multidisciplinary Seafloor Observatory – Portugal (EMSO-PT)

7.3.1 Mission and Positioning

EMSO-PT is a research infrastructure lead by IPMA (Instituto Português do Mar e da Atmosfera) and involving 15 other research institutions working on ocean science or technology, including INESC TEC.

The ultimate goal of EMSO-PT is to organise the Portuguese contribution to the EMSO-ERIC network, a large-scale European Research Infrastructure, networking fixed point, deep sea multidisciplinary observatories, with the scientific objective of real-time, long-term monitoring of environmental processes related to the interaction between the geosphere, biosphere, and hydrosphere. It is a geographically distributed infrastructure at key sites in European waters, spanning the Arctic, the Atlantic, and the Mediterranean, up to the Black Sea. It will be in place by the end of the decade.

EMSO identifies eight main scientific questions where advances are foreseen: 1) Dynamics of tectonic plates and magmatic systems; 2) Climate and greenhouse gas cycling; 3) Ocean productivity and ocean dynamics; 4) Marine mammal and fish stocks; 5) Non-renewable marine resources; 6) Episodes, events and catastrophes; 7) Origins and limits of life; 8) marine ecosystems dynamics. All these topics are dependent on long-term, continuous observations, able to capture significant episodes as they occur.

So far, the Portuguese participation in EMSO has been focused on the Azores and Cadiz nodes, in cooperation with France (Azores) and Italy (Cadiz) using two of the few available technological solutions for long term seafloor monitoring (ASSEM and GEOSTAR). Within the scope of EMSO-PT two sites will be considered close to the mainland: a deep water one, located in the Gulf of Cadiz, and another shallow water, located off North Portugal. The later one will also be a test bench for emerging monitoring strategies.

EMSO-PT observatories will merge “off-the-shelf” technology, which will ensure that they will meet the international standards, with novel approaches (based on networked, autonomous observation platforms) that will contribute to more sustainable monitoring operations and will create the basis for the development of new marine products and services, creating value and qualified jobs.

INESC TEC involvement in EMSO-PT addresses the establishment of long-term non-fixed observatories. Such work is organised along two complementary lines: relocatable nodes and long-endurance mobile platforms. In the first case, INESC TEC is building an EGIM (EMSO Generic Instrument Module) for integration and use in a Turtle relocatable node. In the second one, INESC TEC is implementing a network of underwater gliders for collection of oceanographic data.

While the goal of the EMSO-PT infrastructure is the implementation of a network of ocean observatories for data gathering, the underlying activities are aligned with CRAS research line associated with long term deployments.

7.3.2 INESC TEC Research Team

INESC TEC core research team associated with this infrastructure includes Eduardo Silva, Aníbal Matos, Hugo Ferreira and Nuno Abreu.

8 SPECIAL PROJECTS

8.1 UT Austin

Coordinators: José Manuel Mendonça and Rui Oliveira

The UT Austin Portugal Program is a partnership program in Science and Technology between the Portuguese Foundation for Science and Technology and the University of Texas at Austin, supported by the Ministry of Science, Technology, and Higher Education in close collaboration with the Council of Rectors of the Portuguese Universities.

Launched in 2007, the partnership was renewed in 2018, towards a new decade until 2030. The UT Austin Portugal Program addresses a number of knowledge areas where scientists and companies in Portugal will engage with the University and other institutions in Texas in multidisciplinary research and technology transfer and commercialization. The vision is to develop knowledge-based society, and foster science and innovation-based companies to help Portugal face the challenges of the future.

The Program focuses on enabling technologies: **nanotechnologies**, which bring a revolution to products and systems through novel advanced materials, and **advanced computing** technologies and services which, together with simulation of complex physical and chemical systems, big data analytics, and training of deep neural networks pave the way for a whole new generation of exascale computing infrastructures worldwide. Additionally, two big challenges will be tackled with the establishment of new joint ventures: in **medical physics**, proton therapies, and radiation oncology, impacting on health and quality of life; and in **space-earth interactions**, with the cooperation in complex engineering systems and science towards an integrative approach to space technologies, sea, climate and clean energy, developed together with the installation of the new Atlantic International Research (AIR) Centre, which will be looking at some of the country's most valuable assets. Finally, **TIE|UTEN**, the technology, innovation and entrepreneurship area, provides a comprehensive early venture assessment strategy, leveraging the UTEN - University Technology Enterprise Network's previous high-impact work in transforming science into valuable technologies for businesses and helping Portuguese startup to attain success globally.

Since 2018, the Program is hosted at INESC TEC. Based out of INESC TEC, the Programs' Directors, Prof. José Manuel Mendonça and Prof. Rui Oliveira, with the support of an executive team, carry out the planning, management and coordination of the activities of the partnership in Portugal, including the promotion of the cooperation between UT Austin and the Portuguese institutions. The executive team also works closely with INESC TEC's support services and staff to ensure a smooth management of the Program's administrative, legal, and financial aspects.

After ten years of joint collaboration, it is proposed that UT Austin and the involved Portuguese universities develop a cooperative effort to promote a thriving research agenda, strongly aligned with the strategy of the country in the different scientific and technological areas. The following lines of action are foreseen:

- **Competitive funding for medium to large-scale collaborative research projects** involving researchers at UT Austin and Portuguese researchers and led by a Portuguese company;
- **Advanced training programs** in topics on the forefront of knowledge, within the research areas of the UT Austin Portugal Program;
- **Research exchanges** of Portuguese and UT Austin faculty, researchers, and graduate students, to explore relevant research collaboration within the Program areas;
- **New entrepreneurial initiatives**, through UTEN, to prepare Portuguese researchers and innovators for scientific readiness for commercialisation success.

The collaboration should be oriented towards the development of a sound and scientifically relevant research-based agenda at an international level, while paving the way for new networks of opportunities far beyond the boundaries of UT Austin and Portugal.

8.1.1 Main Achievements in 2018

The main activities developed during 2018 included:

- The planning and coordination of the workshop “UT Austin and Portugal Building the Future” under the “Global Science and Technology Partnerships Portugal”, which aimed to present the opportunities and challenges brought by the third phase of the Program, from 2018 to 2030.
- The participation in the “Ciência 2018” in Lisbon, where a session devoted to the Program was organised under the theme “UT Austin and Portugal – Emerging Challenges of Knowledge”. The session brought together a panel of experts in the Program’s areas of knowledge.
- The launch of an intensive training program in Advanced Computing - ACTP, Advanced Computing Training Program, under which researchers in Portugal area granted a fellowship to spend up to 4 months at the University of Texas at Austin’s Texas Advanced Computing Center. A total of 14 candidates were selected. The training plans run from September 2018 to December 2019.
- The organisation of the 1st Area Directors Meeting, in Porto.
- The involvement in national and international events, where some of the Program’s current and former governance stakeholders intervened as invited speakers on behalf of the Program or participated as delegates: “SuperComputing 2018”, in Dallas; “Digital Media Doctoral Symposium 2018”, in Lisbon; “2nd Conference of the National Forum for Digital Competences INCode.2030”, in Lisbon; “Portugal Space 2030”, in Coimbra.

Throughout 2018, the leadership and executive teams at INESC TEC were very much involved in a set of key activities to ensure a smooth takeover of the Program. These activities included: the definition of the governance and financing models for the third phase of the international partnerships; the definition of the core scientific areas of the Program; the design and planning of new instruments, in close collaboration with FCT, Austin, and the Program’s Areas Directors; the development of a brand new visual identity and communication strategy.

8.2 DIGITAL COMPETENCE INITIATIVE

Coordinator: Pedro Guedes de Oliveira

In 2018 the Digital Competence Initiative was developed under the National Initiative for Digital Competences, e.2030, the Portuguese acronym of which is INCoDe.2030, created by a Resolution of the Council of Ministers of 13th of February and running under the supervision of the Minister of the Presidency and of Administrative Modernisation and the Minister of Science Technology and Higher Education

INCoDe.2030 is structured in 5 Action Lines (AL):

AL 1, INCLUSION: making sure that the whole population has equal access to digital technologies to obtain information, communicate, and interact with others;

AL 2, EDUCATION: stimulating digital thinking among young population, reinforcing digital literacy and competences at all levels of schooling and as part of lifelong learning;

AL 3, QUALIFICATION: qualifying the working population by providing them with the knowledge they need to become a part of a labour market that relies heavily on digital skills;

AL 4, SPECIALISATION: promoting specialisation in digital technologies and applications to improve employability and create a higher added value in the economy;

AL 5, RESEARCH: enhancing the conditions for the production of new knowledge and active participation in international R&D networks and programmes.

The coordination of the program was assigned to Pedro Guedes de Oliveira, with two Associated Coordinators – Sofia Marques da Silva, Prof. at FPCEUP e Nuno Rodrigues, Prof. at IPCA. The group activities were supported by FCT that for this purpose signed a protocol with INESC TEC, and INESC TEC paid for 60% of Sofia's time through an agreement with FPCEUP. The team could also count with the collaboration of Prof. Francisco Vaz for some special tasks and the secretarial and administrative support of Lucília Fernandes. Finally, João Neves was also be involved in a special group dedicated to planning an Integrated Network for Public Communication Services.

8.2.1 Main Achievements in 2018

- AL 1

Creation of 10 Creative Communities for Digital Inclusion (CCDI) with more than 750 direct beneficiaries;

Training of 40 mentors through an Accredited Training Programme at the FPCEUP;

Action plan for “CLOSING THE GENDER GAP IN DIGITAL TECHNOLOGIES” submitted to EC.

- AL 2

Promotion of a Portuguese initiative for Computing at School (CaS), including meetings in Cambridge and Lisbon with Peyton Jones and Simon Humphreys (responsible for UK initiative), and work meetings with town halls in Lisbon, Aveiro, Ílhavo, Amares, Braga Porto e Fundão, to discuss the deployment of CaS in primary schools;

Submission of an application to the European call “Complementarities and synergies between the European Funds: 3rd call of the Structural Reform Support Programme”, with ANI and the support of the MCTES. The application was not successful.

- AL 3

Work meetings for the deployment of joint initiatives with Amazon AWS and Google, for short specialization courses, including local discussions with several Polytechnic Institutes;

Continued support to the programme SWitCH and negotiations with HE institutions for the reproduction of the model.

- AL 4

Initial phase of the preparation of TeSP degrees for the qualification of workers of technologic companies. The programme is being designed in collaboration with Porto Polytechnic (ISEP and ESTG in Felgueiras) and AEBA (the Baixo Ave Enterprise Association);

Initial negotiations with companies and HE institutions for the development Executive Courses in areas of great importance to institutions, like Cybersecurity, Introduction to Data Science and AI, BlockChain, etc.

- AL 5

Data Science projects between R&D institutions and entities of Public Administration: collaboration in the programme definition and deployment;

Participation in deployment of the National Strategy for AI.

- Other activities

Organisation of the INCoDe.2030 Forum Conference, in Lisbon, in December. Development of a full report of INCoDe;

Participation in the task force for the planning of the Integrated Network for Public Communication Services, the output of which is public;

Participation of all the members involved, in a large number of conferences and seminars for the presentation of INCoDe.2030 and its activities;

Development of a digital platform to allow external institutions to apply for INCoDe.2030 partnership recognition.

9 SUPPORT SERVICES

9.1 LEGAL SUPPORT SERVICE

Manager: Maria da Graça Barbosa

Table 8.1-AJ - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	1	2	2	
	Academic Staff				
	Grant Holders and Trainees	2			
	Affiliated Researchers				
	Total Integrated HR	3	2	2	
	Total Integrated PhD				
External Collaborators					
Total		3	2	2	

9.1.1 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 of 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.

9.1.2 Highlights in 2018

- Participation in the multidisciplinary team nominated for accompanying the implementation of and monitoring the compliance with the European General Data Protection Regulation (Regulation EU 2016/679) and any complementary national legislation; contribution to the preparation and design of Data Protection Management Plans and Agreements, Data protection related Policies and Personal Data Sharing Agreements, with strong emphasis in european projects under the H2020 framework programme;
- Implement and adapt internal procedures to the revision of the Portuguese Public Procurement Code and to the new framework on "excluded" public procurement for research activities; launching of open tenders for acquisition of critical services and goods.
- Promotion of awareness and information on legal subjects with relevant or high impact to INESC TEC, namely:
 - Scientific Employment;
 - Revision of the Public Procurement Code;
 - Entry and stay of foreign citizens in Portugal and research visa.
- Participation in the conclusion of the IP Regulation proposal, to be submitted to General Council approval.
- Preparation and follow-up of the processes related to INESC TEC's participation in companies (mainly Ubirider and Mitmynid), collaborative laboratories (ForestWISE, B2E, VORTEX) and other associations.



- Scientific Employment: Preparation of job advertisements for hiring PhD under the provisional rule and R&D projects; preparation of employment contracts; Preparation of preliminary hearing submission in order to contest the evaluation panel's decision regarding INESC TEC Application to the Institucional Support call for proposals 2018.
- Support to the Executive Board in its relations with the recently created Workers' Committee.
- Request for the recognition of the scientific nature of the activity of INESC TEC, for the purpose of Scientific Patronage.

9.2 FINANCE AND ACCOUNTING SERVICE

Manager: Paula Faria

Table 8.1-CF - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	4	6	8	2
	Academic Staff				
	Grant Holders and Trainees	3	3	2	-1
	Affiliated Researchers				
	Total Integrated HR	7	9	10	1
	Total Integrated PhD	1	1	1	
External Collaborators					
Total		7	9	10	1

9.2.1 Presentation of the Service

The Accounting and Finance service is responsible for coordinating and executing the accounting activities, for fulfilling 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.

9.2.2 Highlights in 2018

According with the main actions planned for 2018 and the Accounting and Finance service goals, the most important highlights are:

- New approach for the personnel expenses increases
- VAT analysis for reimbursement
- Skill matrix and task allocation for the Accounting and Finance team
- Development of accounting process and procedure handbooks
- Impact analysis for the implementation of Electronic billing and platforms benchmarking
- Disclosure of invoice receipt information by project
- Report of asset information by user

9.3 MANAGEMENT CONTROL SERVICE

Manager: Marta Barbas

Assistant Manager: Vanda Ferreira

Table 8.1-CG - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	8	8	10	2
	Academic Staff				
	Grant Holders and Trainees	1	2	1	-1
	Affiliated Researchers				
	Total Integrated HR	9	10	11	1
	Total Integrated PhD				
External Collaborators					
Total		9	10	11	1

9.3.1 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 produce, coordinate and disseminate management information in order to ensure 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 continuous reporting to funding agencies of financial reports and the reimbursement of expenses, monitoring funded projects for compliance with funding agencies terms and conditions by working closely with researchers and providing training whenever necessary.

9.3.2 Highlights in 2018

In 2018, the number of funded projects was 180, meaning, those with obligations of report to funding agencies, which means an increase of 65 projects. In order to face this challenge the “reporting” team was reinforced through the recruitment of one person since September.

Apart from this, we should highlight:

- Improvement of intranet supporting tools for projects monitoring
- Development of monthly internal reporting tools to implement in 2019
- Undertaken of a deep analysis of VAT refund methodology
- Working on validation of assets depreciation method by funding agencies

9.4 HUMAN RESOURCES SERVICE

Manager: Maria da Graça Barbosa

Assistant Manager: Margarida Gonçalves

Table 8.1-RH - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	3	4	4	
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	3	4	4	
	Total Integrated PhD				
External Collaborators					
Total		3	4	4	

9.4.1 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 Health at Work.

9.4.2 Highlights in 2018

- Continuous updating and improvement of the intranet HR processes, in order to reduce workload, time of processing and error occurrences;
- Based on the historical record implementation, generation of the most frequently needed reports and lists, as versatile as possible, in order to help HR management at global and centre levels;
- Generate strategic HR indicators, organised by function besides legal status of the collaborators;
- Availability of employment and grant contracts in the respective intranet processes, allowing authorised persons from other services to consult them;
- Implementation of automatic reminders, so as have the activities reports of grant holders submitted on time;
- Organisation, control and conclusion of the process of hiring several doctorates under the provisional rule and in the ambit of projects, according to the Legal Framework of Scientific Employment;
- Recruitment process improvement: revision of the effectiveness of our dissemination sources and participation in job fairs; implementation of the preliminary hearing phase and other alterations required by FCT;
- Welcoming sessions: implementation of coffee-breaks at the end of the sessions, in order to encourage the new collaborators to get to know each other, promote networking and allow further clarification of doubts;
- Responsibility for compiling, updating, managing and reporting the "Training" dossier;

- Promotion of information internal sessions, addressed to the Secretariat or other attendees, on changes in HR processes and new legal or internal requirements;
- Revision of all processes involving personal data treatment, in order to comply to the requirements of the General Data Protection Regulation, to be applied from May 2018;
- Clarifications on the obligation of academic recognition and foreign diplomas and visa procedures;
- Promotion of collaborators' well-being by concluding protocols with gymnasiums and disseminating the information.

9.5 MANAGEMENT SUPPORT

Manager: Isabel Macedo

Table 8.1-AG - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	1	2	1	-1
	Academic Staff				
	Grant Holders and Trainees			1	1
	Affiliated Researchers				
	Total Integrated HR	1	2	2	
	Total Integrated PhD				
External Collaborators			1		-1
Total		1	3	2	-1

9.5.1 Presentation of the Service

The Management Support Service facilitates effective decision-making in the following governing bodies of INESC TEC: General Council, Board of Directors, Executive Board and Council of R&D Centres.

In addition to its operational focus, it also assists the Board of Directors and the Executive Board in streamlining internal strategic initiatives. With a cross-cutting perspective, it ensures institution-wide coordinated information management, and seeks to improve current processes and procedures, namely by developing data-driven recommendations and solutions.

Areas of Activity	Operational	Strategic
Decision-making process	Prepares and operationalizes decision-making processes at multiple levels (General Council, Board of Directors, Executive Board and Council of R&D Centres)	
Direct support to Management (Board of Directors and Executive Board)	Supports action planning and follow-up Assists with internal and external communication	Streamlines strategic initiatives based on the priorities of the Board of Directors and the Executive Board Monitors organisational priorities, goals and metrics Collaborates in the drafting of strategic plans and reports
Information management	Coordinates institution-wide information management Ensures liaison with FEUP Library	Assists in the validation and maintenance of institutional strategic indicators Identifies knowledge gaps and assists in addressing them
Continuous improvement	Analyses and follows up on improvement ideas received in the Intranet suggestion box	Provides analytical support and data-driven recommendations and solutions to the Board of Directors and the Executive Board

9.5.2 Highlights in 2018

Decision-making process

- Deployment of INESC TEC's management model in the intranet through the implementation of electronic approval workflows at subdelegated levels (in collaboration with the Management Information Systems Service (SIG));
- Dematerialization of the subdelegation process of expenses' authorisations (in collaboration with SIG);

Direct Support to Management

- Support to INESC TEC's participation in other entities and companies, namely the new participation in the associations ACPMR, AQUAVALOR, World Alliance for Efficient Solutions, in the National Collaborative Laboratories ADVID and ForestWISE, and in the companies MITMYNID, Lda. and UBIRIDER, Lda.
- Direct assistance to the launch and follow-up of the 1st call of Internal Seed Projects;
- Support to the Board within the FCT International Evaluation visit;

Information Management

- Definition of an institutional procedure for quality control of the institutional strategic performance indicators; in collaboration with SIG, quality control assessment of publication indicators on Authenticus Platform and IRIS; systematic upload of several years' range of strategic indicators for their deployment in IRIS.
- Full implementation of INESC TEC's Institutional Repository, with the classification and upload of the institution's documental collections, making them available to INESC TEC community, and with special emphasis on the new availability option of contracts/protocols according to users' access permissions.

9.6 SECRETARIAL COORDINATION

Manager: Grasiela Almeida

9.6.1 Presentation of the Service

Administrative Assistants are responsible for effectively executing the secretariat tasks required for the development of the activities of the Research Centre or Service they support, in accordance with the INESC TEC processes.

The Manager coordinates and supervises the team of Administrative Assistants, providing feedback to the Board on performance and anticipating any needed intervention.

9.6.2 Highlights in 2018

The team has grown due to the absence of 2 colleagues on maternity leave. This led to additional recruitment, training and monitoring activities, resulting in a team of 19 members as presented below.

Assistant	Organizational Structures / Associate Organs	Intervention Areas/ Special Projects	Personal Assistance
Ana Isabel Oliveira	General Council (CG) Fiscal Council (CF) Infrastructures Maintenance Service (SGI)	Board of Directors Budget Infrastructure Management Communications Continuous Improvement	José Manuel Mendonça Gabriel David João Claro Luís Carneiro
Lídia Vilas Boas		GC Plan and Report FCT Report Scientific Activity – Quarterly control Activity Indicators	João Peças Lopes Luís Seca Manuel Ricardo Mário Jorge Leitão
Sandra Nunes	Conflict of Interest Management Commission (CGCI) Scientific Advisory Board (SAB) Business Advisory Board (BAB) International Relations Office – India (GRI)	Conflict of Interest Process Management Document Repository	Bernardo Almada Lobo José Carlos Caldeira Rui Oliveira Vladimiro Miranda
Lucília Fernandes		National ICT Training Project	Pedro Guedes de Oliveira José Carlos Príncipe José Fortes
Ana Paula Silva	Information Systems and Computer Graphics (CSIG)		
Bárbara Veloso	High-Assurance Software (HASLAB)		
Catarina Leones Fernandes	High-Assurance Software (HASLAB)		

Assistant	Organizational Structures / Associate Organs	Intervention Areas/ Special Projects	Personal Assistance
Cláudia Almeida	Robotics and Autonomous Systems @ISEP LSA (CRAS)		
Flávia Ferreira	Robotics in Industry and Intelligent Systems (CRIIS)		
Grasiela Almeida	Enterprise Systems Engineering (CESE) Innovation, Technology and Entrepreneurship (CITE) International Relations Office – Brazil (GRI) Networks and Communications Service (SRC)	Secretarial Coordination Member of the Social Responsability Steering Committee	
Helena Silva	Industrial Engineering and Management (CEGI) Communication Service (SCOM) Organization and Management Services (SOG) Funding Opportunities Office (SAAF)		
Joana Dumas	Artificial Intelligence and Decision Support (LIAAD) Advanced Computing Systems (CRACS)		
Luísa Mendonça	Applied Photonics (CAP)		
Marta Oliveira	Enterprise Systems Engineering (CESE) Innovation, Technology and Entrepreneurship (CITE) Systems Administration Service (SAS) Management Information Systems Service (SIG)		
Paula Castro	Power and Energy Systems (CPES)		
Renata Rodrigues	Telecommunications and Multimedia (CTM)		
Rute Ferreira	Biomedical Engineering Research (C- BER) Industry Partnership Service (SAPE) Technology Licensing Office (SAL)		
Sílvia Pina	CRAS @FEUP		

Vera Pinto		International Office (GPI)	Partnership	
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As Coordinator, I have developed the following activities:

1. **Team Management**, through:
 - a. Training and coaching, promoting
 - i. a “Time Management with Mindfulness” professional course, lectured by IFE Portugal, with the presence of 14 assistants and other 16 researchers;
 - ii. 2 team meetings and coaching sessions regarding the update of rules/processes, namely the Human Resources (HR), the Systems Administration Service and the Management Information Systems Service, but also pursuing engagement towards a more efficient, productive and fulfilled team.
 - b. Recruitment of 1 new assistant and support to the training of 2 assistants;
 - c. Consulting on performance evaluation.
2. **Supplier Relationship Management** of the institution’s suppliers directly related to secretariat’s activity:
 - a. Management of contract and service relations with fidelity suppliers INESC TEC cooperated in 2018: 2 new contracts with travel agencies, maintenance of the service relations with 2 rental car companies, a private transport company and 66 hotels (including the opening of a checking account with 4 hotel groups that correspond to 22 hotels). This resulted in better service solutions and conditions for the team and institution to work with.
 - b. Management of suppliers financial control to comply with Portuguese Laws in terms of transparency in purchases.
3. **Information Management**, through the convey of information and organized Directory feed in Secr-Drive, including the creation and sharing of several useful templates for our activity.
4. **Focus on Continuous Improvement**, working in close collaboration with the Organization and Management and Technical Support Services, regarding procedures and support applications, resulting in process improvement examples such as:
 - a. the creation of the bi-weekly email digest regarding all HR processes renewal;
 - b. the change of the HR processes renewal workflow, notifying scholars and scientific advisors for the necessary steps towards the process completion;
 - c. the integration of “subdelegation of competences” form in plone workflows to abolish the paper form.

2018 was a dynamic year that resulted in vital training opportunities, more productive processes, organized information and stronger supplier relations (with better service terms). All these factors combined, definitely contributed to a powerful, efficient and motivated team.

9.7 FUNDING OPPORTUNITIES OFFICE

Manager: Marta Barbas

Table 8.1-SAAF - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees			1	1
	Academic Staff				
	Grant Holders and Trainees	1	1		-1
	Affiliated Researchers				
	Total Integrated HR	1	1	1	
	Total Integrated PhD				
External Collaborators					
Total		1	1	1	

9.7.1 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.

9.7.2 Highlights in 2018

From all the activities developed we shall highlight the support and development of procedures regarding 44 approved projects under the 2017 call "Projetos em Todos os Domínios Científicos da FCT (Aviso 02/SAICT/2017).

In addition to the very consuming time task mentioned above and the individual support to several proposals submission we should highlight the development and submission of a proposal under national call P2020 03/SAICT/2017 in order to fund INEC TEC internationalization activities regarding H2020 proposals submission.

9.8 INDUSTRY PARTNERSHIP SERVICE

Manager: Augustin Olivier

Table 8.1-SAPE - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	4	4	4	
	Academic Staff				
	Grant Holders and Trainees	1	1	1	
	Affiliated Researchers				
	Total Integrated HR	5	5	5	
	Total Integrated PhD	2	2	2	
External Collaborators		2	2	2	
Total		7	7	7	

9.8.1 Presentation of the Service

The Industry Partnership Service aims at strengthening INESC TEC's approach to the market and achieve higher revenues from industry contracts.

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. Furthermore, SAPE plans different strategies and prepares 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.

9.8.2 Highlights in 2018

Activity 1: Organisation based on a multidisciplinary approach

In 2018, INESC TEC continue to present its competencies on the market based on its multidisciplinary approach organized in innovation areas, called TEC4 ("TEChnology FOR ...").

During 2018, all TEC4 areas were pushed forward in terms of structuring their activities and establishment of stronger relations with their stakeholders. Namely, TEC4SEA and TEC4Energy focused their efforts in the implementation of their R&D infrastructure; TEC4Media was reformulated under the umbrella of TICE.PT, accessing a broader scope of sectors; TEC4Industry is strengthening its relations with the main stakeholders and companies; TEC4AGRO-FOOD asserted as a preferential partner for the national agricultural and forestry sectors' digital (r)evolution. These activities will have further impacts in the years of 2019 and 2020.

Activity 2: Networking and promotion activities for knowledge transfer

The main objectives of this activity was:

- to increase the networking activities with national and international partners as well as the efficiency of these networking activities;

- to extract more knowledge and value from the regular interactions with partners, supporting better targeting and, if possible, anticipating needs;
- to strengthen the INESC TEC positioning as an RTD partner of businesses, by increasing the number of national and international projects;

During 2018, those global objectives are reached by the following tasks:

- Networking and promotion activities - participation in exhibition fairs/events. Aligned with the TEC4, INESC TEC considers the participation in Business2Sea (Ocean Forum), EMAF (manufacturing and logistics sector), FIMA 2018 (agricultural machinery), Agroglobal 2018 (agriculture), TechDays (ICT);
- National networking and promotion activities – Seminars organization, aligned with the smart specialization thematic areas and/or societal challenges identified in Horizon 2020;
- Networking and promotion activities by through Business Clusters. The establishment of strong links with the Business Clusters, strategic aligned with the TEC4, is a means to access people with power to decide, influence and/or provide valuable feedbacks. The National Business Clusters aligned with the previously presented TEC4, are: Forum Oceano, Portugal Mineral Resources, Produtech, Smartwaste, Mobinov, NEM Portugal, Porto4Ageing, HEALTH CLUSTER Portugal, ADVID, aiff, Portuguese AgroFood Cluster and TICE.PT.

Activity 3: New technologies and knowledge dissemination for business

Communicating and disseminating the new thematic organization, supported by the TEC4.

9.9 TECHNOLOGY LICENSING OFFICE

Manager: Catarina Maia

Table 8.1 - SAL - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	1	1	2	1
	Academic Staff				
	Grant Holders and Trainees	1	2	1	-1
	Affiliated Researchers				
	Total Integrated HR	2	3	3	
	Total Integrated PhD		1	1	
External Collaborators					
Total		2	3	3	

9.9.1 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.

9.9.2 Highlights in 2018

Following its mission and goals, SAL developed numerous activities during 2018. There was a strong focus on scouting in order to fulfil the integrated programs' KPIs, supporting 28 new patent applications of which 10 were priority filing (new patent families) and 6 were European Patent applications. In addition to the notorious internationalization of INESC TEC's patent portfolio, 6 patents were granted to INESC TEC in 2018 – 2 in the U.S., 1 in Japan, 1 in South Korea, and 2 in the Europe. There was also a strong focus on securing competitive funding for patent internationalization (eight applications, 100% approval, securing over 400 000 Euros). Our business development activities increased both nationally and internationally. We organized the international conference "Software IP Conference", with the support of Scale-UP Porto.

We would like to highlight the following activities:

- Internal technology scouting: meetings with researchers, provision of information and understanding of which and how technologies are patentable, and roadmap definition towards a successful patent application;
- Meetings with patent lawyers and researchers to develop the terms for patent application;
- Application and execution to national funding for patent applications (Aviso 4 - Sistema de Apoio à Investigação Científica e Tecnológica – Propriedade Intelectual (SAICT – PI). During 2017, 15 projects were under execution;
- Collect information and provide INESC TEC's contribution about IPR to official surveys and requests (e.g. ASTP Proton, ANI);
- Background assessment, intellectual property right management, development of exploitation plans, and follow-up in the context of INESC TEC's projects (e.g. InterConnect);

- Free and Open Source Software license compatibility and commercialization analysis for INESC TEC's softwares, and in the scope of the Safeccloud project.
- Technology vigilance, market research, and business development for licensing opportunities;
- Freedom-to-operate search and analysis for INESC TEC projects and results;
- Application to Scale-UP Porto for LIPPS proposal - approved, supported with 10 000 Euros - for the organization of the Software IP Conference;
- Participation in the national matchmaking event Health Innovation Market Portugal 2018;
- Content development for INESC TEC's new website and corresponding SAL's webpage;
- Participation of Catarina Maia as European IPR Helpdesk Ambassador for Portugal, integrating INESC TEC European Enterprise Network team, supporting several companies in IPR information and strategy;
- Organization and hosting of the IP4Business event, with the support of the European IPR Helpdesk and the European Patent Office, at INESC TEC, in September 2018;
- Contribution for and development of internal policies, namely Intellectual Property and Spin-off companies;
- Advanced training in patenting and exploiting computer-implemented methods (software) in top international organizations (CEIPI Executive IP Management Days – Protecting Digital Business Models with Digital Patents, Strasbourg (FR), November 29-30th, 2018 | Patenting Artificial Intelligence – European Patent Office, Munich (DE), May 30th, 2018 | Advanced Course on Software Licensing including Open Source (DL 101) - World Intellectual Property Organization, April 10th -May 30th 2018 | Search Matters 2018 - European Patent Office, The Hague (NL), April 24-25th, 2018);
- Provide training and raising awareness of IPR matters, both internally at INESC TEC (e.g., tailor-made workshop for CPES on open source) and externally in events, workshops, and courses, such as “Software Specific Challenges in Technology Transfer” ASTP Training Course, Sitges (ES), January 2018 and “Organising your KTO for Growth and Success” ASTP training course, Leiden (NL), September 2018.

9.10 INTERNATIONAL RELATIONS OFFICE

Manager: Vladimiro Miranda

Table 8.1 - GRI - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees				
	Academic Staff				
	Grant Holders and Trainees	1	1	1	
	Affiliated Researchers				
	Total Integrated HR	1	1	1	
	Total Integrated PhD				
External Collaborators		23	3	23	20
Total		24	4	24	20

9.10.1 Presentation of the Service

The International Relations Office (GRI) 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.

The GRI 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.

9.10.2 Highlights in 2018

The actions during 2018 maintained a focus on the two main geographic areas of concern: Brazil and India. However, attention was devoted to other areas in South America and Africa, with emphasis to Morocco.

Brazil Office

The Brazil Office kept following the evolution of INESC P&D Brasil (the IB) and the relations between that sister institute and INESC TEC. The context of a radical change in the laws governing higher education imposed a robust degree of attention, namely to the consequences of the publication of a new Regulatory Framework for Higher Education in Brazil. Its analysis demonstrated that it opened possibilities highly favorable to the IB and thus to INESC TEC. In fact, the single most radical evolution is the one that allowed public universities – basically, the partners of INESC TEC in the IB – to become members of a private non-profit organization.

This led to a diplomatic movement of transforming the IB network, built upon agreements and MoUs, into a real shared membership organization. During 2018, four (4) Federal Universities saw their processes of becoming associates of the juridical entity approved and duly registered, with the expectation of a greater number taking the same step in 2019. This is, in itself, a major transformation of the Brazilian landscape and INESC TEC is starting to become recognized for inducing such transformation.

Aside from this diplomatic movement, boosting INESC TEC's interests in Brazil, it is important to mention that the IB keeps steadily growing and consolidating its organization. In 2018, the IB closed its operation

with the execution of a budget of approx. R\$4.5 million and presented a planned budget for 2019 of R\$12 million.

In all the recent five years, INESC TEC had projects in partnership with the IB, in a direct percentage of the IB budget of about 10%. In addition, with the Brazil Office rendering assistance, it was possible to launch and win a Horizon 2020 proposal in the EU-Brazil cooperation framework, where both IB and INESC TEC are partners, and where the participation of INESC TEC, mainly through CESE, is noteworthy. It is undoubtful that this positive result was only possible due to the leverage provided by the existence of the IB in connection with INESC TEC, allowing a coordinated operation on both sides of the Atlantic.

In the domestic domain, the Brazil Office kept rolling the series of events denoted “Café com pão de queijo”, targeting the community of Brazilian researchers in INESC TEC (which is the largest one aside from the Portuguese), with the positive effect of generation cohesion, trust and sense of belonging. Also, the activity of the Office proceeded with the general actions of rendering assistance to visitors from Brazil, as well as to candidates and newly arrived researchers from Brazil.

India Office

The Action of the India Office was driven by the strategic objective of making INESC TEC known to specific institutions in India and accepted as partner. Also, awareness of the opportunities for cooperation with India was improved in INESC TEC’s research centres.

A major step was finally done with the signing of an MoU between INESC Tec and the IIT Madras (Indian Institute of Technology Madras, in Chennai). This is the Engineering University number 1 in the NIRF ranking of higher education institutions of the Government of India, for three years in a row. The plan to promote joint projects will proceed in 2019, in agreement with the IIT-M, by organizing joint events (workshops) for mutual acquaintance of researchers and research leaders.

Meanwhile, the assistance of the India Office allowed an EU Horizon 2020 project proposal to be launched (involving mainly CRAS), in the EU-India cooperation framework. This proposal was approved, representing a major step in the construction of a cooperation relation of INESC TEC with India. Presently, INESC TEC has actions and projects with some off the major players in the Engineering Higher Education system in India: a EU project partnering with the IIT Gawahati and IIT Kharagpur, a FCT-DST project partnering with the IIT Bombay, a SPARC project partnering with the IIT Patna and IIT Kharagpur. In addition, an effort started in the establishment of an alliance with institutions in Goa, with a seed project funded by INESC TEC in the area of Biomedical Engineering. It is worth mentioning that, before the creation of the India Office, the awareness of India opportunities was minimal and cooperation was at a virtually zero level.

The diplomatic action of the India Office was not restricted to contacts and visits in India. A good relation and cooperation platform has been established with the Embassy of India in Lisbon, which has been extremely helpful in supporting INESC TEC’s efforts, with the high patronage of the Ambassador Nandini Singla herself.

Other actions

The following up of cooperation actions in Africa was also a concern of the International Relations Office, with special emphasis in Morocco but also in other instances, with Angola, Mozambique and Cabo Verde. In 2019, hopefully, a more intense cooperation action will be witnessed.

9.11 COMMUNICATION SERVICE

Manager: Sandra Pinto

Table 8.1 - SCOM - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	3	4	5	1
	Academic Staff				
	Grant Holders and Trainees	3	3	1	-2
	Affiliated Researchers				
	Total Integrated HR	6	7	6	-1
	Total Integrated PhD				
External Collaborators					
Total		6	7	6	-1

9.11.1 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 planning, implementing, organising and coordinating both internal and external communication in accordance with the regulations and procedures established, promoting the image and prestige of the institution.

9.11.2 Highlights in 2018

External Communication

- One of the most important events was the **FCT's evaluation visit to INESC TEC**. Besides the strong involvement in the organisation of the visit, SCOM had to prepare several communication supports, including: 68 posters, 7 videos, 23 fact sheets and 1 institutional presentation.
- 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 1175 news pieces in 2018, 144 more than in the previous year. The Automatic Advertising Value (AAV) return was EUR 6.3 million, half a million Euros more than in 2017. It's important to emphasise that SCOM had set out the goal for 2018 of promoting the mediatisation of the least active Centres with at least two news per year/centre and the obtained results exceeded the expectations: CAP (2 news; $\Delta +2$), CRACS (28 news; $\Delta +28$), LIAAD (20 news; $\Delta +13$), CEGI (69 news; $\Delta +62$) and CESE (22 news; $\Delta +14$).
- With regard to **Social Networks**, the INESC TEC pages on Facebook, LinkedIn, Twitter and Instagram registered a good performance in 2018, contributing to the dissemination and recognition of the brand and to the creation of a community involved. Facebook: it is the social network with the greatest organic reach, and the publications of the last quarter of 2018 reached more than 191 000 followers. LinkedIn: it was the second social network with the biggest increase of the community with more than 32% followers compared to the previous year. Twitter: it remains as the social network with more followers, accounting for 7.851 followers at the end of the year. Instagram: it remains the biggest growing social network (65% compared to 2017).
- In an effort to **optimise the new website**, the improvements in the platform were aligned with SIG, with SCOM also updating it with news, events and clipping on a daily basis. It should be noted that, according to Google Analytics figures, the number of visitors of INESC TEC's website has grown exponentially from 3.256 users in 2017 to 75.244 in 2018 ($\Delta +71.988$) and from 19.624 pageviews in 2017 to 370.250 in 2018 ($\Delta +350.626$).

- The “**Fórum INESC TEC do Outono**” is an annual event exclusively organised by INESC TEC and open to the public. The 2018 edition focused on the theme “As Empresas que fazem o digital. As Empresas que o digital refaz”. This event, which featured SCOM in the organising team, had a tremendous impact and increased INESC TEC’s reputation for the quality of their presentations and debates, the number of executives and managers that were present (a total of 240 participants) and the opportunity to promote new business partnerships.
- INESC TEC also participated in **various events that promoted its image abroad**, such as the European Utility Week (Austria) for the first time in its own stand, Hannover Messe (Germany) where the European Commission under the project BEinCPPS invited INESC TEC. In Portugal, it should be highlighted the Business2Sea 2018, Ocean Business 2018, EMAF 2018, Agroglobal 2018, TechDays 2018, IEEE SYP Congress 2018 or the “Caminho da Inovação”.
- In its mission to **support the R&D centres**, it is important to stress the European projects FEEdBACK, GReSBAS and InteGrid, whose dissemination activities are carried out by a SCOM collaborator. Additionally, SCOM supports activities related to the Network Enterprise European Network (EEN), the CHIC - Cooperative Holistic View on Internet and Content project, and AV360 from the Google Digital News Initiative. It should also be noted the support in the conception of applications in three H2020 projects and in one national project.
- It is worth mentioning the **production of promotional videos** for events and exhibitions: 75 videos in 2018 (45 more than in 2017). The **photographic coverage of events** has reached a total of 82 albums in 2018.
- When it comes to the **communication material**, exhibition stands, outdoor screens, project logos, flyers, pop-ups and roll-ups were produced for various Centres, as well as templates, fact sheets, brochures, booklets, vinyl banners, stickers, and merchandise (such as pens, lanyards, USB pens and bag packs).
- 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”, reception of the FEUP New Students and the Mostra of the U.Porto.
- The renewal process of **INESC TEC’s monthly newsletter (BIP)** was started. The newsletter will have a new image and the sections will be restructured. From January 2018, the English version of BIP, which was initially sent every three months, was updated to be sent on a monthly basis while it remained being sent to universities from 25 different countries. By using the AWStats statistics system it is possible to see that people from 96 different countries have visited the newsletter’s website, with Portugal, USA, Brazil, Poland and the United Kingdom being the most frequent ones, in a total of 371.545 page hits and 84.980 visitors.
- Also a note for **the sponsorship of INESC TEC at events** such as the 9th Symposium on Bioengineering, NEEEL IT competition, Bin@Porto, Team Weekend of ANEEB, “Jornadas de Eletrotecnia”, Concert from the “Ópera na Academia e Cidade”, Talk a Bit Conference. In these events, in addition to receiving support requests and issuing an opinion (20 requests in 2018), SCOM dealt with the operationalisation of all counterparts offered by the organisers.

Internal Communication

- A Team Building action called “**INESC TEC on the move**” was organised for the second time in 2018 with 110 participants. It aimed to provide moments of cooperation and teamwork, and putting participants to the test with competition activities.
- The second edition of the annual **Strategic Meeting** brought together around 280 employees aiming at reflecting and discussing basic themes for the Institution’s future.
- For the first time, two hikes known as “**INESC TEC on foot**” were organised. The first one, which was carried out at Sistelo, had 70 participants, while the second one was held at Paredes de

Coura and had 65 participants. This is another beneficial tool of internal communication, which encourages the interaction, the group participation and networking.

- In 2018, in order to strengthen the internal cohesion, SCOM continued to **promote group activities for employees**, such as the photo contest, the Roasted Chestnuts party, the Multicultural Party and a solidarity campaign.
- In 2018, **11 monthly sessions were organised in order to welcome 180 new employees**. These sessions were designed by SCOM, always in articulation with the Human Resources service.
- Considering that the Media are increasingly using researchers for their interviews and news reports, SCOM organised two **Media Training sessions** with 26 participants to upgrade the communication skills of INESC TEC researchers. Also two **workshops entitled “O Facebook também tem ciência”** were organised in order to reinforce the communication skills in social media of 40 collaborators. The first edition of the **Workshop “Técnicas para apresentações eficazes”** also took place, with 28 participants, in order to strengthen the ability to communicate in public events.
- All the **translation** and **proofreading** requests by the Centres and Services were carried out, within the opportunity in SCOM’s schedule. In addition to the translations into English and Portuguese, translations into Spanish were also done.

9.12 NETWORKS AND INFORMATICS SERVICE

Manager: Gil Coutinho

Table 8.1 - SCI - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	2	2	2	
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	2	2	2	
	Total Integrated PhD				
External Collaborators		1	1	1	
Total		3	3	3	

9.12.1 Presentation of the Service

The mission of the Networks and Informatics Service is to provide for the communication needs of INESC TEC's community. This service manages INESC TEC's voice and data infrastructures and is responsible for the implementation and maintenance of network-based services, as well as for providing the respective support.

9.12.2 Highlights in 2018

Early 2018 most significant highlight was the transition to the national research and education network (RCTS) as the INESC TEC's internet provider, a process started the previous year. Alongside with the termination of the commercial operated internet access circuits, benefits of this transition include an access rate of 10 gigabit/s and access to other services provided by RCTS' operator (FCCN).

Throughout 2018, a restructuration of the datacenters' cabling and switching infrastructures was conducted, in order to improve speed and effectiveness of fault tolerance mechanisms, as well as to provide simpler and more efficient cable handling procedures. 10gigabit/s per port switches and pre-connectorized fiber cabling were deployed in INESC TEC's datacenters, simplifying, standardizing and speeding-up server deployment. A great deal of emphasis has been also given to the installation and continuous improvement of monitoring and alarmistic platforms, which provide a looking glass to the health and availability of INESC TEC's network and improves overall service efficiency.

INESC TEC's buildings A and B wi-fi equipment has been fully replaced by a centrally controlled solution, which not only offers faster access rates but also allows for greater user density per access point, broader and more homogenous radio coverage, interference avoidance capabilities and much simpler management.

The acquisition process of two peripheric firewalls was concluded in 2018, having their deployment began later in the year. The unavoidable impact of such a transition to INESC TEC's users and/or services motivates a gradual and slow transition process, to be concluded in 2019.

During 2018 a new interface to INESC TEC's printing equipment was developed and deployed. The new system abandons the need for maintaining static access lists and provides dynamic printer discovery, automatic installation and directory-based user authentication.

In cooperation with the Systems Administration Service, a clean slate solution for INESC TEC's email was devised and implemented. Along with the new Exchange based frontend servers, a completely



redesigned system of backend servers was installed, with much more effective redundancy mechanisms, faster processing, updated mail handling and spam/virus detection software.

Finally, and also worthy of remark, 2018 ended with the change of designation of the service to “Networks and Communications Services” which we believe better adjusts to the service’s mission and activities, and helps to clarify its responsibilities and those of its counterparts.

9.13 MANAGEMENT INFORMATION SYSTEMS SERVICE

Manager: José Carlos Sousa

Table 8.1 - SIG - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	3	4	4	
	Academic Staff				
	Grant Holders and Trainees	2			
	Affiliated Researchers				
	Total Integrated HR	5	4	4	
	Total Integrated PhD				
External Collaborators					
Total		5	4	4	

9.13.1 Presentation of the Service

The Management Information Systems Service is in charge of the development and maintenance of INESC TEC's management information system.

9.13.2 Highlights in 2018

- Improvement of the publications in IRIS - INESC TEC Research Information System: upload documents to INESC TEC's Institutional Repository, Authenticus automatic synchronization, advanced search and real-time indicators;
- Enhanced of human resource recruitment in INESC TEC website (online selection process, candidate minute access, new applications models);
- Increased SAP integration with the institution's intranet (supplier data, control of purchases from suppliers, automatic update from human resources processes);
- Enhanced the systematic collection of all institutional indicators and improvement of its visualization;
- Partial implementation of an system for reporting research results to the Associates and FCT (publication classification, thesis, ...);
- Partial implementation of the new Projects Database;
- Increased system notifications to prevent delays in processes;
- Intranet integration of new access control and employee attendance equipments;
- Implement an system to manage Seed Projects application and selection;
- Implementation of Conflict of Interest Management process;
- Preparing the various systems to be compliance with General Data Protection Regulation (GDPR).

9.14 SYSTEM ADMINISTRATION SERVICE

Manager: Jaime Dias

Table 8.1 - SAS - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	3	3	3	
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	3	3	3	
	Total Integrated PhD				
External Collaborators					
Total		3	3	3	

9.14.1 Presentation of the Service

The System Administration Service is responsible for managing servers, computer systems and common applications, and for providing support to end-users, administrative staff as well as research and development teams. This Service is also responsible for managing the INESC TEC Living Lab, in collaboration with Research Centres and other Services, to enable INESC TEC's building and infrastructures as real-life testbeds while promoting R&D results.

9.14.2 Highlights in 2018

The computing cluster was extended with five new servers, and the Network-Attached Storage (NAS) capacity was increased. The cluster hosted around 260 virtual machines, which includes the INESC TEC main services and Research & Development applications. In order to satisfy the growing demand for HPC and HPC-GPGPU resources, a set of six new servers were acquired at the end of 2018, two for HPC and four for HPC-GPGPU.

The new email front-end service was deployed. The new service is comprised by a cluster of MS Exchange servers linked with the INESC TEC Directory and the Human Resource's database, enabling:

- Directory accounts and mailboxes to be created/terminated automatically, with proper user notifications, without requiring intervention from the secretariat;
- Up-to-date mailing lists;
- Login with the Directory credentials – the same user password to access INESC TEC main services, such as the Intranet, that can be easily but securely reset in a single place.

Besides the e-mail service, the following functionalities are now available:

- Personal/shared calendars;
- Meetings/appointments;
- Personal contacts synchronization between computers and mobile devices;
- INESC TEC collaborators contacts;
- Mobile devices native support.

The performance of the email service is now much improved, with emails between users now being delivered within the second (Exchange servers), and emails from external users being delivered within

only a few seconds, which includes the processing time of the anti-SPAM and anti-malware of the Mail Transfer Agents (servers handling the e-mail exchange with the Internet) that were redesigned by SRC.

Due to the incompatibility of the architectures and formats between the old and new email servers, a solution was devised and deployed in collaboration with SRC to enable both e-mail services to work simultaneously and seamlessly during the transition period.

The auditoriums were equipped with wireless systems that allow users to project wirelessly with the built-in capabilities of the operating systems – without requiring the use of dongles nor the installation of software.

Besides new services, SAS has the responsibility of administering and maintaining existing services/systems with minimal downtime and needs to continuously improve them. Next, we highlight the main web-based services available to end-users that are administered by SAS:

- The Drive (drive.inesctec.pt), an on-premises file access and sharing service for Services and Centres. During 2018, its usage has grown from around 120 users to more than 630.
- The Gitlab (gitlab.inesctec.pt), an on-premise Git repository service. The Gitlab service has seen an increment from 379 to more than 500 active accounts, including 86 accounts from external users (INESC TEC partners) that rely on INESC TEC services to actively develop and store the code. The number of projects grew from 945 on 2017 to more than 1300 on 2018.
- The Chat (chat.inesctec.pt), an on-premises ChatOps service, grew from 30 teams with around 180 users to 40 teams with around 280 users.
- The RDM (rdm.inesctec.pt), the INESC TEC scientific dataset repository, has been receiving more than 20 datasets from INESC TEC researchers.
- SAS hosted around 80 web sites during 2018, most of them are wordpress instances (55). SAS is responsible for the hosting and security monitoring of web framework instances.

Since 2018, SAS is part of the Data Protection Officer group and contributes on system security audit and security policy definition to enforce the deployment of the General Data Protection Regulation.

Like in 2017, the tasks related with support to end-users and for Research and Development were those that took the most part of the time. Two thirds of the SAS team spent around 80% of their time on support requests. The SAS team handled and closed more 1300 support tickets, a number close to 2017. Still, like in 2017, these support tickets only account for around 60% of the support requests, which means that the total number of support request during 2018 exceeded the 2000 support requests mark.

The SAS Team manages around 200 PCs, 70 of services and 130 of centres. The management includes software and hardware maintenance.

In 2018, a new, more advanced, corporate anti-virus solution was deployed, with machine learning and cloud threats analysis.

During 2018, SAS renegotiated the Matworks License Agreement (Matlab) and the Microsoft Site License Agreement for Schools (OVS-ES), including Office 365 licenses for all the INESC TEC users with no additional costs.

Whenever required, SAS helps secretaries and users assessing technical requirements of computer and software acquisitions and, when these are more complex, SAS also requests the quotes.

9.15 INFRASTRUCTURE MANAGEMENT SERVICE

Manager: Jorge Couto

Table 8.1 - SGI - Service team composition

Type of Human Resources		2016	2017	2018	Δ 2017-2018
Integrated HR	Employees	5	4	4	
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	5	4	4	
	Total Integrated PhD				
External Collaborators					
Total		5	4	4	

9.15.1 Presentation of the Service

The Infrastructure Management Service assures the support services necessary for the adequate management and maintenance of INESC TEC buildings infrastructures.

9.15.2 Highlights in 2018

- The active and passive security of the INESC TEC building was improved with the implementation of safety regulations, and improved access control;
- Maintenance actions in the buildings' electrical infrastructure were implemented on the main and partial LV switchboards;
- Maintenance action in the power station of the building;
- Maintenance and optimization actions of the air conditioning infrastructure in order to improve comfort levels and reduce costs;
- Actions to prevent and fight building fires were also implemented, namely improvement and technical verifications of equipment installed at INESC TEC buildings to detect and fight building fires;
- Improve internal processes allowing better maintenance and support services with the existing resources;
- Recycling processes and awareness were improved.