INSTITUTE FOR SYSTEMS
AND COMPUTER ENGINEERING,
TECHNOLOGY AND SCIENCE

INESCTEC

ACTIVITY REPORT 2020

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Editorial Notes

INESC TEC
Campus da FEUP, Rua Dr. Roberto Frias
ag@inesctec.pt | www.inesctec.pt

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GLOBAL ACTIVITY REPORT 2020

EXECUTIVE SUMMARY

We will remember 2020 as a dramatically atypical and challenging year, but also as a year in which all of us at INESC TEC were capable of instantly holding hands in solidarity to strengthen and protect our community, while joining global scientific efforts to tackle an unprecedented health and economic crisis. Not only was our community able to adapt to working remotely without significant disruption to the on-going activity, but also our researchers instantly pledged to fight the pandemic, directing their know-how and efforts to multiple initiatives and collaborative projects.

INESC TEC launched and participated in many actions that brought together experts from different disciplines as part of the response to the COVID-19 pandemic, from the early production of protective visors to the development of the emergency ventilator PNEUMA, the study "Diaries of a Pandemic", the contribution to the free app "Psicovida" and the world-wide CoronaSurveys, as well as the development of an Autonomous Robot for Disinfection in Hospitals – RADAR – and a COVID-19 Diagnosis System applied to chest X-Ray images. Among these many actions, INESC TEC's most prominent contribution was the design and development of the Portuguese digital contact tracing system for COVID-19, STAYAWAY COVID, which also leveraged the institute's contribution, as a partner of the Decentralised Privacy-Preserving Proximity Tracing consortium, to the protocol underlying the Apple/Google Exposure Notification service and Huawei's Contact Shield.

In addition to the activity related to the Pandemic, 2020 was also a year of important advances in multiple fields of Science and Technology (S&T) at INESC TEC. In line with the European Green Deal and the Europe Fit for the Digital Age priorities, as well as with the Portuguese Government's Digital Transition, Climate Transition, and Resiliency priorities, the institute continued to advance in the realisation of its S&T aspiration to Foster Pervasive Intelligence by creating new digital intelligence paradigms and applying them to its domains of expertise.

As an illustration of those advances, in 2020 our researchers developed a multi-sensor system for underwater docking operations, combining short-range acoustic positioning with visual perception to solve the associated relative localisation problem; designed and implemented a second generation home energy management system, capable of determining the flexibility within a household or building, represented under a single battery formulation, to support a modular and privacy preserving approach; created a real time production scheduling engine integrated with an IoT manufacturing platform to detect deviations in the plan execution, and suggest corrective measures; and contributed with theoretical groundwork deemed referential to the Immersive Learning Research Network (ILRN) and multiple advances in the domain of multisensory stimuli in virtual environments.

At the macro-economic level, 2020 was deeply marked by the adverse effects of the COVID-19 pandemic. The Portuguese GDP decreased by 7.6%, but the reaction of the Portuguese economy to the pandemic shock proved to be less negative than initially anticipated. This behaviour was common to most economies in the euro zone and globally. With regard to the Science and Innovation context, Portugal became a "strong innovator" for the first time in the European Innovation Scoreboard, but the year also marked the beginning of an always challenging period of transition between S&I funding cycles, both at European and national levels. INESC TEC's R&D activity continued to be greatly influenced by two relevant public policy measures: the further implementation of the Portuguese Government's policy for scientific employment and the modification of the Research Grant Holder Statute that came into force in 2019 constraining the award of grants to non-PhD researchers to those who are enrolled in a higher education program.

Despite this unfavourable context, INESC TEC's activity increased 2%, extending a period of more than a decade of continuous and sustainable growth, maintaining a high level of R&D contracts with industry (3.6 M€, representing an increase of 10%) and thus contributing to the advancement of science and technology, economic development and social progress in Portugal. INESC TEC remained one of the top 5 Portuguese organisations in net contribution and participation in H2020 competitive research funding, with 36% of its total project funding (90 projects) coming from European programmes. Already since 2019, the institute's research teams have participated intensively in the extremely competitive final calls of the closing funding cycles, striving to reinforce the multiannual funding as to bridge this always highly uncertain transition, with visible and impactful outcomes, e.g., in the National Cooperation Programmes with Industry and the large Portugal 2020 Mobiliser Programmes.

For the fourth consecutive year, INESC TEC was also one of the top five national entities in patent applications submitted to the European Patent Office (EPO). INESC TEC patent applications comprehended medical

technologies to support diagnosis, telecommunications, cybersecurity and instrumentation. Furthermore, in 2020, three spin-offs were in a development phase, one in geological consulting and two in Medtech.

Publications in indexed journals, a priority for INESC TEC, increased slightly to 398 articles, 62% of which in first quartile journals, whereas indexed conference publications decreased 44% to 317, due to the negative impact of COVID-19 on the organisation of conferences. The number of PhD theses supervised by INESC TEC researchers that were completed in 2020 increased 39% to 46.

At the end of 2020, INESC TEC hosted more than 730 integrated researchers, 350+ with a PhD. As expected, the most noticeable evolution in Human Resources was the significant increase (26%) in the number of R&D employees (reaching a total of 152), due to the abovementioned Portuguese Government policy for scientific employment. This has been decisive to the progressive transformation of the profile of our research teams, with a gradual decrease in the number of grant holders and a steady growth in research contracts.

For most of the year, INESC TEC operated in a hybrid mode: with most research team members in remote work, and with only essential support services shifts ensured in the premises. Guidelines and support tools for researchers and project leaders were disseminated through the community, and special attention was given to ensure appropriate conditions for remote work, namely through the reinforcement of the central support infrastructures. INESC TEC's premises were adapted to the new shifts' reality, laptops and web conferencing equipment went predominant, and digital repositories and processes reinforced. Laboratory work was stopped in March and restarted around June 2020 with new rules enforced.

As for support to public policies, INESC TEC provided contributions to the bureaucratic simplification in the area of S&T at a national level, in addition to a continuous involvement in the update of the regional and national smart specialisation strategies in the institute's areas of expertise, and an active participation in nine Collaborative Laboratories (CoLABs), which took major initial steps in 2020. Still in the realm of its role as a key actor in public policies, INESC TEC applied in 2020 for the renewal of its title as Associate Laboratory. The results of the call were disclosed early 2021 and INESC TEC received a classification of excellent and saw its title renewed for 10 years.

Our most recent initiatives did not falter in the face of the crisis. Five new Internal Seed Projects aiming at supporting internal exploratory R&D activity started in 2020, and INESC Brussels Hub, the Brussels representation of INESC TEC, INESC Coimbra, INESC ID, INOV INESC and INESC MN, entered into full operation. A new magazine, "INESC TEC Science & Society", aiming at disseminating science in society and contributing to the discussion of technology-influenced public policies was successfully launched.

Undoubtedly, most events that had been planned to generate public enthusiasm and interest in science, or to commemorate INESC TEC's 35th and INESC's 40th anniversary, had to be altered due to the pandemic crisis. However, virtual alternatives, such as hybrid conferences or full remote participation, were rapidly adopted in many events and allowed communities to come back together or, in some cases, bring new ones together as digital tools oftentimes even favour.

The year 2020 proved our resilience, adaptability, inner strength and determination to face uncertainty. It has brought the scientific community and society closer together, and INESC TEC stood up to help and solve problems, as inscribed in our DNA. It is already clear now that 2021 will still be a challenging and disrupted year. But, as the world endeavours to recover, we will be here to contribute, with our unwavering dedication and spirit of service, as we have been for the last 35 years.

1 INTRODUCTION

This document presents the scientific and technological activities, as well as the results of INESC TEC for the year 2020.

Section 2 offers a summarised presentation of the institute's profile, vision, mission, organisational model, policy priorities, institutional objectives and research and innovation goals. Section 3 presents the highlights and main activity indicators for 2020, namely those regarding Human Resources, Activity in Projects and Publications.

Research at INESC TEC is developed in thirteen Research Centres and organised in four core scientific domains denoted as Clusters: Computer Science (CS), Industrial and Systems Engineering (ISE), Networked Intelligent Systems (NIS), and Power and Energy (PE). Section 4 presents these four Clusters and their scientific outcomes in 2020.

Section 5 focuses on the TEC4 initiatives, platforms that articulate the activity towards economic and societal impacts, presenting their main achievements in 2020 for the following domains: AGRO-FOOD, ENERGY, HEALTH, INDUSTRY and SEA.

Section 6 presents the scientific and technological activities developed by the 13 Research Centres, including their research and innovation outcomes.

Section 7 describes some of the institute's main research infrastructures that support both research and technology transfer activities, besides its active participation in several national Research Infrastructures.

Section 8 introduces one special project running at INESC TEC, the UT Austin Portugal Program, a significant contribution of the institute to public policies in education and science.

In Section 9, a thorough description of the activities of the Support Services is presented, 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 of Porto, the University of Minho and the University of Trás-os-Montes e Alto Douro are INESC TEC's associates. Presently, INESC TEC's main sites are located in the cities of Porto, Braga and Vila Real. By the end of 2020, INESC TEC's 13 R&D Centres hosted 732 integrated researchers (354 PhDs), including R&D employees, academic staff, grant holders and affiliated researchers. INESC TEC's team also includes technical and administrative support staff and trainees.

INESC TEC envisions to be a relevant international player in Science and Technology in the domains of Computer Science, Industrial and Systems Engineering, 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 generates knowledge as part of its research, and leverages that knowledge in technology transfer projects, seeking impact both through value creation and social relevance.

The dual mission of INESC TEC is to excel in research and to seek its social and economic impact, with a unifying commitment to the scientific and technological aspiration of fostering pervasive intelligence.

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 variety of technology transfer processes and tools.

Figure 2.2.1 – End-to-end knowledge value chain: an integrated two-way pipeline

The concept is illustrated in a simplified manner in the figure above, which presents the knowledge value chain as a seamless integration of four stages – knowledge production, applied research, development, and technology transfer. Project activities and outcomes of projects active in 2020 fall in different ranges of Technology Readiness Levels (TRLs) and are linked to different funding typologies. As with any model depicting a complex reality, the transitions between stages are fluid.

2.2.2 Centres, Clusters and TEC4s

Research at INESC TEC is undertaken by its 13 Research Centres and organised in four core scientific domains called Clusters: Networked Intelligent Systems (NIS), Power and Energy (PE), Industrial and Systems Engineering (ISE) and Computer Science (CS). The interaction with the main market areas, which are also major societal challenges, is articulated by five initiatives called TEC4: TEC4AGRO-FOOD, TEC4ENERGY, TEC4HEALTH, TEC4INDUSTRY and TEC4SEA.

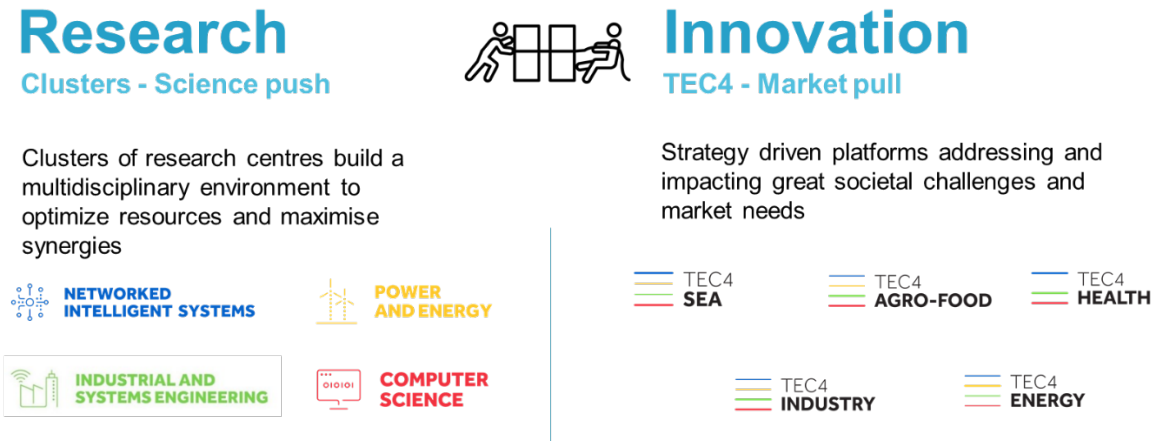


Figure 2.2.2 - Putting pervasive intelligence to work

The Centres are INESC TEC's R&D organisational base units, each focused in specific scientific and technological domains. Each Centre is responsible for its own planning, strategy and resources, and reports directly to the Board regarding its budget, operation and scientific and innovation performance indicators. All project activities are carried out at Centre level.

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. Performance indicators are consolidated at Cluster level to enable proper planning and follow-up for the forthcoming periods. Each Cluster is directly coordinated by a Member of the Board, with the support of a Cluster Council, composed by the Centres' Coordinators. Recently, the concept of Cluster has been evolving and it is currently being considered as a scientific domain characterised by a set of Research Lines which are expected to become anchors in the recognition and development of both current and future activity.

The TEC4 initiatives articulate the activities of the institution towards the economic and business fabric, defining market strategies and planning the interaction with INESC TEC's current and emerging markets. A TEC4 initiative structures and provides coherence to the activities towards specific markets carried out in the Centres, integrating and articulating their competencies. A TEC4 is fundamentally driven by a market application domain perspective, where multidisciplinary interventions are usually necessary, instead of a more in-depth science perspective. A TEC4 initiative establishes a network of external contacts with industrial partners and brings back major challenges in the shape of opportunities to the multiple Centres. The TEC4s are flexible, dynamic and adaptive to both external conditions and internal response. While seeking the impact of research in real world multidisciplinary environments, the TEC4 initiatives allow INESC TEC to address broad societal challenges. Each TEC4 initiative has a management committee, composed by its Coordinator, a Business developer and representatives of the relevant Centres. Each TEC4 reports directly to a Member of the Board.

2.3 Organisational structure

The figure below describes 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 four members from the Board of Directors. The Boards act in coordination with the Council of R&D Centres, meeting every other week with Centre Coordinators and Service Managers. This ensures institution-wide coherence in vision, policy and operations, as well as joint responsibility and commitment in both strategic and operational management decisions. As detailed before, Clusters articulate the long-term strategy of the Centres in core scientific domains and TEC4s articulate the activities of the Centres towards main market domains.

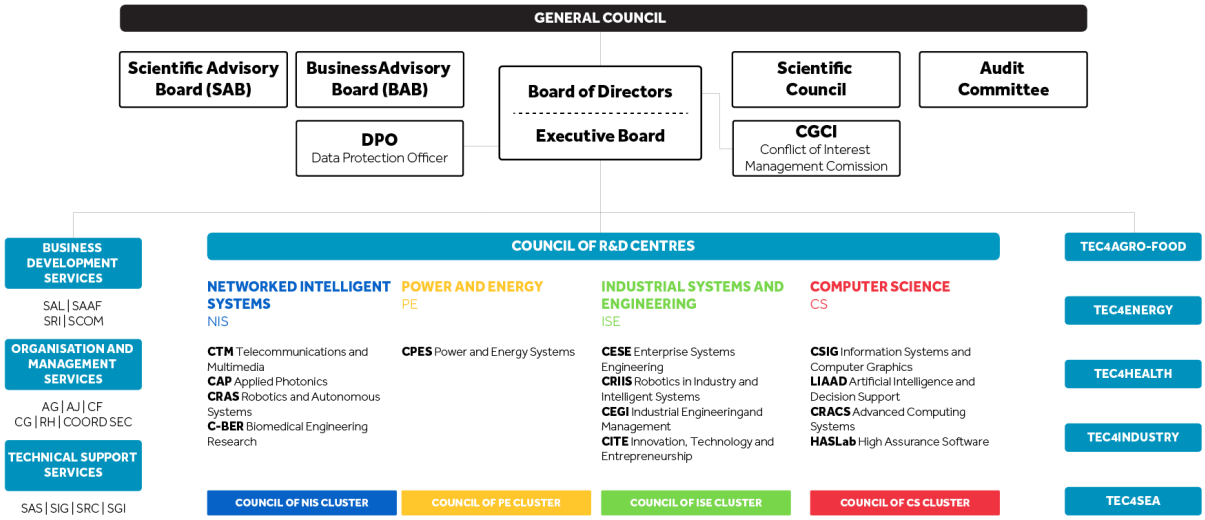


Figure 2.3.1 - Organisational Structure

The external Scientific Advisory Board is composed of internationally recognised scientists from prestigious institutions, experts in INESC TEC's fields of scientific competence, that support the institution in its search for continuous improvement and excellence, as well as in building a vision for future research through a valuable benchmark at an international level. The external monitoring, orientation and evaluation of the innovation and technology transfer activities are entrusted to the Business Advisory Board, whose members have deep knowledge and expertise in many of the economic sectors of relevance to INESC TEC.

The Scientific Council is an internal body responsible for monitoring and guiding scientific activity, and it includes one representative from each Centre and three additional members appointed by the Board.

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.

Table 2.3.1 - Support Services

Business Development	Organisation and Management	Technical Support
SAL: Technology Licencing SAAF: Funding Opportunities SRI : International Relations SCOM : Communication	AG: Management Support AJ: Legal Support CF: Accounting and Finance 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

To accomplish its mission, INESC TEC sets the following policy priorities:

- Full coverage of the knowledge value chain;
- Excellence in research, talent development, and innovation;
- Integration and multi-disciplinarity;
- Scale, density, and critical mass;
- International visibility and presence;
- Ethics, social responsibility, and diversity and inclusion.

2.4.1 Full coverage of the knowledge value chain

INESC TEC creates new knowledge and technology and supports innovation in products, processes, services and business models, contributing to the competitiveness of companies and institutions, ensuring economic and social impact. 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 companies, hospitals, and local and central administration is essential for the identification of new research lines, and the valorisation of research results is also key to the economic sustainability of the institute.

In order to excel in these dynamics and to be able to fully accomplish its dual mission, INESC TEC is increasingly challenged to ensure that individual researchers focus where they feel more comfortable to perform at their best. 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 among Centres.

2.4.2 Excellence in research, talent development, and innovation

Knowledge generation at INESC TEC 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 involvement in PhD and Masters Programmes strengthens the institute's ability to attract and involve young talent in conducting and disseminating excellent research. The institute's focus on finding solutions to important problems, along with its culture of collaboration with industry, thus providing an ideal environment for innovators.

The reinforcement of its global dynamics of excellence is a permanent priority for the institution, whose expansion in recent years required 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 diversity and inclusion policies.

2.4.3 Integration and multidisciplinarity

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-fertilisation, 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. Other instruments, such as the Internal Seed Projects, which support inter-Centre research, junior researcher development, and proof-of-concept activities, also play a key infrastructural role towards this purpose.

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 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 near future is a consistent effort to widen 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 global arena. INESC TEC permanently directs significant efforts to its international activities, so that they continue to play a major role in the institution, increasing the capacity to promote projects, securing funding, and attracting human resources at an international level.

2.4.6 Ethics, social responsibility, and diversity and inclusion

Ethics is core to INESC TEC's multiple endeavours. The institute's community has a shared interest in protecting its research, education and innovation environment, which the recently proposed Code of Ethics reinforces, through the formalisation of the ethical principles that must guide individual and institutional conducts.

As an institution, INESC TEC exists and operates on an implicit social contract with its community at large. As such, in addition to the desired outcomes for its associates and research and innovation partners, the institute's strategy and activity must also be concerned with other stakeholder outcomes. This shared realisation has been taking shape in the institute and has led to the appointment of a Social Responsibility Technical Committee and the adoption of a plan aiming at the embedment of the values and concerns of social responsibility in INESC TEC.

Building on a practice of compliance with non-discrimination and equality rules, INESC TEC is now committing to a more pro-active approach to building a diverse and inclusive community. This approach is not only in line with the institute values and law requirements, but also with the value of well-established contributions to research and innovation outcomes. Gender, ethnic and cultural diversity are among key priorities to be addressed.

2.5 Research and innovation goals

The institution's scientific objectives defined for 2018-2022 are aligned with its vision, and in particular with the commitment to **fostering pervasive intelligence,** translated at mission level as the creation of new digital intelligence paradigms and their application in its domains of expertise. 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 TEC's 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 - In this Cluster, we work in systems which can aggregate sensing, computer vision, communications, and navigation components. These systems are mostly low power and implement edge intelligence (including cyber-physical systems and autonomous systems), adapt and cooperate, and are able to learn from past experience. More specifically, we will design (1) smart modular sensing platforms to extract information from the environment and the human body, (2) intelligent computer vision architectures which will achieve functionality and performance surpassing humans, (3) adaptive and self-learning autonomous systems, and (4) self-learning communications for supporting these systems also in immersive and extreme environments. The Cluster's **5-year objectives** include the following: in **Sensing**, we will fabricate micro-optical devices, create new fabrication techniques, develop low-power hardware, work in sensing textiles, develop multimodal sensing systems with embedded AI, and create digital twinning in real-time; in **Computer Vision** we will improve our current CV techniques in order to reduce dependency on labelled data, improve performance in close-world scenarios, define CV and other sensory processing information architectures which are increasingly independent from applications, reduce energy consumption of algorithms, develop new explainable deep learning architectures, infer information through multimodal approaches including other sensors, and cooperate in the fabrication of low-power sensory enabled chips; in **Autonomous Systems** our focus will be in underwater robotics and we will design robots with more flexible roles that can operate in more complex and open environments, which may have more flexible plans of operation, that can function in deeper waters, and increasingly augmenting the percentage of information processed and learned locally; in **Communications** we will design and develop smart antenna arrays with digital control beam steering, on adaptive modulations, and with the integration of machine learning approaches in selected communications layers.
- POWER AND ENERGY - The Cluster's vision is aligned with the EU policies for digitalisation, energy efficiency and increase in Renewable based Energy Sources (RES) integration, and includes as main challenges the transformation of the energy sector through synergies between advanced mathematical modelling and digital technologies, the full decarbonisation 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) **Renewable Energy Integration**; (2) **Power and Energy Systems Planning and Operation**; (3) **Smart Grids and Digital Energy Systems**.
- INDUSTRIAL AND SYSTEMS ENGINEERING - Future European industry has to combine high and widespread productivity with a high level of environmental and social sustainability. This will mean moving from local optimisation – for individual companies or clusters of firms - to complex systems optimisation, with major impacts on the way supply chains and factories are designed, on the technologies used, infrastructure and wider government policies. Some of these technologies are being thoroughly studied within the Cluster of Industrial and Systems Engineering (ISE) from the lens of operations management and decision support, namely collaborative robots, optimisation, machine learning and blockchain. In order to make more supported, informed and intelligent decisions, there is a need to conveniently extract knowledge from data that could be leveraged to increase efficiency and growth of businesses and promote sustainability. Moreover, the next generation of robots is able, in a variety of degrees, to work side by side with humans. However, the full potential of technological innovations, can only be achieved in case technology is appropriately adopted and diffused. The Cluster ISE researches and innovates in systems and services applied to the management of value streams in different industries (e.g., manufacturing, process industries, retail, health and mobility), and tackles the aforementioned challenges developing state-of-the-art breakthroughs across cross-fertilising five research lines: **Operations Management**, **Operations Research & Management Science**, **Autonomous Systems**, **Technology-enabled Innovation**, and **Industrial Information Systems**.
- COMPUTER SCIENCE - Computing is reaching all aspects of modern life. Sensing and computing devices are increasingly found in all sorts of equipment and appliances. This trend is impacting human society and will also reach other living beings, giving rise to a potentially intense cyber-bio-physical interconnectivity and interplay. This pervasive digitalisation brings several transversal challenges. As

computing becomes fully decentralised, mobile, increasingly autonomous, and ubiquitous current information and communications systems pose many hard and intricate challenges associated to scalability, security and criticality. The amounts of data that need to be efficiently, timely and ethically explored and exploited, challenges our capacity to filter, curate, store, process, query and visualise the data. In addition, the economic data value, trade and state secrets, and individual rights require data manipulation to comply with demanding levels of privacy. Smarter and autonomous systems in critical realms such as utilities, health care, transportation and finance require dealing with new, and often unanticipated, that challenge the best practices of software engineering, network and information security and human-computer interaction. INESC TEC is in a unique position to address many of these technological and societal challenges with its competences on **Artificial Intelligence, Computer Graphics and Virtual Environments**, **Cryptography and Information Security**, **Information Management and Systems**, **Parallel and Distributed Computing** and **Software Theory and Engineering**.

These scientific objectives are complemented by knowledge valorisation and technology transfer targets, structured namely by TEC4 initiatives, as thoroughly covered in Section 5.

3 RESULTS ACHIEVED IN 2020

This section presents a short summary of the results INESC TEC achieved during 2020, including highlights of the activity and the main indicators for human resources, activity in projects, scientific publications, IP protection and dissemination. 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 Facing the COVID-19 Pandemic

For years to come, to mention the year 2020 will be to refer to the COVID-19 Pandemic that has gripped the world and redefined our lives.

From the outbreak of the sanitary crisis in Portugal, INESC TEC instantly mobilised along two clear strategic lines. The first was to protect INESC TEC community while ensuring the continuation of its activity and its commitments towards its partners. On the other hand, to be part of the solution, channelling all its know-how to contribute to the scientific response to the Pandemic.

As for the first part, in mid-March, INESC TEC's co-workers were all sent home to work remotely. For the first time in its history, INESC TEC's premises, normally full of life and people, were silent. According to its Contingency Plan, INESC TEC started operating in a hybrid mode: most researchers teleworking, and only essential technical support services at the premises, on a rotating basis to ensure minimum interaction with other co-workers. The Plan defined all the measures and procedures for prevention and action in the context, including basic protection measures (respiratory etiquette, hand asepsis, physical distance), use of PPE (made available from the first moment without any shortages) and also the procedures to be followed in case of detection of infection, either through the expression of symptoms or through epidemiological screening. Particular measures were also taken in the buildings, such as the adaptation of social areas that remained in operation (meal areas), the creation of a code to identify the areas that may be occupied by team members simultaneously, the definition of rules for permanence and circulation and the definition of procedures for cleaning and disinfection of the premises.

With the arrival of winter, the Board of Directors also decided to grant its contracted employees an energy subsidy, based on a calculation of the energy needs of a typical office in the District of Porto, seeking to support the increase in energy costs that the employees incurred as a result of working from home.

All the measures were described comprehensively in the Contingency plan, which was widely disseminated among the community. Moreover, regular, proportional and simple communication was carried out to ensure that, at every moment, there were no uncertainties on how to act. Guidelines and support tools were prepared and disseminated for researchers and project leaders, and special attention was also given to the necessary and adequate conditions for teleworking, namely through the reinforcement of the central support infrastructures and the provision of office equipment and computer/communication hardware whenever necessary (internet, web conferencing gear). To avoid the need for paper-based document exchange, digital repositories and processes were reinforced. The laboratory activities were suspended in March and only restarted in the last week of May, under strong protection measures, including the preparation of individual plans for each of the infrastructures, where occupancy limits and individual/team protection procedures were defined.

To keep the community informed and united in such difficult times, internal communication between the Board and all the co-workers was strengthened. Regular messages were sent, both from the pandemic support line (with informative messages ensuring an inclusive and motivational tone) and from the Board of Directors, in order to maintain a sense of belonging and a concern for the wellbeing of everyone. Finally, specific training actions were promoted to reinforce internal skills and capacities, and to ensure good performance in this new operational environment.

In order to ensure their activity, regular and frequent communication with the project teams was ensured. Communication with partner organisations was strengthened and articulated with the support of TEC4 initiatives. Project meetings became fully virtual, and scientific conferences and workshops were suspended for some time before being successfully resumed as online events.

A detailed analysis of possible risks and impacts was carried out. Ongoing activity was reviewed and rescheduled where necessary. A great effort was made to keep the relations with INESC TEC's partners active and to design new projects and new proposals to ensure the continuity of the activity in the institute. The fact that most of

INESC TEC's partners and clients are technology-based public enterprises and services justified a smaller impact on these sectors, as opposed to, for instance, the industry sector.

At the peak of the Pandemic, and aware of its social responsibility, INESC TEC extended, to all its community, the decision to automatically renew grants and fixed-term contracts that were due to end during this period, being aware of the difficulty in finding new professional opportunities in this context. Also, in this framework of social responsibility, the organisation made available to school age children of its co-workers (when such need was expressed), reconditioned computer equipment to have distance learning classes, which, although already limited for research activity, still served this purpose. This work was done by INESC TEC's volunteers and at weekends, having managed to support some families in a very difficult moment.

As the sanitary crisis broke out and worsened, INESC TEC researchers promptly rallied and started coordinating/participating in several initiatives to fight against the COVID-19 Pandemic, while producing socially relevant and impactful science.

INESC TEC used its digital skills to **help and guide its industrial partners in the context of the pandemic for rapid conversion to remote working**.

At the beginning of the outbreak, several INESC TEC researchers partnered ith UP and INEGI for **the production of protective visors**, to be distributed among the São João, Santo António, Gaia-Espinho and Pedro Hispano **hospitals**, as well as healthcare units in the Northern region. These visors were 3D printed and were crucial to protect the healthcare professionals who were fighting against this pandemic when there was still a short supply of protective material.

Considering the scarcity of ventilators in the first months of the Pandemic, INESC TEC and several other partners started working on **PNEUMA**, a prototype for a low-cost and easy to assemble field **ventilator** which aimed to address the following demands: 1) Temporary support in second and third-line hospitals (with patients awaiting transfer to central hospitals, including patients without COVID-19); 2) Scenario of moderate shortage of ventilators (as an alternative to transient invasive ventilation in patients with acute respiratory failure requiring volume and respiratory rate control, Availability of ventilators for cases that require the fine monitoring of parameters - pressure exerted, inspiratory/expiratory ratio (I:E), etc.); and 3) Scenario of critical shortage of ventilators, as a possible alternative in the event of the complete absence of ventilators. The team responsible for the development of this ventilator worked pro bono and was composed by the Faculty of Engineering of the University of Porto (FEUP), IEP – Instituto Electrotécnico Português and INEGI – Institute of Science and Innovation in Mechanical and Industrial Engineering. The results are available as open source, in order to enable the local production of this alternative ventilator in any country. AIMMAP (Association of Metallurgical, Metalworking and Related Industries in Portugal) and FLAD (Luso-American Development Foundation) supported the acquisition of components to build near 90 of those ventilators.

Launched on March 23, the **study "Diaries of a pandemic"** invited citizens to answer a set of questions on a daily basis, in order to help understanding the evolution in the lives of Portuguese people during the COVID-19 Pandemic. Coordinated by ISPUP - Institute of Public Health of the University of Porto, it also counted with the strong involvement of INESC TEC and the newspaper Público.

INESC TEC's most prominent contribution to the response to the Pandemic might be the **STAYAWAY COVID** Application, the **official Portuguese digital contact tracing application**, launched in the second semester of 2020, and which reached over 3 million downloads. STAYAWAY COVID app can be installed on mobile phones and used to detect the physical proximity between smartphones, in order to inform users who have been in the same space as someone infected with the new coronavirus over the previous 14 days. Thanks to this information, users can promptly request a diagnosis for the infection, even before the occurrence of any symptoms. When a user is diagnosed with COVID-19, and after his/her permission, the codes he/she has broadcast over the previous 14 days will be publicly shared via an official server. This way, the application helps others by alerting and notifying them about their contact with someone infected with the virus. This process takes places without ever revealing the identity of the users involved. The application was developed with the partnership of ISPUP, Keyruptive, and Ubirider, as an initiative of INCoDe.2030 and co-funded by FCT - the Foundation for Science and Technology.

Another free app to which INESC TEC contributed was **Psicovida**, an **application that provided free psychological support** during the pandemic. Psicovida's goal was to support the national community by ensuring equitable and free access to psychological crisis intervention in the current pandemic context. It was a mobile application that

allowed users to speak directly with qualified psychologists, through video calls, while providing several self-help strategies. The psychologists collaborating in each of the modules were hired through a register of civil society psychologists, and their participation was voluntary and supportive. INESC TEC partnered with Outsystems, University of Minho and the Psychology Association of the University of Minho (APsi-UMinho).

Another initiative **was CoronaSurveys**, dedicated to **measuring the real impact of COVID-19 in 150 countries**, through research carried out on social media. The survey "Measuring the Iceberg" is available online, in 60 different languages and in addition to providing the total number of symptomatic infected people per day, the study helps researchers observe the evolution of the disease. Everyone can access the survey, available online and in order to facilitate people's participation, the project developed a mobile app, thus promoting citizens' involvement. This study was one of the five finalists of the international competition COVID-19 Symptom Data Challenge and received an honourable mention and $3,000 in AWS credit in the XPRIZE Pandemic Response Challenge. The initiative has 2 Portuguese partners, University of Minho and INESC TEC, besides several international Universities and research institutions as partners.

RADAR – an Autonomous Robot for Disinfection in Hospitals – was one of INESC TEC's projects approved by the Foundation for Science and Technology (FCT) within the scope of the Research 4 COVID-19 financing line. The autonomous robot developed helps disinfecting rooms at hospital units, through sensors and UV lamps. The prototype was in the testing phase in 2020. The robot includes an autonomous navigation system, i.e. it is able to locate and navigate through contaminated rooms, monitor the presence of people in the surroundings, and carry out the disinfection process independently. The architecture is modular and adaptable to different robotic platforms that already exist. The project was developed with the partnership of the Faculty of Engineering, University of Porto (FEUP), the São João and São Martinho Hospitals.

Another project supported by the RESEARCH 4 COVID-19 financing line was the **COVID-19 Diagnosis System applied to chest X-Ray images** that can help define the diagnosis and treatment strategies for each patient, by proposing a second opinion to radiologists or other non-specialised staff. This computer-assisted diagnosis system was developed in partnership with radiologists from the Vila Nova de Gaia/Espinho hospital centre (CHVNGE) and the Northern Region Health Administration (ARS Norte).

At the end of 2020, INESC TEC was still actively preparing or entering new initiatives and projects in the context of the Pandemic. As the world will endure to forget the year 2020 and all the disastrous consequences in the lives of individuals and economy at large, INESC TEC will nevertheless remember it as the year when the scientific community came together and rose up to face an unknown and invisible threat, and INESC TEC stood up to take part in its efforts.

3.2 Highlights in 2020

Notwithstanding the activity conditioned or focused on the COVID-19 Pandemic, the year of 2020 was still a year of significant results and institutional accomplishments. Overall, INESC TEC carried out the steps foreseen for the main initiatives planned for 2020, with more or less extensive adaptations arising from the pandemic, depending on the nature of each initiative. INESC TEC strove to strengthen its fundamentals and maintain its financial robustness, while reinforcing its intervention capacity in the national and international Science and Technology systems and its ability to carry out its mission for the benefit of society.

The main achievements in 2020 are summarised next, broadly under the same categories that were adopted for the 2020 plan: INESC TEC as engine of science-based innovation, managed science model, internal activities, internationalisation, calls of strategic importance and contributions for public policy, openness to society, support structure, infrastructures and structural initiatives.

INESC TEC AS AN ENGINE OF SCIENCE-BASED INNOVATION

- According to the 2020 edition of the European Innovation Scoreboard, Portugal was the fourth country in the EU with the strongest progress in innovation since 2016 and became a "strongly innovative" country for the first time. A similar innovation category progress had already been observed for the Norte region in 2019. The two achievements are the result of decades of dedication and hard work by multiple stakeholders in the Portuguese economy, that INESC TEC is proud to be a part of;

- Despite an adverse context, INESC TEC's activity increased 2%, extending a period of more than a decade of continuous and sustainable growth, contributing to the advancement of science and technology, economic development and social progress. In addition to maintaining a high level of R&D contracts with industry (3.6 M€, representing an increase of 10%);
- INESC TEC remained one of the top 5 Portuguese organisations in net contribution and participation in H2020 competitive research funding, with 36% of its total project funding (90 projects) coming from European programmes. For the fourth consecutive year, INESC TEC was also one of the top five national entities in patent applications submitted to the European Patent Office (EPO);
- Indexed journal publications increased slightly to 398 articles, 62% of them in first quartile journals, whereas indexed conference publications decreased 44% to 317, due to the negative impact of COVID-19 on the organisation of conferences. The number of PhD theses supervised by INESC TEC researchers that were defended in 2020 increased 39% to 46;
- At the end of 2020, INESC TEC hosted more than 730 integrated researchers, 354 with a PhD. In 2020, the most noticeable evolution in Human Resources was the significant increase (26%) in the number of R&D employees (reaching a total of 152), in the scope of the continued implementation of the Government's policy for scientific employment;
- The institute continued to improve existing laboratories, concluded significant upgrades in the Energy and Sea infrastructures, and launched the expansion of iiLab (Industry and Innovation Lab) to PORTIC, a P. Porto building, in a global investment of 3.3 M€ (85% funded by NORTE 2020 regional programme).

MAIN INITIATIVES

- **Managed science model**
  - Organisation of a TEC4Clusters internal workshop that gathered all senior researchers and focused on the interplay between Clusters and TEC4s. Its conclusions were key for the preparation of the virtual meeting with the Scientific Advisory Board in October 2020;
  - Progressive redefinition of the concept of Cluster as a means to strengthen the Institution's scientific strategy, grouping and characterising the developed activity in Research Lines, which become the strategic scientific anchors of the organisation, both in the recognition of its current activity and in the development of future activity;
  - Reinforcement of the research team with the recruitment of researchers for key strategic areas (31 hired researchers), in line with the government policy for scientific employment.
- **Internal activities**
  - The second call for Internal Seed Projects, aiming at supporting internal exploratory R&D activity, was launched in late 2019 and its results were known in 2020. The Evaluation Committee was composed by Manuel Ricardo (Chair), Jorge Pinho de Sousa, Francisco Moura, José Nuno Fidalgo, José Fernando Oliveira and José Ruela. The Committee carried out a highly demanding work with outstanding diligence. With an outcome similar to the previous year, five new projects were approved, two in the inter-centre research category, one in junior researcher development, and two in commercialisation proof-of-concept. The scientific areas covered Graphene, Underwater Robotics, Data Marketplaces, Crowd Computing, and Quantum Simulations;

    Due to the severe conditioning of the execution of the projects from the first edition, caused by COVID-19, their extension was authorised and they are expected to be completed in the first months of 2021;
  - Also due to COVID-19, the visit of the new Scientific Advisory Board planned for October 2020, for the periodic review and discussion of the institute's scientific strategy, switched to a virtual meeting. Despite the limitations of a virtual event, it allowed a fruitful first contact and the definition of future work, and a site visit was rescheduled for September 2021.

- **Internationalisation**
  - Formalisation of SRI, the new service to reinforce the management of international relations, which integrates also the Brazil and India offices and INESC Brussels Hub;
  - Entry into full operation of INESC Brussels Hub, the Brussels representation of INESC TEC, INESC Coimbra, INESC ID, INOV INESC and INESC MN, set up in 2019:
    - The physical space and basic services in Brussels were established, and the office hosted international project meetings (2 from INESC TEC) and 17 meetings with European stakeholders to introduce the new representation;
    - A set of robust activity indicators and information from all institutes were structured for internationally-oriented presentations, which have been used in visibility raising, representation, and lobbying activities, in particular in meetings with the European Commission (4), European Parliament, and European networks and platforms, including the 7 EARTO thematic work groups;
    - Support was also provided to 5 tenders (1 approved with the participation of INESC TEC) and 1 COST Action (also with the participation of INESC TEC);
    - Two initial thematic workgroups (Health Technologies, and Agriculture, Food and Forestry) were chosen, to strengthen areas where European presence is not yet at the desired level, but already have the critical mass to increase participation in projects and open new industrial collaborations. These groups produced high-quality outputs and allowed an increased collaboration between INESC researchers, namely resulting in the joint submission of projects - 3 tenders, 1 H2020 and 1 FCT proposal identified by the researchers as having resulted from this activity;
    - This work was complemented with internal capacity building through training workshops, as well as analysis and positioning efforts to influence the first Horizon Europe work programmes and key policy areas (such as synergies between EU and national funding programmes and instruments, or the role of technology infrastructures and related EU funding opportunities);
    - At the same time, an intense effort to promote visibility and strategic positioning was made, in particular through the integration of key EU networks (such as EARTO) and a close partnership with the main visibility platforms for research and innovation at EU level (such as Science Business). The joint efforts of the 5 INESC institutes allowed for a strong positioning when, in one voice, Directors of all the institutes met with the European Commission and the European Parliament, or when thematic work groups met and presented jointly to relevant sectoral EU networks.
  - Consolidation of INESC P&D Brasil, with the formal entry of one new associate, Universidade Federal de Campina Grande (UFCG), while negotiations for the entry of 3 other Universities were delayed by the Pandemic. Thus, in 2020, INESC P&D Brasil counted 8 Associates (INESC TEC and 7 Brazilian Universities) completed by the Network INESC BRASIL which gathers 12 additional HEI;
  - Continued hosting of the Coordination of the UT Austin Portugal Program by INESC TEC, as developed in detail in Section 8;
  - Intensification of the participation in the European Knowledge and Innovation Communities (KICs) EIT Raw Materials, EIT Manufacturing and EIT Digital;
  - Active participation in 15+ international associations. Besides a special mention to its participation in EARTO - the European Association of Research and Technology Organisations - in its first full year as a member, in 2020, INESC TEC joined the international Associations EERA – European Energy Research Alliance and IDSA - International Data Spaces Association, as well as the network ERMA - European Raw Materials Alliance;

- Implementation of a set of Memoranda of Understanding with research organisations from Japan (AIST), India (IIT Delhi and IIT Madras), Thailand (Thammasat University) and Taiwan (NARLabs).

- **Calls of strategic importance**
  - By the end of 2020, INESC TEC applied for renewal of the title of Associate Laboratory and the corresponding additional funding awarded by FCT. The results of the call were disclosed early 2021, INESC TEC received a classification of excellent and saw the title renewed for 10 years;
  - In early 2020, INESC TEC submitted a formal complaint regarding its disappointing evaluation in FCT's 2018 R&D Units assessment. In early 2021, the formal complaint Evaluation Panel decided to uphold the prior outcome, in an assessment that the institute once more regarded as very unsatisfactory and for which different reaction scenarios are being considered;
  - Submission of 100 proposals in the last calls of Horizon 2020 and 33 in ANI P2020, which were of very high importance for the period of bridging to the new funding programmes, for many of which the results are still awaited;
  - INESC TEC submitted 188 proposals to the extremely competitive FCT Calls in 2020, 12 of which were approved;
  - Funding request to FAI and FEE, a project to develop a technological solution to support the sustainable operation of the supercomputing infrastructure associated to the deployment of the Deucalion computer, taking advantage of the local availability of renewable resources and reusing the heat resulting from the cooling process of the machine. This will be an innovative project at European level, with great impact on the scientific community by providing a sustainable computing platform for its use.

- **Contributions for public policy**
  - Contributions to administrative simplification in the area of Science and Technology at a national level, namely being part of the Working group created by the Portuguese Government to simplify R&D applications for the Portugal 2020 programme;
  - Continuing involvement in the update of the regional and national smart specialisation strategies in the institute's areas of expertise, including Advanced Manufacturing Systems; Culture, Creation and Fashion; Life Sciences and Health; Mobility Industries and Environment; Marine Resources and Economy; Agri-environmental Systems and Food;
  - Contributions to the procurement, funding and hosting conditions of the EuroHPC JU petascale system "Deucalion" to be installed in the AvePark;
  - The nine Collaborative Laboratories (CoLABs) that INESC TEC is associated with, gave major initial steps in 2020, opening opportunities to expand research into their areas of application, strengthen knowledge sharing and enhancement, create highly qualified jobs for young talent, and overall strengthen the institute's position as an interface institution of excellence. A more detailed review of their progress is provided at the end of this chapter.

- **Openness to society**
  - The pandemic forced a change to virtual alternatives of the activities planned for INESC TEC's 35th anniversary, which were associated with the commemorations of the 40th anniversary of INESC, including the hybrid commemorative session held in Porto in July;
  - A new magazine, "INESC TEC Science & Society", was launched, aiming at disseminating science in society and contributing to the discussion of technology-influenced public policies. The inaugural issue's special topic was "Data Science, Artificial Intelligence and Health" and included 11 articles by 19 authors with research and education careers focused on those fields. The magazine publishes opinion articles by researchers on the topic of each issue, seeking to contextualise and clarify readers, highlighting solutions enabled by scientific and technological advances;

- Due to the pandemic, INESC TEC's Autumn Forum was cancelled. The event, where relevant actors are annually invited to present and discuss their views on topics of importance for the country, will be rescheduled for 2021, if the sanitary conditions allow it;
- 2020 was the year that recorded the highest number of INESC TEC news over the last 20 years. In fact, in this atypical pandemic year, INESC TEC's media projection increased greatly, largely due to the STAYAWAY COVID app;
- In the first part of the year, until it was cancelled because of the pandemic, INESC TEC was one of the R&D institutions on board of the School-Ship Sagres, on a mission serving as a scientific observation platform, within the scope of project "SAIL – Space-Atmosphere-Ocean Interactions in the marine boundary Layer". On January 2020, Sagres left Lisbon to start a 371-day trip around the world. However, the crew was instructed to anticipate its return to Portugal, due to the pandemic. The measurements that were collected are nevertheless being exploited for research purposes.

- **Support structure**
  - The implementation of a new model for Human Resources management continued in 2020, following the recommendations from the diagnostics carried out in 2019. For that purpose, the charges for five specialised work groups - on performance appraisal, training, career development, recruitment, and employee life cycle - were defined and two groups - performance appraisal and career development - were established and started their activities. A foundational mapping of functions and skills was also launched, and will be concluded in 2021;
  - In accordance with the 2019 revisions to the Research Fellowship Holder Statute, the new INESC TEC Grants Regulation was approved and implemented which, among other measures, provides for the payment of student fees by the institution as a measure to attract talent;
  - Following the Funding Opportunities Office plan, in 2020 the team was reinforced with one new element, focused on international opportunities (namely European Funding). Simultanesously, the office developed a series of thematic webinars to support researchers in the different opportunities and provided a review on specific section of proposals. The office has been in articulation with INESC Brussels HUB to foster INESC TEC position in the European context;
  - Launch of an initiative to reinforce the institution's information systems to support the sudden shift to remote work during the pandemic. The main data centre has been completely rebuilt, the dematerialisation plan was accelerated and several services were reinforced (VPN, backups) and secured, by expandinf the firewall perimeter.
- **Infrastructures**
  - Adaptation works were launched in PORTIC, a P. Porto building, for the relocation and expansion of the technological infrastructure in the Industry 4.0 domain, aiming at expanding the already existing iiLab – Industry and Innovation Lab that covers areas such as Cyber Physical Systems (CPS) & Internet of Things (IoT), Business Intelligence & Decision Support Systems, Advanced Automation & Industrial Robotics, Mobile Robotics & Internal Logistics, Industrial Vision Systems for Inspection and Quality Control;
  - In addition to the continuous improvement of the existing laboratories, significant upgrades in the Energy and Sea infrastructures were concluded in the scope of projects SGEVL, EMSO-PT and TEC4Sea. In the latter, the construction of one research vessel (+850k€) that will allow autonomous access to deep sea was commissioned and will be ready in 2021;
  - An important number of larger scale maintenance and conservation actions (ventilation and air conditioning, Transformer Substations, electrical installations, etc.) were carried out in the various buildings, taking advantage of the lower usage by the community.
- **Structural initiatives**

- An open discussion of a draft proposal of a Code of Ethics was concluded in early 2020 and the proposal was preliminarily shared with INESC TEC's General Council. Its approval will take place following the conclusion of additional formal steps with the Associates;
- In 2020, the diligent work in the internal strategic areas of conflict of interest management, diversity and inclusion, social responsibility and data protection, which had been consolidating in previous years, became fully developed and matured. Therefore, they are presented in more detail in the following subsection 3.3 by the respective Commissions and Working Groups.

MAIN S&T ACHIEVEMENTS

INESC TEC's Science and Technology achievements in 2020 are described in greater detail later in the report, in the Clusters and Centres sections. This section presents the achievements selected by the Clusters as highlights of the advances carried out by the institute's R&D team in 2020:

- In the Networked Intelligent Systems Cluster, the 2020 highlights are: **Optical Graphene Microphone.** Fabrication of graphene oxide thin films through dip coating technique was employed for the assembly of membranes in optical fibres for acoustic or pressure sensing. This deposition process allowed the development of ultrasonic sensors for broadband spectrum and were compared with a conventional microphone. The deposition technology is being adapted for the manufacture of graphene-based antennas in the GHz range. The study of graphene inks is also being explored for sensing applications. **Parallel Implementation of K-Means Algorithm on FPGA**. A fully parallel K-means algorithm was implemented on FPGA to optimise the system's processing time, a key enabler for real-time applications taking advantage of machine learning techniques and enabling the edge intelligence concept. **Uncertainty-aware deep learning-based approach for computer-aided diagnosis and grading.** A CAD grading system that supports the clinical decision and the assigned pathology grades by providing a medically interpretable explanation. This methodology was successively tested in grading Diabetic Retinopathy. A deep learning model for Covid-19 detection in X-ray images was also designed using a dataset containing the manual labels given by two radiologists, including intra and inter-observer variability, in 1.845 chest X-ray images. **Underwater docking**. A multi-sensor system for underwater docking operations - this system combines short-range acoustic positioning with visual perception, allowing for a global solution of the relative localisation problem in underwater docking maneuvers;
- In the Power and Energy Cluster, the 2020 highlights are: Design and implementation of the second generation of a home energy management system (HEMS) within the InteGrid project. The new version is capable of determining the flexibility within a household, represented under a single battery formulation, for modular clustering and privacy design implementation. First prototype (P2PChain) of a local market platform for energy trading based on Ethereum blockchain technology with an innovative post-delivery local energy market design (INESC TEC seed project). Data-driven methodology to predict distribution lines (overhead and subterranean) failure location in HV and MV networks operated by E-REDES, considering meteorological variables, geographical location, and physical characteristics (e.g. conductor material). Development of a methodology to monetise the benefits of the investments in the distribution system concerning the security of supply, the quality of service, the distribution losses and operational efficiency. The tool includes the estimation of the distribution grid quality indices evolution and assists the DSO on the medium and long-term planning decisions;
- In the Industrial and Systems Engineering Cluster, the 2020 highlights are: **Production Planning and Scheduling.** A real time scheduling engine integrated with an IIoT platform to monitor, detect and evaluate disturbances on plan execution, and suggest corrective measures. **Mathematical Programming-based heuristics.** New insights were obtained on how to deal with uncertainty and hybridize heuristics and mathematical programming (matheuristics). These approaches have been applied on emerging topics related to urban logistics (in particular "last mile"). **Navigation, Localisation and Coordination of Mobile Robots.** A novel open-source Path Planning solution Aware of Robot's Centre of Mass for Steep Slope Vineyards. **Service Design.** Co-creation and launch of the ServCollab, a global initiative of service researchers to improve well-being;
- In the Computer Science Cluster, the 2020 highlights are: INESC TEC has designed and developed the Portuguese digital contact tracing system for COVID-19, STAYAWAY COVID. As a partner of the

Decentralised Privacy-Preserving Proximity Tracing consortium, INESC TEC contributed to the protocol underlying the Apple/Google Exposure Notification service and Huawei's Contact Shield. INESC TEC co-chairs the Portuguese node of the Research Data Alliance (RDA), a third-party agreement in the context of the RDA-Europe 4.0 European project and became involved in the European Network of Excellence on Artificial Intelligence through the H2020 flagship Project HumanEAI. INESC TEC's theoretical groundwork has been deemed referential to the Immersive Learning Research Network (ILRN) and multiple contributions on the impact of multisensory stimuli in virtual environments have been published in IEEE Transactions on Visualisation and Computer Graphics. The University of Porto, the Polytechnic of Porto and INESC TEC have organised a Summer School on Machine Learning and Big Data with Quantum Computing that brought together about 2 000 participants.

In addition, the following awards and recognitions deserve a special mention:

- INESC TEC received the Scientia Mare 2020 Award attributed by PwC – PricewaterhouseCoopers – at the Webinar "Excellens Mare". The Scientia Mare Award is one of the seven accolades included in the Excellens Mare 2020 Awards, which aim to acknowledge the excellence and value of those who produce significant advances in sea knowledge or who promote blue innovation;
- INESC TEC projects ScalABLE 4.0 - Scalable automation for flexible production systems - and KnowLogis - Expertise in Healthcare Logistics, were acknowledged at the Portugal Digital Awards 2020, an initiative promoted by IDC, in partnership with Axians;
- INESC TEC's researcher João Gama, also full professor at the Faculty of Economics of the University of Porto, was appointed Fellow of IEEE - Institute of Electrical and Electronics Engineers. This distinction was awarded as a result "of his contributions in terms of techniques of knowledge extraction from continuous data flows". Few months before, João Gama had been nominated EurAI Fellow by the European Association for Artificial Intelligence, a very exclusive recognition, restricted to a set of researchers who stand out due to the quality and relevance of their work in the field of Artificial Intelligence;
- At the annual REN Prize Awards, João Graça Ramos, João Megre Barbosa and Luís Brito Teixeira received the first, second and third prizes respectively for their Master's theses. Created in 1995, the REN Prize is one of the oldest scientific awards in Portugal. Awarded by a jury composed of renowned professionals, it chooses the best Master's theses (annually) and PhD theses (biannually) in the area of energy developed in Portuguese universities;
- Three researchers from INESC TEC occupied the podium in the edition of the APREN 2020 awards. The award, attributed by the Associação de Energias Renováveis (Renewable Energy Association), recognises the best academic dissertations carried out in Portuguese universities on electricity from renewable sources. The awards were received at the APREN Annual Conference (Portugal Renewable Energy Summit), which took place, online, on 6 and 7 October 2020;
- Two researchers from INESC TEC's Telecommunications and Multimedia Centre (CTM) were distinguished with three awards, given by Fraunhofer Portugal and the Portuguese Association for Pattern Recognition (APRP) - the latter, within the scope of the 26th edition of RECPAD - Portuguese Conference on Pattern Recognition;
- A researcher from the Centre for enterprise systems engineering (CESE) was one of the winners of the 11th edition of the Mário Quartin 2020 Scientific Award, in the Economic and Business Sciences category. This award annually distinguishes the best doctoral theses carried out in Portugal and Latin America. The Mário Quartin Graça Scientific Award, established by "Casa da América Latina" and Banco Santander, is intended to distinguish doctoral theses by Portuguese or Latin American researchers in universities in Portugal or Latin America.

3.3 Commissions and Working Groups

3.3.1 Conflict of Interest Management Commission

Chairperson: José Carlos Marques dos Santos

Presentation

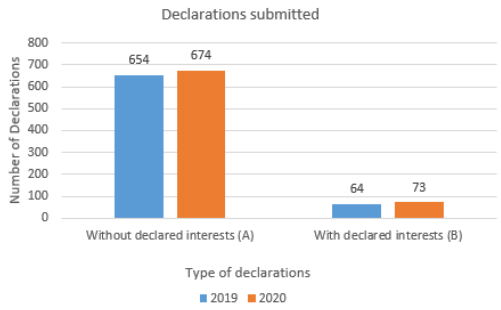
INESC TEC has a Conflict of Interest Management Policy, which applies to all integrated human resources. The Conflicts of Interest Management Commission has the responsibility to ensure compliance throughout the Institution, namely by:

- Assessing the declarations of interests and identifying the conflicts of interest;
- Agreeing with the members of INESC TEC on the terms and proposing to the Board of Directors management plans for the identified conflicts of interest, in order to reduce or eliminate those conflicts;
- Informing the members of INESC TEC about the conclusion of the assessment processes and about the terms of possible management plans for identified conflicts of interest;
- Formulating general recommendations concerning conflict of interest management.

Highlights in 2020

During 2020, the Commission, within the scope of its mission, developed a set of activities, of which the following stand out:

- Monitoring compliance throughout the Institution;
- Advising the Board of Directors;
- Elaboration and dissemination of important guidelines on policy procedures;
- Parameterisation and implementation of improvements in the IT platform, to better assist management processes;
- Declarations of Interest reception, assessment and handling:



To be noted that there are declarations classified by the employee as having interests, which turn out not to be the case, therefore do not give rise to any plan.

- Conflict of Interest Management Plans conception and monitoring:

To be noted that there are declarations (with declared interests) which are submitted at the end of a given calendar year, so the plan can only be generated at the beginning of the following year.

3.3.2 Working Group for Gender Equality

Chairperson: José Manuel Mendonça

Presentation

The Working Group for Gender Equality (hereinafter GTIG) was established in February 2019, as part of the strategic goal to promote gender equality, under the coordination of José Manuel Mendonça. GTIG's mission was to structure and propose an action plan, drawing upon a characterisation of the current situation of INESC TEC and the identification of best practices in other institutions and countries. The scope of the group acquired a wider range to address Diversity & Inclusion (D&I), following a discussion with the Board of INESC TEC.

Highlights in 2020

The original purpose of GTIG was to analyse the current situation of INESC TEC regarding Gender Equality and propose an action plan to promote gender balance/equality.

Following the proposal and discussion with the Board of Directors, the Gender Equality policy acquired a wider scope, to address Diversity & Inclusion (D&I).

In 2020, GTIG proceeded with the activities in order to achieve the above objectives:

- Characterisation of the current situation of INESC TEC regarding gender equality (in a first stage) and diversity & inclusion (in a subsequent stage), through interviews on existing D&I practices and key D&I indicators collection (Gender, Ethnicity/Nationality and Age);
- Collection, analysis and selection of a comprehensive list of D&I best practices, that were mapped according to their feasibility, organisational impact, implementation cost and priority to INESC TEC;
- Proposal of a long-term Action Plan for D&I, considering the current situation of INESC TEC and the selected best practices, which addresses the following strategic priority actions, meanwhile included in the activity Plan for 2021:
    - Creation of a "Commission for D&I";
    - Subscription of the letter "Carta Portuguesa para a Diversidade";
    - Presentation of a comprehensive proposal for a D&I Program that links the aims of D&I to key organisational domains: (1) Raising Awareness for D&I; (2) Talent Attraction; (3) Recruitment; (4) Selection; (5) Inclusion and Integration; (6) Training and Development; (7) Motivation, Reward and Retention; and (8) Management of D&I Processes and Communication.
- Delivery and Presentation of GTIG's final report to the Board of Directors, as well as a proposal for the respective presentation to the INESC TEC community.

3.3.3 Data Protection Officer

Data Protection Officer: Vasco Rosa Dias

Presentation

According to its legal statute, the DPO's principal role is to inform, advise about and monitor compliance with data protection law provisions and with the policies of the controller in relation to the protection of personal data, including the assignment of responsibilities, awareness-raising and training of staff involved in processing operations, and the related audits.

Highlights in 2020

- Approval and implementation of new data protection internal procedures, namely, those related to external audits and inspections, the operation of CCTV Systems, the registration or project proposals and the performance of Data Protection Impact Assessments, Response to Personal Data Breaches and the Exercise of Data Subjects' Rights;
- Continued implementation of the cooperation agreement established with ISPUP in the field of Data Protection;
- Advise and follow up of an increasing number of Data Protection Impact Assessments performed in the context of R&D projects of INESC TEC and ISPUP, many of which concerning Covid-19 related projects, such as: Diários da Pandemia; P&R 4 COVID-19: Preparação, resposta e vivência dos profissionais de saúde perante a epidemia por COVID-19 em Portugal; STAYAWAY COVID; and Fatores de risco para infeção por SARS-CoV-2 em Portugal: um estudo caso-controlo de âmbito regional;
- The contribution to the privacy preserving engineering project STAYAWAY COVID, in cooperation with governmental entities and the data protection national supervisory authority;
- Participation in the EDPS / Internet Privacy Engineering Network (IPEN) webinar on "Contact Tracing Apps as a large scale exercise in privacy engineering";
- Presence in several data protection and ethics governance bodies in H2020 projects coordinated by INESC TEC;
- Participation in two prior consultation procedures before the Portuguese supervisory authority;
- Monitoring of data protection related aspects of Data Management Plans in several H2020 projects;
- Preparation of an online course and several contents as part of the training and awareness plan for staff members and researchers;
- Continuation of the awareness-raising initiatives at INESC TEC and ISPUP with the organisation of the 3rd Open Talk on data protection and research and a data protection training Workshop;
- Production of guidelines and policies, e.g., privacy policies in mobile apps, or website development;
- Opinions and recommendations regarding, e.g., remote work, online processing of personal data and the Intranet, COVID-19 and the processing of health data;
- Negotiation and implementation of a large number of data processing and joint controllership agreements, including the establishment of a framework DPA with a foreign university;
- Monitoring and auditing activities, including the continuous update of the processing activities' records and the execution of regular programmed internal data protection related audits.

3.3.4 Technical Committee for Social Responsibility

Team: Sara Brandão, Joana Coelho, Bernardo Silva, Lídia Vilas Boas, Miguel Melo and Rita Cardoso

Presentation

Social Responsibility is "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis", as defined by the European Commission in 2011.

INESC TEC's Technical Committee for Social Responsibility was created in November 2019 and aims to promote both internal and external Social Responsibility actions, addressing issues related not only to the institution itself and its members, but also actions that support the local community and society in general.

The institution is still at an early Social Responsibility maturity stage and this committee aims to incorporate its principles into the organisational culture, working closely with INESC TEC' Executive Board. To this purpose, a full set of activities was strategically planned for the entire year of 2020. With the pandemic situation faced since March 2020, most of the planned activities were forced to be postponed and a revised action plan was presented in a public virtual session in September 2020.

Highlights in 2020

The worsening of the pandemic situation and its impact on day-to-day professional and personal lives, and the relationship with internal and external communities, were aspects that no one could foresee.

Most of the planned activities required people to be present in the institution. With creativity and a dedication much beyond normal duty, additionally complicated by the multiple confinements, the committee carried out 29 of its 49 planned actions. Even so, the balance was positive. The committee achieved 60% effectiveness in 4 months of activity, which was only possible with the help of others members of the INESC TEC community who kindly joined in.

In summary, the following actions were carried out:

- Creation of a Mascot that will help incorporate Social Responsibility as a value of the institution;
- Public presentation session; creation of an internal newsletter; creation of a new space on the intranet; launch of a new section of the BIP newsletter dedicated to Social Responsibility;
- Launch of the initiative "TECH Converter: Toma e Retoma" and promotion of other volunteer actions, such as awareness-raising for blood and bone marrow donations;
- Advising the Executive Board on requests for possible collaborations;
- First steps in the validation of institutional values, to raise awareness and foster their alignment with the actions of INESC TEC members;
- Two recycling campaigns: collection of Nespresso used capsules to be recycled and used as rice fertilizer, with the resulting rice crop being donated to "Banco Alimentar"; collection of plastic bottle caps to be further donated to a Humanitarian Institution for recycling and valuing;
- Healthier offers were made available in vending machines, raising awareness for healthy working habits;
- Gathering of information on research projects with an impact on civil society, with emphasis on initiatives related to the COVID-19 response;
- Production of an annual activity report, presenting all the activities developed and the impacts achieved, conveyed to the Executive Board, which can be consulted for more detailed information on all the activities carried out by this committee.

All the actions that were not carried out in 2020 were included in the 2021 plan. Others were added, responding to all the transformations required by the changes in daily activities currently being faced.

3.4 Human Resources

3.4.1 Global Indicators

Table 3.4.1 and Figure 3.4.1 show the breakdown of Human Resources by type of contractual relation with INESC TEC and its evolution since 2018. The number of researchers with PhDs is also shown (354 at the end of 2020).

It should be noted that, in terms of Full-Time Equivalent (FTE) measures, INESC TEC employees and grant holders have typically a FTE corresponding to 100%, while academic staff usually have a 50% FTE and affiliated researchers no more than 30% FTE.

Table 3.4.1 - Evolution of Human Resources

Type of Human Resources			2018	2019	2020	Δ 2019-20	
Integrated HR	Core Research Team	Employees	102	121	152	31	26%
		Academic Staff	155	160	169	9	6%
		Grant Holders and Trainees	418	351	334	-17	-5%
		Total Core Researchers	**675**	**632**	**655**	**23**	**4%**
		Total Core PhD	**259**	**257**	**264**	**7**	**3%**
	Affiliated Researchers		70	72	77	5	7%
	Administrative and Technical	Employees	80	84	94	10	12%
		Academic Staff	9	9	11	2	22%
		Grant Holders and Trainees	14	7	9	2	29%
		Total Mgmt, Admin and Tech	**103**	**100**	**114**	**14**	**14%**
		Total Integrated HR	**848**	**804**	**846**	**42**	**5%**
		Total Integrated PhD	**339**	**341**	**354**	**13**	**4%**
Curricular Trainees			15	21	38	17	81%
External Research Collaborators			203	216	237	21	10%
External Administrative and Technical Staff			12	7	7		
External Students			121	138	141	3	2%
Total			**1199**	**1186**	**1269**	**83**	**7%**

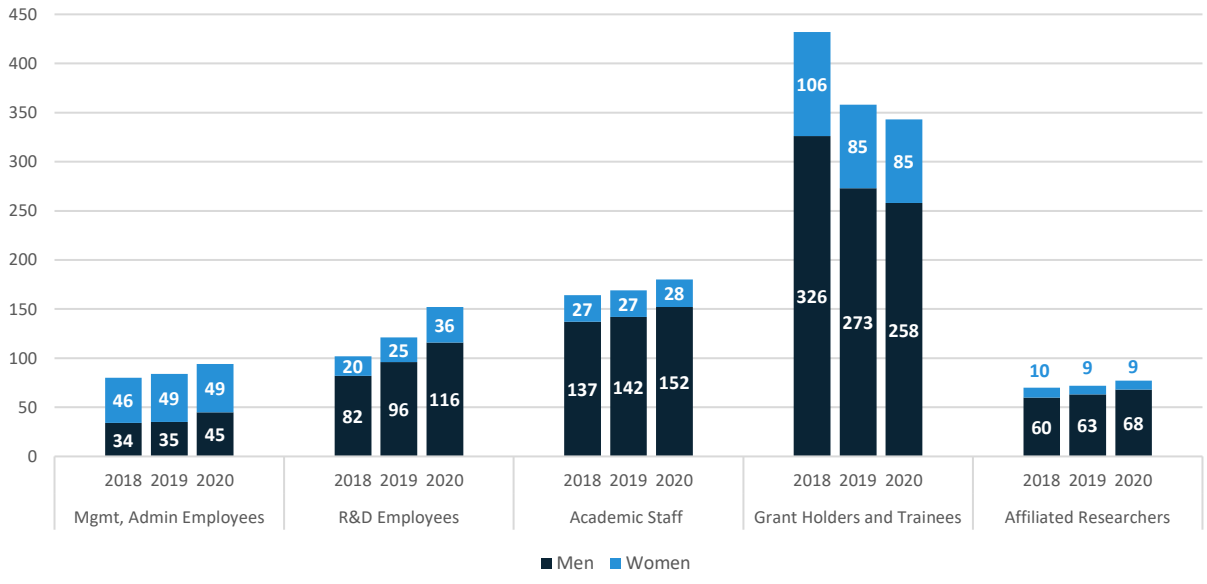


Figure 3.4.1 - Evolution of Human Resources

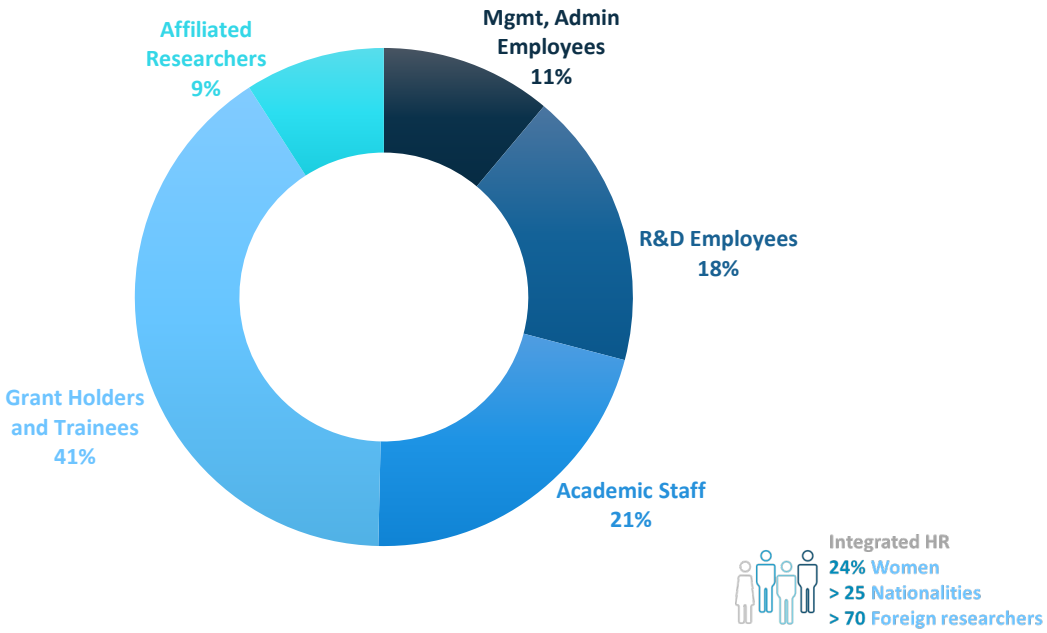


Figure 3.4.2 - Distribution of Human Resources

As seen in Figure 3.4.2, grant holders and trainees are still the largest group of human resources (41%) at INESC TEC, featuring, nevertheless, another decrease in 2020 (Figure 3.4.1). This reduction is mostly the result of the continued implementation of the Portuguese Government's policy for scientific employment stimulus, which has led to a steady rise in the number of R&D employees (152 in 2020), namely PhD researchers. The sharp decrease trend in grant holders, felt in 2019 associated to the new Grant Regulation, was attenuated and the number of new R&D employees more than doubled the reduction of grant holders.

The increase in Human Resources in the Support Services aims at supporting the continued growth of the institute's activity and the operationalisation of new strategic objectives, such as the implementation of the new TEC4 model, the reinforcement of international relations management, and the implementation of a new model of human resources management.

Overall, the total number of integrated human resources remained relatively stable between 2018 and 2020. The team profile followed very closely the profile included in the 2020 plan, while the total numbers were slightly above the planned estimates.

With a growing attention to dimensions of Diversity and Inclusion (D&I), INESC TEC has been monitoring closely some related indicators, namely those relating to gender balance. For the last five years, the percentage of women has been growing modestly in Global HR (reaching 26% in 2020) while in the groups of Integrated HR and more specifically Integrated Researchers, the percentages of women have remained almost unchanged (24% for Integrated HR and 23% for Integrated Researchers). This situation has been analysed by the Working Group for Gender Equality and will be addressed in the Action Plan for D&I to be implemented. As part of this Action Plan, INESC TEC will also work to address the related evolving requirements of funding programmes, such as the Gender Equality Plan that will be required in the scope of the participation in the Horizon Europe Programme.

3.4.2 R&D Clusters Indicators

This section presents an overview of the relative size and composition of Human Resources in the R&D Clusters in 2020 (Table 3.4.2 and Figure 3.4.3).

Table 3.4.2 - Human Resources by Cluster

Type of Human Resources			Clusters			
			NIS	PE	ISE	CS
Integrated HR	Core Research Team	Employees	43	28	49	32
		Academic Staff	40	9	33	87
		Grant Holders and Trainees	113	42	67	111
		Total Core Researchers	**196**	**79**	**149**	**230**
		Total Core PhD	**66**	**25**	**63**	**110**
	Affiliated Researchers		15	7	24	31
	Administrative and Technical		6	3	5	4
		Total Integrated HR	**217**	**89**	**178**	**265**
		Total Integrated PhD	**80**	**32**	**84**	**140**
Curricular Trainees			10	0	24	1
External Research Collaborators			48	14	59	87
External Administrative and Technical Staff			0	1	3	0
External Students			41	49	22	74
		Total	**316**	**108**	**286**	**427**

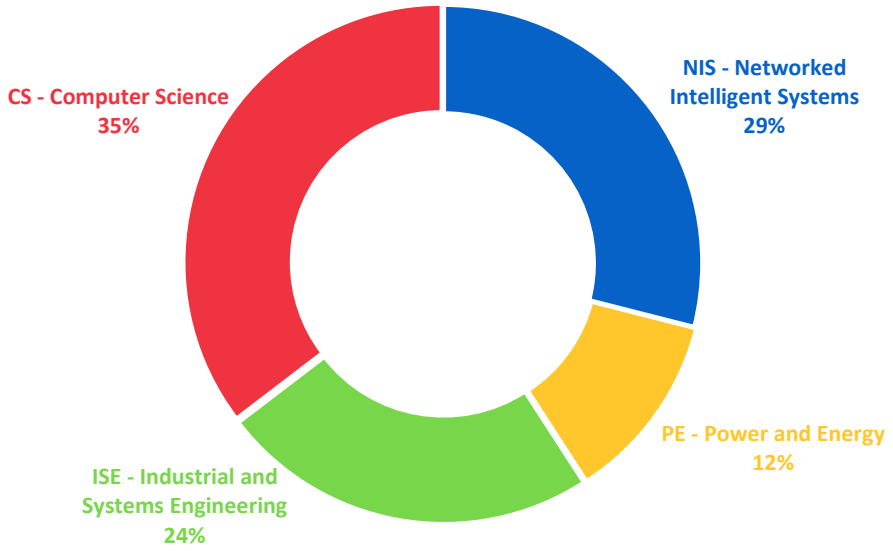


Figure 3.4.3 - Human Resources by Cluster

3.4.3 R&D Centres Indicators

The number and structure of Human Resources in each R&D Centre is detailed in Table 3.4.3.

Table 3.4.3 - Human Resources by type and R&D Centre

Type of Human Resources			Total R&D Centres	R&D Centres												
				CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	CSIG	LIAAD	CRACS	HASLAB
Integrated HR	Core Research Team	Employees	**152**	10	10	18	5	28	21	13	10	5	14	8	1	9
		Academic Staff	**169**	14	8	12	6	9	4	12	15	2	27	24	17	19
		Grant Holders and Trainees	**333**	52	18	32	11	42	16	22	28	1	42	25	16	28
		Total Core Researchers	**654**	**76**	**36**	**62**	**22**	**79**	**41**	**47**	**53**	**8**	**83**	**57**	**34**	**56**
		Total Core PhD	**264**	**26**	**15**	**16**	**9**	**25**	**13**	**18**	**28**	**4**	**32**	**33**	**19**	**26**
	Affiliated Researchers		**77**	9	5		1	7	9	6	7	2	17	7	1	6
	Administrative and Technical	Employees	**18**	1	1	3	1	3	2	2	1		1		1	2
		Total Admin and Tech	**18**	1	1	3	1	3	2	2	1		1		1	2
	Total Integrated HR		**749**	**86**	**42**	**65**	**24**	**89**	**52**	**55**	**61**	**10**	**101**	**64**	**36**	**64**
	Total Integrated PhD		**336**	**35**	**20**	**16**	**9**	**32**	**21**	**23**	**34**	**6**	**49**	**40**	**19**	**32**
Curricular Trainees			**35**	**2**	**4**		**4**		**15**	**2**	**3**	**4**			**1**	
External Researchers			**208**	**28**	**2**	**1**	**17**	**14**	**17**	**16**	**14**	**12**	**16**	**45**	**9**	**17**
External Administrative and Technical Staff			**4**					**1**		**1**	**2**					
External Students			**141**	**23**	**10**		**8**	**4**	**1**	**9**	**8**	**4**	**15**	**23**	**7**	**29**
Total			**1 137**	**139**	**58**	**66**	**53**	**108**	**85**	**83**	**88**	**30**	**132**	**132**	**53**	**110**

R&D Centres:

CTM Centre for Telecommunications and Multimedia
CAP Centre for Applied Photonics
CRAS Centre for Robotics and Autonomous Systems
CBER Centre for Biomedical Engineering Research
CPES Centre for Power and Energy Systems
CESE Centre for Enterprise Systems Engineering
CRIIS Centre for Robotics 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
CITE Centre for Industrial Engineering and Management
LIAAD Laboratory of Artificial Intelligence and Decision Support
CRACS Centre for Research in Advanced Computing Systems
HASLAB High-Assurance Software Laboratory

3.4.4 Support Services Indicators

The Human Resources figures by the end of 2020 for the Board of Directors, the TEC4 teams, and the Support Services are provided in Table 3.4.4.

Table 3.4.4 - Human Resources by type and Service

Type of Human Resources		Total	Board and Advisors	Support Services															
				TEC4	DPO	Organisation and Management Services					Business Development Services				Technical Support Services			
						AG	AJ	CF	CG	RH	SAAF	SAL	SRI	SCOM	SRC	SIG	SAS	SGI
Integrated HR	Employees	76	11	6	2	2	2	8	10	5	1	3	4	4	2	6	4	6
	Academic Staff	11	8	3														
	Grant Holders and Trainees	7		1		1		1	1		1			1	1			
	Affiliated Researchers																	
	Total Integrated HR	**94**	**19**	**10**	**2**	**3**	**2**	**9**	**11**	**5**	**2**	**3**	**4**	**5**	**3**	**6**	**4**	**6**
	Total Integrated PhD	**18**	**10**	**5**				**1**				**2**						

Support Services:

AG	Management Support [1]
AJ	Legal Support
CF	Accounting and Finance
CG	Management Control
RH	Human Resources
SAAF	Funding Opportunities
SAL	Technology Licensing
SRI	International Relations
SCOM	Communication
SRC	Networks and Communications
SIG	Management Information Systems
SAS	System Administration
SGI	Infrastructure Management

[1] *Includes Secretarial Coordination*

3.5 Activity in Projects

3.5.1 Global Indicators

Table 3.5.1 shows the breakdown of INESC TEC's funding sources and the evolution from 2016 to 2020.

Table 3.5.1 - Funding sources and evolution

Sources			Value (k€)					Δ (k€ | %)	
			2016	2017	2018	2019	2020	2019-20	
Projects	PN-FCT	National R&D Programmes - FCT	490	1 143	2 279	3 677	3 524	-153	-4%
	PN-PICT	National R&D Programmes - S&T Integrated Projects	1 464	2 644	2 428	468	22	-446	
	PN-COOP	National Cooperation Programmes with Industry	263	1 060	1 251	928	1 250	322	35%
	PUE-FP	EU Framework Programmes	4 494	3 306	3 628	3 910	4 903	994	25%
	PUE-DIV	EU Cooperation Programmes - Other	632	686	707	713	300	-412	-58%
	SERV-NAC	R&D Services and Consulting - National	2 259	2 538	2 525	2 527	2 899	372	15%
	SERV-INT	R&D Services and Consulting - International	287	355	509	410	547	136	33%
	OP	Other Funding Programmes	703	1 040	841	1 067	955	-112	-11%
	Closed Projects		418	140	309	185	0	-185	-100%
		Total Projects	**11 010**	**12 912**	**14 477**	**13 884**	**14 399**	**515**	**4%**
National Strategic Programme - Pluriannual			2 615	3 003	2 485	2 307	2 396	90	4%
National Strategic Programme - RHAQ			0	0	0	0	289	289	
National Strategic Programme - EEC			0	0	0	368	460	92	25%
National Strategic Programme - CIT			0	0	13	961	599	-362	-38%
National Strategic Programmes - Other			112	130	170	73	10	-63	-87%
Other Revenues			270	260	383	375	102	-273	-73%
		Total Revenues	**14 008**	**16 305**	**17 529**	**17 966**	**18 255**	**288**	**2%**

Figure 3.5.1 illustrates the distribution of funding for the projects carried out in 2020, and its evolution since 2016. 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 funding programs.

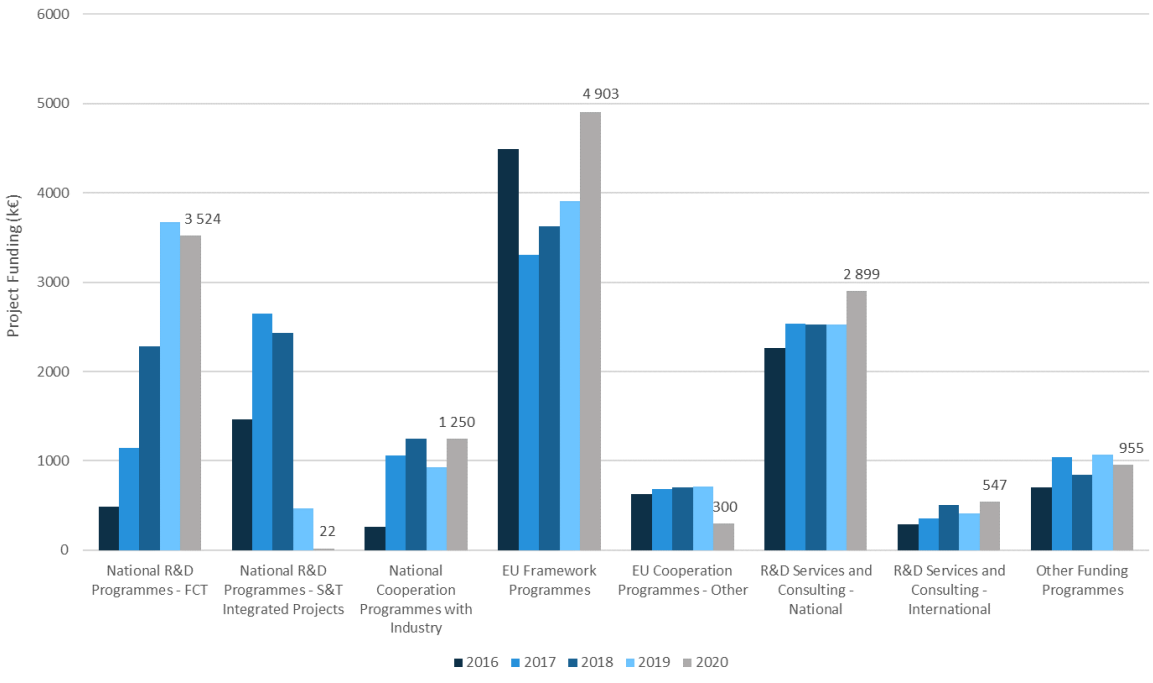


Figure 3.5.1 - Evolution of project funding by source (k€)

Figure 3.5.2 shows the project funding distribution by source, in comparison with the previous year.

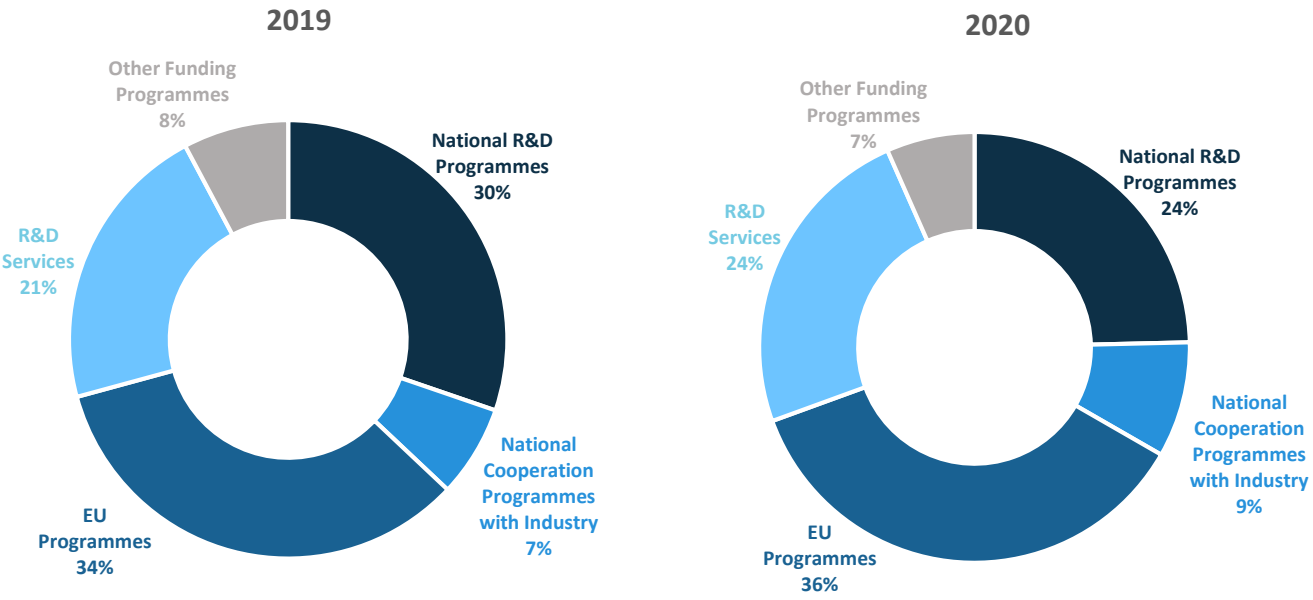


Figure 3.5.2 - Distribution of project funding by source – 2019 and 2020

The number of active projects and the average funding per project by source are also of interest, and are shown in Table 3.5.2.

Table 3.5.2 - Number of active projects and average funding by source

Type of Project		Number of Active Projects					Δ (%)	Average Funding (k€)	
		2016	2017	2018	2019	2020	2019-20	2019	2020
PN-FCT	National R&D Programmes - FCT	22	28	66	74	68	-6	50	52
PN-PICT	National R&D Programmes - S&T Integrated Projects	10	10	10	10	0	-10	47	0
PN-COOP	National Cooperation Programmes with Industry	13	22	23	21	33	12	44	38
PUE-FP	EU Framework Programmes	37	35	30	48	72	24	81	68
PUE-DIV	EU Cooperation Programmes - Other	12	20	18	20	18	-2	36	17
SERV-NAC	R&D Services and Consulting - National	67	84	87	121	126	5	21	23
SERV-INT	R&D Services and Consulting - International	11	10	19	13	20	7	32	27
OP	Other Funding Programmes	19	30	30	31	40	9	34	24
	Total	**191**	**239**	**283**	**338**	**377**	**39**	**41**	**38**

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

- INESC TEC maintained a diversified and sustainable activity according to its funding model, with a turnover of about 18 M€, 377 R&D projects, and 32% of project funding from international sources. Despite the pandemic context, INESC TEC was able to slightly increase its level of activity, with an increase in activity of about 2%, consolidating the continuous growth observed in previous years;
- A balance between the different funding sources was successfully maintained, and even improved when compared with the previous year and with the plan for 2020, with an increase in the level of funding of European projects, as well as in contract research and consulting activities and R&D projects in collaboration with industry, more than compensating the reduction in FCT projects, in other EU programmes and the end of S&T integrated projects;

- The National Strategic Programme – "Pluriannual" – amounted to 13% of the total funding sources, while the base funding for technology transfer activities, "CIT", accounted for 3% of the total revenues;
- The National Strategic Programme for hiring Highly Qualified Human Resources represented 1.6% of the total funding, complementing the funding for implementing the national scientific employment policies;
- EU Framework Projects are the largest projects in terms of funding volume. At the opposite end, R&D and Consulting Services are often short duration projects and therefore below average funding per project.

3.5.2 Clusters Indicators

This section presents in Table 3.5.3 and Figure 3.5.3 the funding by source and Cluster, providing an overview of their relative size and results in 2020.

Table 3.5.3 - Activity (k€) in projects by Cluster and funding source

Funding Source			Clusters			
			NIS	PE	ISE	CS
Projects	PN-FCT	National R&D Programmes - FCT	1 419	246	754	706
	PN-PICT	National R&D Programmes - S&T Integrated Projects	22	0	0	0
	PN-COOP	National Cooperation Programmes with Industry	561	25	459	205
	PUE-FP	EU Framework Programmes	1 219	1 693	1 341	643
	PUE-DIV	EU Cooperation Programmes - Other	159	0	55	86
	SERV-NAC	R&D Services and Consulting - National	449	802	656	980
	SERV-INT	R&D Services and Consulting - International	349	131	5	61
	OP	Other Funding Programmes	79	157	4	210
Total Funding			**4 257**	**3 055**	**3 275**	**2892**

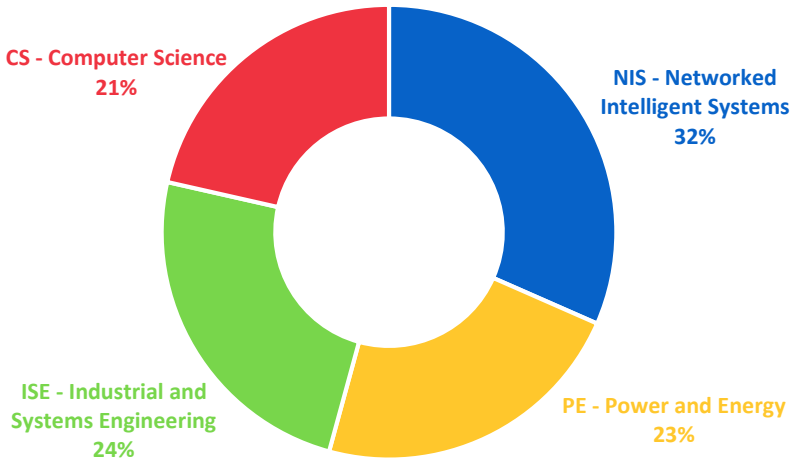


Figure 3.5.3 - Project Funding by Cluster

3.5.3 R&D Centres Indicators

A detailed view of the total funding by source per R&D Centre is given in Table 3.5.4 and Figure 3.5.4.

Table 3.5.4 - Project Funding (k€) per R&D Centre

Funding Source		Total (k€)	R&D Centres												
			CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	CSIG	LIAAD	CRACS	HASLAB
Projects	PN-FCT	**3 524**	470	289	507	153	246	159	269	317	8	294	190	16	206
	PN-PICT	**22**	0	22	0	0	0	0	0	0	0	0	0	0	0
	PN-COOP	**1 250**	322	0	210	28	25	388	48	23	0	45	38	0	122
	PUE-FP	**4 903**	240	211	767	0	1 693	473	535	191	143	443	51	1	148
	PUE-DIV	**300**	-3	38	124	0	0	0	17	20	19	34	1	50	0
	SERV-NAC	**2 899**	295	46	73	35	802	342	113	148	53	293	239	94	353
	SERV-INT	**547**	123	4	222	0	131	2	0	3	0	31	1	0	30
	OP	**955**	51	0	28	0	157	0	4	0	0	55	7	11	137
Total Funding		**14 399**	**1 498**	**610**	**1 932**	**216**	**3 055**	**1 363**	**986**	**702**	**224**	**1 194**	**528**	**173**	**997**

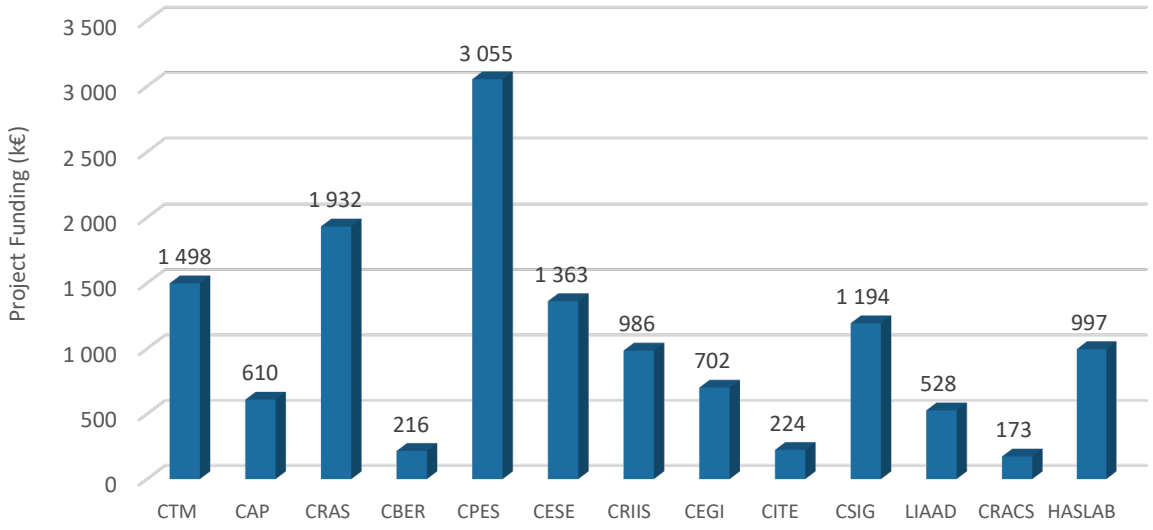


Figure 3.5.4 - Total Project Funding per R&D Centre (k€)

3.6 Publications

3.6.1 Global Indicators

Table 3.6.1 and Figure 3.6.1 show the number of INESC TEC publications and their evolution between 2016 and 2020.

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 author's Centre, but the institution total removes repetitions, whenever they occur.

Table 3.6.1 - Number of Publications

Publication Type	2016	2017	2018	2019	2020
Indexed Journals	311	318	312	381	398
Indexed Conferences	476	492	494	570	317
Books	1	1	7	6	2
Book Chapters	37	27	40	29	25
PhD Theses - Members	38	34	38	19	28
PhD Theses - Supervised	56	56	56	33	46

Surpassing the estimates included in the 2020 plan, INESC TEC increased slightly the number of publications in indexed journals, the institute's main overall publication priority. The number of publications in indexed conferences decreased 44%, mostly due to the limitations resulting from the pandemic. The total number of indexed publications decreased in 2020 (25%) as the result of the reduction of publications in indexed conferences.

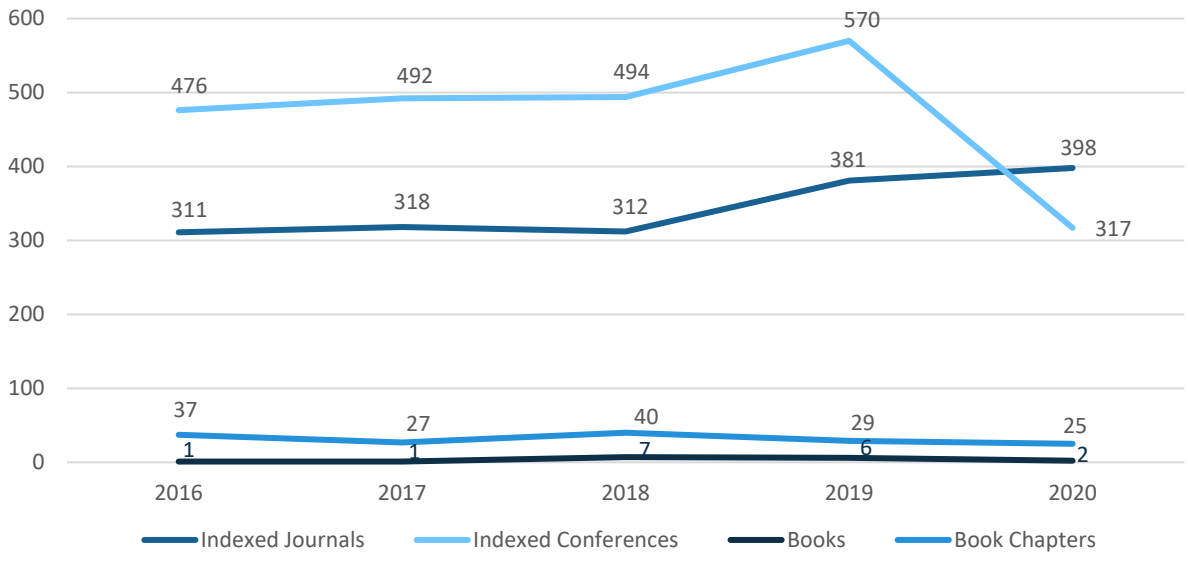


Figure 3.6.1 - Evolution of Publications

The evolution of publications per capita followed the trend of the absolute values, namely with the number of articles in indexed journals per Core PhD, as presented in Figure 3.6.2.

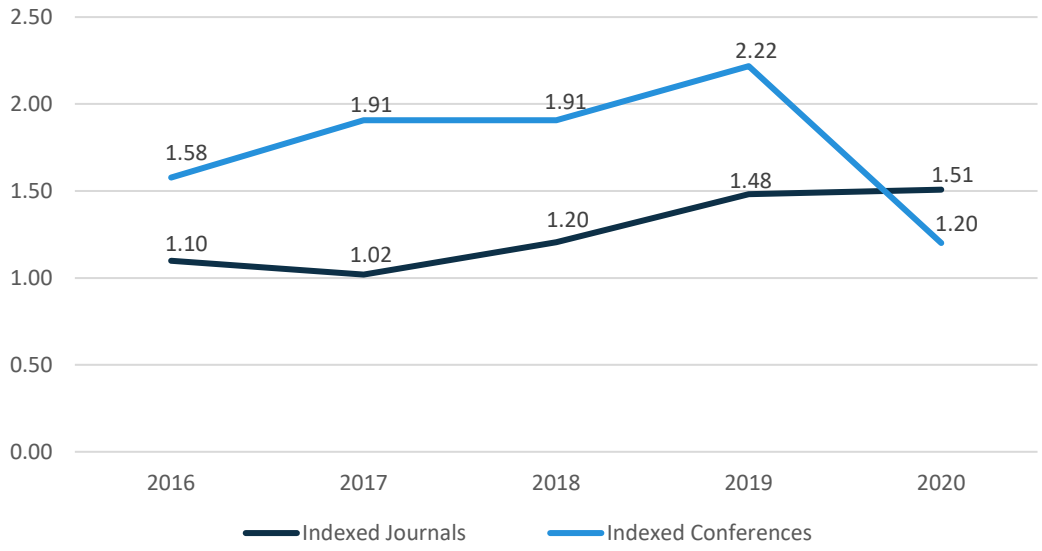


Figure 3.6.2 - Evolution of Publications per Core PhD

For the publications in journals indexed by Scopus, the Figure 3.6.3 shows its distribution per impact factor quartile: 245 of them were in First Quartile journals (compared to 230 articles in 2019) which correspond to 62% of the articles in indexed journals.

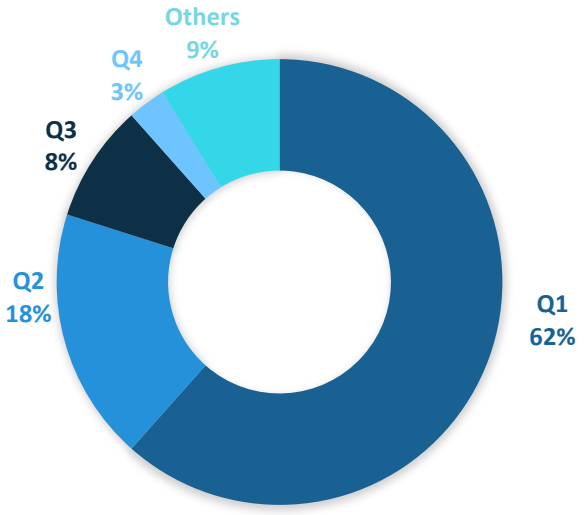


Figure 3.6.3 – Indexed Journal impact factor Quartile distribution (Scopus)

3.6.2 R&D Clusters Indicators

The Clusters' main publication indicators are presented in Table 3.6.2 and Figure 3.6.4.

Table 3.6.2 - Publications by Cluster and publication type

Publication Type	Clusters			
	NIS	PE	ISE	CS
Indexed Journals	94	110	100	114
Indexed Conferences	66	49	78	147
Books	0	1	1	0
Book Chapters	3	6	11	5
Concluded PhD Theses - Members	4	3	6	15
Concluded PhD Theses - Supervised	4	4	8	30

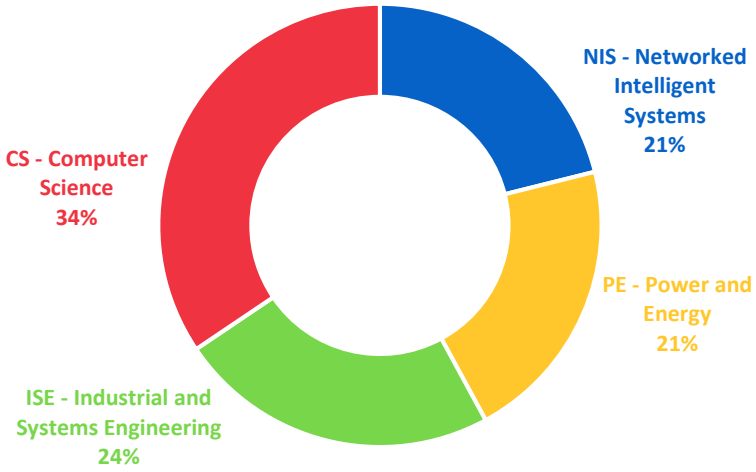


Figure 3.6.4 - Indexed publications by Cluster

3.6.3 R&D Centres Indicators

Figure 3.6.5 presents the number of indexed publications in journals and conferences per R&D Centre. The figures and their evolution are presented in greater detail in Annex I.

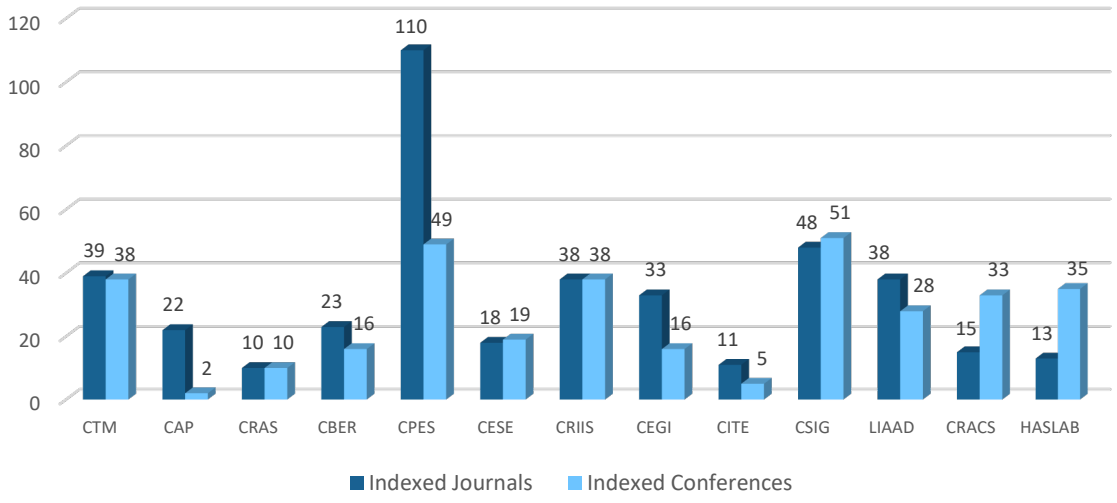


Figure 3.6.5 - Indexed Publications in Journals and Conferences by Centre

3.7 IP Protection, Exploitation and Technology Transfer

As mentioned previously, in 2020 and for the fourth consecutive year, INESC TEC was in the top five of national entities with the most patent applications submitted to the European Patent Office (EPO). According to data announced by the EPO, in 2020, INESC TEC submitted 12 patent applications, being the third institution at national level with more applications submitted. INESC TEC patent applications comprehended medical technologies to support diagnosis, telecommunications, cybersecurity and instrumentation. In 2020, the institute also received very positive preliminary reports for multiple applications.

This is the result of a renewed strategic commitment of INESC TEC's R&D Centres in addition to a reinforcement of the scouting activities of INESC TEC's Technology Licensing Office (SAL), an effort that will likely be strengthened by the release of a short disclosure form at the end of 2020, which will contribute to simplify initial communication phases. Furthermore, Daniel Vasconcelos, Head of the Office, was appointed in 2020 as the new ambassador for the European IP Helpdesk in Portugal, besides representing INESC TEC at the high-ranked TTO Circle.

Table 3.7.1 - Results related with IP Protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	15	9	26
Software copyright registrations	3	2	6
Patent first priority filings (New inventions)	11	1	7
Patent applications (Internationalisation)	22	26	30
Granted patents	6	4	7
Licence agreements	1	3	5
Spin-offs established	2	2	0
Spin-offs in development	2	3	3

Overall, the results related with IP Protection, exploitation and technology transfer (Table 3.7.1) were above or in line with the estimates included in the 2020 plan.

The reinforcement of internal scouting activities by SAL led to an increase in Invention Disclosures in 2020. At the same time, after the concentration of patent applications for new inventions in 2018, driven by the evaluation criteria of several projects, and an associated compensation in 2019, this figure returned to a more moderate level, in line with the average annual number and quality of new inventions/technologies at INESC TEC. Patent applications for internationalisation purposes remained high as a result of the funding raised by SAL to support the formation of patent families with a large global breadth.

Several patents were granted in 2020, reflecting the quality of the 2017 and 2018 patent applications and the joint work of SAL, inventors and patent attorneys, in disputes with the various patent offices. Licence agreements increased, in part as a result of an improved recognition of their occurrence within multiple types of contracts with industry.

Finally, in 2020, three spin-offs were in a development phase, UNEXMIN GeoRobotics, iLoF and WeSenss. Due to complex negotiations and formalities resulting from the international nature of both companies, INESC TEC's formal participation in iLoF and UNEXMIN GeoRobotics was not achieved in 2020 but is expected in 2021. Moreover, the creation of the spinoff "WeSenss" is planned for 2021, in association with the licensing of three patents.

3.7.1 Technological entrepreneurship

INESC TEC supports the launch of technology-based spin-offs, expressly established to further develop and exploit IP created by INESC TEC. The table below provides an overview of INESC TEC's most recent spin-offs, established and in development since 2015, and their main developments in 2020.

Table 3.7.2 - Overview on INESC TEC's most recent established spin-offs

Established Spin-offs				
Name and description	**Year of incorporation**	**Sector**	**Employees (FTE)**	**Main developments in 2020**
Keyruptive Technologies Mobile app solution for secure cloud storage and management of digital assets such as crypto currency, using patent pending technology that enables the distribution of trust among multiple entities.	2019	Software security / Fintech	< 5	Collaboration in the development and deployment of the STAYAWAY COVID app. This is allowing the company to position itself in 2021 as an innovative development company exposing the team to a number of new problems and challenges.
Insignals Neurotech Wearable wireless devices to precisely measure wrist rigidity, helping surgeons place brain implants more accurately during surgery on patients with Parkinson's, epilepsy, and other neural conditions.	2019	Medtech	< 5	Confirmed interest from university-hospitals to join the European Multi-Centre Clinical Study to validate the technology (Univ. Maastricht; Bellvitge Univ. Hospital, Barcelona Spain; Univ. of Würzburg), Contacts established with key players in industry; Nature spinoff prize 2020: recognition as a "One to Watch" company.
Ubirider Develop solutions to make urban mobility smarter and to improve travellers' overall experience. Pick is a universal app which integrates any mobility service for multimodal trip planning and mobile payment of fares.	2018	Digital mobility	10-20	Ubirider built the Pick platform, which aims at helping move people, information and payments seamlessly, making fragmented mobility experiences a thing from the past. The company also collaborated in the development and deployment of the STAYAWAY COVID app.
MITMYNID Marketplace to search and compare transport and logistics services with simple or multimodal door-to-door solutions. Intelligent Routing System to search and combine logistics services (air, rail, road, sea) to provide optimised solutions.	2015	IT for transport and logistics	< 5	Downscaling of the activity, due to the pandemic, and a focus on technology development projects and consulting contracts.

Table 3.7.3 - Overview on INESC TEC's spin-offs in development

Spin-offs in Development				
Name and description	**Year of incorporation**	**Sector**	**Employees (FTE)**	**Main developments in 2020**
iLoF Leverage machine learning to drastically reduce the cost and time of drug discovery, using a patented photonics and Artificial Intelligence system to identify unique features of various gold-standard biomarkers, capturing their signature on a cloud-based library.	2019	Medtech, Digital health	5-10	Collected over 1.000 different biological samples. Got selected by CB insights as one of the Top 150 digital health companies in the world.
UNEXMIN Georobotics Underwater mine exploration robotic system for commercial mine surveying, exploration and geoscientific purposes.	2018	Geological consulting	< 5	Development of the UX1Neo prototype in the UNEXUP project – new version of the UX1, modular, easy to maintenance, much more operational and with additional capabilities. Interest of surveying services in mines in Canada and Brazil.
WeSENSS Corporate solutions for security and quantified occupational health approaches to promote worker wellbeing and improve performance, based on a wearable & IoT platform for hazardous professionals' vitals and work environment monitoring.	N/A	Medtech	N/A	Technological maturation of the wearable sensor platform for safety applications, and fund raising actions.

3.8 Dissemination activities

Table 3.8.1 illustrates the evolution of INESC TEC members and R&D Centres' participation in a variety of categories of dissemination activities.

Table 3.8.1 - Results related with dissemination activity

Type of Activity	2018	2019	2020
Participation as principal editor, editor or associated editor in journals	61	75	90
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	87	75	74
International events in which INESC TEC members participate in the program committees	280	330	273
Participation in events such as fairs, exhibitions or similar	76	66	63
Conferences, workshops and scientific sessions organised by the R&D Centres	*	54	41
Participants in the conferences, workshops and scientific sessions organised by the R&D Centres	*	4 549	5 488
Advanced training courses organised by the R&D Centres	*	19	20

** Uncollected data*

As expected, due to the COVID-19 pandemic, the number of conferences and events in 2020 fell accordingly. The overall uncertainty, the barriers to travel and the sanitary recommendations led many conferences and scientific events to be cancelled or rescheduled for 2021 or 2022.

Although the "21st Power Systems Computation Conference - PSCC'20" was maintained in a virtual mode and gathered 420 participants, on the other hand, INESC TEC's Autumn Forum was postponed for 2021 and the hosting of the 2020 meeting of the CENTRA partnership, the first to be held in Europe, was cancelled.

Nevertheless, except for the organisation of advanced training courses, the results related with dissemination activity surpassed the estimates included in the 2020 plan in all dimensions

In addition to small increases in editorial roles and advanced training, INESC TEC's researchers were able to maintain some dynamic activity in scientific events and other formats. The virtual alternative provided in many events, as hybrid conferences or full remote participation, had an actually virtuous consequence: the possibility to reach world-wide participants who otherwise would not have participated. As an example of this positive side-effect, the "1st Summer School on Machine Learning and Big Data with Quantum Computing" counted around 2000 people following the online sessions.

Finally, as previously mentioned in this report, the year 2020 recorded the highest number of INESC TEC news over the last 20 years. In this atypical pandemic year, INESC TEC's media projection increased greatly, largely due to the STAYAWAY COVID app. When compared to the previous year, the number of news almost tripled and the Automatic Advertising Value (AAV) was almost seven times higher.

3.9 R&D Clusters Activity Overview

Finally, Figure 3.9.1 presents an integrated overview of the activity of the four R&D Clusters, with the axes representing each Cluster's proportion of INESC TEC's total funding, indexed publications and human resources.

The activity in 2020 was quite balanced across the three dimensions for all Clusters. The proportions of each Cluster's integrated human resources remained mostly stable. In terms of publications, the most salient evolution was the increase in the proportion of the NIS Cluster. The NIS and PE Clusters increased their proportions of the overall funding. These variations are mostly the outcome of each Clusters' typical profile of activity, as well as regular oscillations in publishing patterns and success in securing competitive grants and research contracts.

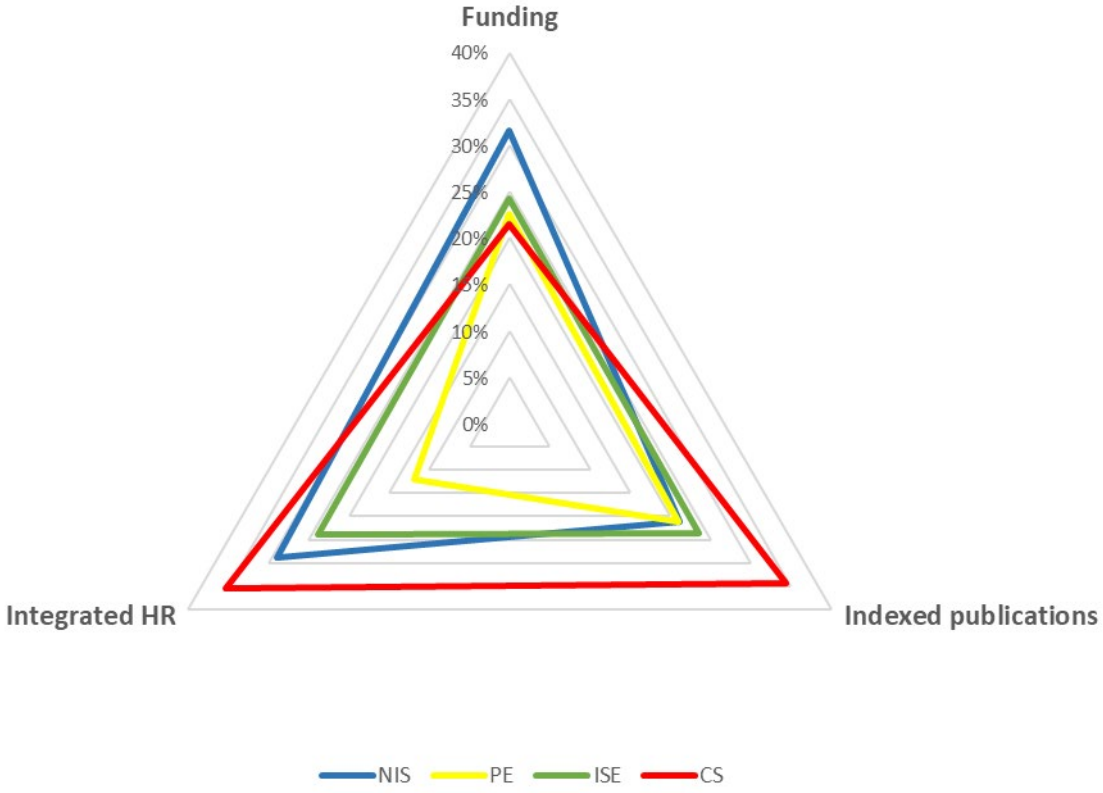


Figure 3.9.1 - Overview of the R&D Clusters' dimension and activity

3.10 Participation in Collaborative Laboratories

3.10.1 The Collaborative Laboratories – Bridging the Valley of Death

The Collaborative Laboratories (CoLABs) are a governmental initiative aimed to foster new institutions in Portugal designed to close the gap between research institutions and the market/industry.

Devised in 2017, their main focus is to create, directly and indirectly, qualified employment in Portugal in close association with the social and economic valorisation of knowledge. The main challenge to which the Collaborative Laboratories must respond is the effective densification of the national territory in terms of knowledge-based activities, through a growing institutionalisation of forms of collaboration between science, technology and higher education institutions and the economic and social fabric, namely companies, the hospital and health system, cultural institutions and social organisations.

The CoLABs may be private, non-profit associations or private companies, specially created for this purpose, that integrate, for example, higher education institutions and their institutes and research units, associated and state laboratories, intermediate and interface institutions, companies, business associations, public institutions and other relevant partners such as social or cultural institutions, incorporated in one independent legal entity.

Some of their idiosyncrasies reside in their strong consortia with financial commitment, and the fact that market players are the ones leading the institutions, aimed to implement medium-term research and innovation agendas.

3.10.2 Alignment with INESC TEC's strategy and evolution in 2020

As demand-driven, business-centric, impact-oriented institutions, CoLABs focus their activities on Technology Readiness Levels (TRL) closer to the market and technology transfer. For INESC TEC, CoLABs are therefore complementary vehicles for new opportunities in applied R&D and technology transfer.

Despite some successful cases, Portugal needs to strengthen itself in bridging the "valley of death". It was precisely to contribute to this important public policy objective that INESC TEC became involved in the launch of several Collaborative Laboratories (CoLABs), in collaboration with academic and business partners.

In 2020, INESC TEC was associated with nine CoLABs. They all assumed a private non-profit association figure and are detailed in the tables below. INESC TEC's involvement with these CoLABs will, in the coming years, result in a new aspect of the institution's activity, in which it will be able to deepen the research oriented to the respective areas of application, to intensify the sharing and valorisation of knowledge, and to contribute to the creation of highly qualified employment for its youngest talent.

It certainly represents an opportunity with great potential to strengthen INESC TEC's position as an interface institution of excellence. The CoLABs may especially be important in stimulating new forms of interaction and a nonlinear relationship between research, innovation and social and economic development activities, by stimulating the co-responsibility of participating institutions through processes of knowledge transfer and dissemination, and improving the value of products and services provided by the companies, as well as facilitating the social relevance of academic research activity and its endogenisation by society.

Despite the severe impact of the COVID-19 pandemic, the resolve and the quality of the work carried out by the teams in the nine CoLABs allowed great progress in the year of initial operation for most CoLABs.

In line with INESC TEC's view on the governance and management of CoLABs, 2020 was a year of recruitment and setting up of support activities and management, aiming at laying the foundations for institutions with growth and sustainability ambitions. In collaboration with their associates, the CoLABs were very active in the definition of their agendas and lines of work, and in the preparation and submission of proposals at both national and European levels. The transfer of researchers from the associates to the CoLABs, the preparation of exchange initiatives, and time of full dedication to the CoLABs by members of the associates' teams, strengthened the connections between teams, an aspect of great importance for the role of the CoLABs in leveraging partnerships. Finally, dissemination and engagement initiatives were also emphasised in 2020.

The tables below provide an overview of INESC TEC's participation in Collaborative Laboratories in 2020 and the main developments in these fruitful relationships.

Table 3.10.1 - CoLAB ForestWISE

CoLAB FORESTWISE	
Name	FORESTWISE – Associação para o Laboratório Colaborativo para a Gestão Integrada da Floresta e do Fogo
Description	Brings together the multiple interdisciplinary areas that are relevant to build up a holistic and cohesive approach to the problem of rural fires and the directly related problem of the valorisation of forest (market and non-market) products and services.
Areas of expertise	Sustainable Forest Management; Knowledge and Technology Transfer
Year of establishment	2018
N.º of Associates / Accession of new Associates in 2020	15 / -
HR hired	11
Base funding planned	844 k€
Competitive funding – submitted and approved proposals	Nine proposals were submitted (including one H2020 – Intuition); Two proposals were approved so far: Mobilizador – rePLANt and Fundo Florestal Permanente – aGIL.TerFoRus
Main activities and achievements in 2020	ForestWISE's activity in 2020 was focused on recruiting the first members of the technical team, operationalising the infrastructure and consolidating the management model and work organisation, following the general guidelines of the Startup Support Plan developed by INESC TEC during 2019. Regarding the management and work organisation model, great progress was made in 2020 in structuring the four lines of work of ForestWISE 20-25, as well as in defining the technical team for each line. The roadmap for the financing of projects needed to undertake the work foreseen in those lines was also outlined. The two projects already approved and the outcome of several project proposals submitted will help to support the activity in 2021.
Activities to foster Associates' involvement	Regular collaboration with the associates, in the promotion of several events. Production of a quarterly newsletter, as a vehicle for information and communication with the community but also with other stakeholders in the areas of forestry and fire in Portugal.
Fulfilment of INESC TEC's strategic objectives related to this participation	INESC TEC incubation effort was followed by assuming the leadership during the first years of ForestWISE, contributing also with a group of experienced senior researchers that moved from INESC TEC. ForestWISE is a truly collaborative laboratory adopting a governance and management model inspired in INESC TEC's and is becoming a national reference in its domain, now engaging INESC TEC in projects of its own initiative and leadership.

Table 3.10.2 - CoLAB B2E

CoLAB B2E	
Name	B2E - Laboratório Colaborativo para a Bioeconomia Azul
Description	Promote the creation of highly qualified jobs, which will contribute to actively increase the economic and social value of products and services based on organic products, new and existing, including processes of internationalisation of national scientific and technological capacity, thus supporting two of the blue growth sectors with the greatest potential: biotechnology and aquaculture.
Areas of expertise	Living marine natural resources; Marine biotechnology; Sustainable aquaculture
Year of establishment	2019
N.º of Associates / Accession of new Associates in 2020	13 / -
HR hired	10
Base funding planned	552 k€
Competitive funding – submitted and approved proposals	3 proposals submitted
Main activities and achievements in 2020	Setup the CoLAB offices and hiring HRs. National and international consortia for project proposals. Management report (2019) and action plans (2020, 2021).
Activities to foster Associates' involvement	Regular engagement with associates (including a visit to INESC TEC). Benchmark of national and international stakeholders, to define and meet industry needs aligned with associates. Challenge/invitation to associates to be part of B2E agenda and proposals. Contribute to associates' national and international visibility within the B2E sectors of intervention. Promote the associates' competencies and technologies towards innovation and tech transfer in the business sectors.
Fulfilment of INESC TEC's strategic objectives related to this participation	Setting up and hiring most of HRs during 2020 is aligned with INESC TEC interests for the coming R&D instruments. Project proposals (total proposals and budgets) show dynamism and address INESC TEC goals. Blue Bioeconomy is a key strategic domain for INESC TEC / TEC4SEA and B2E, still at an early stage, has the potential to contribute to INESC TEC's strategic objectives on this domain.

Table 3.10.3 - CoLAB BUILT

CoLAB BUILT	
Name	BUILT CoLAB – Colaborative Laboratory for The Future Built Environment
Description	The BUILT CoLAB aims to develop research, innovation and knowledge transfer activities, with a view to increasing productivity, competitiveness and sustainable growth of the ecosystem of the AEC (Architecture, Engineering and Construction) sector, promoting the digital and climate transition of buildings and infrastructures, making them adaptable, intelligent, resilient and sustainable.
Areas of expertise	Digital and climate transition of buildings and infrastructures
Year of establishment	2019
N.º of Associates / Accession of new Associates in 2020	19 / -
HR hired	12
Base funding planned	262 k€
Competitive funding – submitted and approved proposals	3 proposals submitted (including one H2020 – Intuition); 2 proposals were approved so far: SIAC – FoC - and Mobilizador – REV@CONSTRUCTION.
Main activities and achievements in 2020	After its official recognition and the approval of the base funding, the BUILT CoLAB started its activity in October 2020. Its first priorities were to implement the internal processes, to hire the R&D team, to implement the web site and to create five Innovation Intensive Groups. With the COVID pandemic and constraints in the recruitment of highly qualified HR for R&D, the activity progress was more timid than planned. The CoLAB foresees a recovery of the planned activity in 2021, including the start of research projects contracted by industry.
Activities to foster Associates' involvement	Creation of 5 Innovation Intensive Groups (IIG, each composed by 2 to 4 partners) to reinforce the R&D cooperation and to contribute to the BUILT's startup phase.
Fulfilment of INESC TEC's strategic objectives related to this participation	Open a new market to apply its skills and apply technology already developed for other sectors.

Table 3.10.4 - CoLAB VORTEX

CoLAB VORTEX	
Name	Vortex – Associação para o Laboratório Colaborativo em Sistemas Cíber-Físicos e Cíber-Segurança
Description	Aims to be National leader and European reference in Cyber-Physical Systems, accelerating solutions and technology blocks to enable co-creation and technology transfer
Sector	Cybersecurity and Cyber-Physical Systems
Year of constitution	2019
N.º of Associates / Accession of new Associates in 2020	5 / -
HR hired	12
Base funding planned	283K€
Competitive funding – submitted and approved proposals	5 proposals submitted, 1 accepted so far (P2020 FLOYD)
Main activities and achievements in 2020	i. Capture a Team of Excellence: successful in attracting talent. ii. Strengthen business development capacity: hired a business developer to mitigate current lack of success in attracting new business. iii. Acceleration Cycles and R&I Projects: implemented acceleration cycles to expand scientific knowledge and know-how. iv. Capture strategic competitive funding calls to leverage R&I funding: 5 proposals submitted; one successful so far. v. Develop competitive R&I Outcomes: a total of 4 assets were developed: (i) AI-powered Labelling tool; (ii) Agile platooning; (iii) Smart traffic avoidance; (iv) Hypervisor on edge. vi. Thriving in the New Normal: VORTEX strengthened the team with resources and methodologies for remote work.
Activities to foster Associates' involvement	VORTEX is hiring HR who will work at partners' sites (1 PhD per partner) in order to foster a better interaction between partner teams and the VORTEX teams, and build common ground on relevant knowledge and expertise for technology transfer. Partners participate in advisory and supervisory activities and proposals for competitive funding are done in collaboration with partners.
Fulfilment of INESC TEC's strategic objectives related to this participation	The vision for VORTEX is one where Altran PT identifies new market opportunities at the international level, where expertise and knowledge available in academic partners is a crucial enabler. In particular, Altran PT's activity in the automotive market holds a potential for technology transfer in High-Assurance Software. Although efforts have been made by all VORTEX partners, this potential has not yet been realised.

Table 3.10.5 - CoLAB SMART ENERGY LAB

CoLAB SEL	
Name	SMART ENERGY LAB – ASSOCIATION
Description	Its purpose is to pursue R&D activities, namely through the implementation of research and scientific and technological innovation programmes, oriented towards economic and social development, the provision of energy and consultancy services, including scientific research and the creation of qualified and scientific employment.
Areas of expertise	New Energy Management Solutions
Year of establishment	2019
N.º of Associates / Accession of new Associates in 2020	7 / -
HR hired	7 hired and 1 assigned by an associate (President of the Board)
Base funding planned	448 k€
Competitive funding – submitted and approved proposals	5 proposals submitted; 2 proposals approved so far (both H2020 Projects)
Main activities and achievements in 2020	SEL's office started to be operational in October 2020 and its first permanent HR were hired in September. SEL developed a 3 month project (NILM) with INESC ID, it accomplished its first project sale to the client EDP Comercial, and two H2020 projects started in 2020. The CoLAB started to develop its Living Lab that operates in a real-life context with a user-centric approach, besides fostering several ideation events.
Activities to foster Associates' involvement	Two Brainforce Workshops were conducted in order to find solutions to solve a specific problem leveraging the multi-disciplinary knowledge of the Associates. Two ideation meetings and four scientific council meetings were organised.
Fulfilment of INESC TEC's strategic objectives related to this participation	Increased collaboration between INESC TEC and SEL is expected to happen through collaborative projects and sub-contracting of advanced consulting and development projects.

Table 3.10.6 - CoLAB VASCO DA GAMA

CoLAB Vasco da Gama	
Name	Vasco da Gama CoLAB – Energy Storage - Associação
Description	Focused on providing high-tech services and value-added products as well as innovative solutions for its partners and the market in the area of electrochemical energy storage. It aims to contribute to the implementation of the European energy transition agendas, foreseeing the development of world leading technologies and solutions in the area of energy transition.
Areas of expertise	Electrochemical energy storage; Electronic energy conversion; Intelligent energy management
Year of establishment	2019
N.º of Associates / Accession of new Associates in 2020	8 / -
HR hired	4
Base funding planned	151 k€
Competitive funding – submitted and approved proposals	No proposals submitted
Main activities and achievements in 2020	VGCoLAB was supposed to onset its activities in July of 2020 hiring twelve (12) human resources during the first month. However, the hiring of the first HR only began in November. The main reason for this delay was the COVID-19 pandemic but also the difficulties in hiring highly qualified human resources in the scientific/engineering areas. By the end of 2020, VGCoLAB comprehends four HR and submitted an amendment request. The HR contracted in 2020 started developing some work, but it is still early to have results. An initial approach to the mentioned projects was done in 2020, mainly focused on the initiation of a learning process about laboratory equipment, testing and design
Activities to foster Associates' involvement	Still under definition
Fulfilment of INESC TEC's strategic objectives related to this participation	Increased collaboration between INESC TEC and VG is expected to happen through collaborative projects.

Table 3.10.7 - CoLAB Vines&Wines

CoLAB Vines&Wines	
Name	Vines&Wines - Vinha e Vinhos Portugueses, Competitividade e Sustentabilidade
Description	Its mission is to develop and communicate knowledge and technology to sustain the ambition expressed by the wine sector to grow by 25% in the export value (in 5 years) and to prepare and adapt the national wine system to the major challenges it faces, of which the climate change is perhaps the greatest
Areas of expertise	Viticulture; Agronomy; Product and service development
Year of establishment	2019
N.º of Associates / Accession of new Associates in 2020	7 / -
HR hired	25 assigned by the associates and 11 hired by the CoLAB
Base funding planned	351 k€
Competitive funding – submitted and approved proposals	14 proposals submitted (including 5 FCT and 3 H2020 Projects) and 3 proposals approved so far (1 FCT, 1 Fundo Ambiental and 1 Interreg Sudoe)
Main activities and achievements in 2020	Despite some impacts from the pandemic crisis, the CoLAB was able to implement its research and innovation agenda, with the development of several R&D activities and technology demonstrations. Besides the submission of several proposals, the CoLAB achieved 18 Scientific Publications and 2 Licensing Agreements, and organised 5 events.
Activities to foster Associates' involvement	Frequent communications with the Associates related with results/databases compiled by the CoLAB. Active involvement of the Associates in the proposals submitted and, with the beginning of the Strategic Council, closer communication between the CoLAB and its Associates on relevant validated knowledge and technologies.
Fulfilment of INESC TEC's strategic objectives related to this participation	The participation in the CoLAB, namely in its Strategic Board, allows to be even closer to the wine companies and consequently increasing the chances for collaborative R&I projects in this sector, being SAT2WATER, the application submitted to The European Green Deal and coordinated by ADVID, a good example.

Table 3.10.8 - CoLAB FEEDINOV

CoLAB FEEDINOV	
Name	FEEDINOV - Associação para a Investigação e Inovação em Nutrição e Alimentação Animal
Description	Aims to improve safety along the food chain, with an impact on the safety of animal products, increasing consumer confidence in domestic production and strengthening the role of the animal feed industry in the production of healthy, sustainable and environmentally friendly products
Areas of expertise	Safety, quality and sustainability of feed and food production; Competitiveness of the livestock sector; Environmental sustainability
Year of establishment	2019
N.º of Associates / Accession of new Associates in 2020	18 / -
HR hired	2 assigned by the associates and 2 hired by the CoLAB
Base funding planned	146 k€
Competitive funding – submitted and approved proposals	1 proposal approved so far (ALT20).
Main activities and achievements in 2020	During its 3 months activity, FeedInov has focused on its implementation requirements and has established informal contacts with international partners and other collaborative laboratories to engage in future formal collaborations. The CoLAB has started the development of its website as well as the evaluation of tenders for the submission of research projects with potential partners.
Activities to foster Associates' involvement	All associates have a place on the General Assembly. In these first months (October to December), meetings were held between the director for science and innovation and the various associates, to strengthen their relationship and to direct and focus actions on the needs of FeedInov members. These meetings will continue in 2021.
Fulfilment of INESC TEC's strategic objectives related to this participation	INESC TEC doesn't have a relevant activity regarding Zootechny *in lato sensu*. The participation in this CoLAB has started to change this situation and a first collaborative project application was submitted to FCT.

Table 3.10.9 - CoLAB SFCoLAB

SFCoLAB	
Name	Associação SFCoLAB – Laboratório Colaborativo para a Inovação Digital na Agricultura
Description	Generation center of innovative digital and automation solutions for efficient resource management, and to maximise the added value of domestic products of horticulture, fruit growing and viticulture
Areas of expertise	Management, Plant Biology, Agronomy, Sustainable Use of Resources, Electronics and Sensors, Robotics and Automation
Year of establishment	2019
N.º of Associates / Accession of new Associates in 2020	17 / 1 (INESC TEC)
HR hired	2 assigned by the associates, 7 hired by the CoLAB
Base funding planned	86 k€
Competitive funding – submitted and approved proposals	8 proposals submitted (including 5 H2020, 1 P2020 Projects) - 2 proposals were still submitted in 2019 (1 P2020 and 1 Mobilizador) and 1 proposal approved so far (1 P2020)
Main activities and achievements in 2020	From April to September 2020, the activities mainly focused on day-to-day management of the CoLAB. From September to December 2020, the activities turned mainly to the definition of focus groups, the identification of the current needs from the agro sector and to the definition of the methodologies for the CoLAB's action plan. Its research & innovation agenda focuses on 8 major work packages and the CoLAB was able to start working on 4 of them in 2020: smart use, smart control & monitoring, smart decision system and prototyping testing and validation.
Activities to foster Associates' involvement	SFCoLAB organised the SFCoLAB Fórum Agricultura 4.0 and, recently, the SFCoLAB International Wednesday's Meetings.
Fulfilment of INESC TEC's strategic objectives related to this participation	The objective of raising projects with CoLAB partners has already started to be fulfilled, with "Programa Mobilizador" Smart Farm 4.0 - Smart solutions for a sustainable, predictive and autonomous agriculture, and SFDIH - Smart Farm Digital Innovation Hub application to Recognition of the Poles of Digital Innovation and Access to the European Network.

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); Industrial and Systems Engineering (ISE); and Computer Science (CS). The next sections present those four Clusters, their objectives and results during 2020.

4.1 NETWORKED INTELLIGENT SYSTEMS

Coordinator: Manuel Ricardo
Assistant to the Cluster Coordinator: Andry Maykol Pinto

***Centres**: CAP, C-BER, CRAS and CTM*

4.1.1 Presentation of the Cluster

The Cluster on **Networked Intelligent Systems (NIS)** envisions to work "*towards autonomous networked intelligent hybrid systems enabled by ubiquitous sensing and processing of information*". The Cluster NIS Council consists of the following members: Manuel Ricardo, Andry Pinto, Aníbal Matos, Aurélio Campilho, Duarte Dias, Filipe Ribeiro, Hélder Oliveira, Ireneu Dias, Jaime Cardoso, João Cunha, José Almeida, Luís Pessoa, Paula Viana, Paulo Marques, and Rui Campos.

NIS plays an important role in scientific areas related to ubiquitous sensing, precise positioning, low latency communications, reconfigurable hardware, machine learning, computer vision, collaborative robots, and edge intelligence. NIS works towards futuristic scenarios in which collections of cooperative systems, communications enabled and carrying advanced sensors, collect information also in extreme environments such as the deep sea or the human body, and process it by using also artificial intelligent tools. NIS contributes to scientific fields related to Signal Processing, Electronics and Computers, Interfaces and Multimedia, Communications, Computer Vision, Intelligent Systems, and Control and Robotics.

NIS has 4 Research Lines (RL): Sensing, Communications, Computer Vision, and Autonomous Systems. A RL is characterised by a set of research topics, each addressed by a group of researchers.

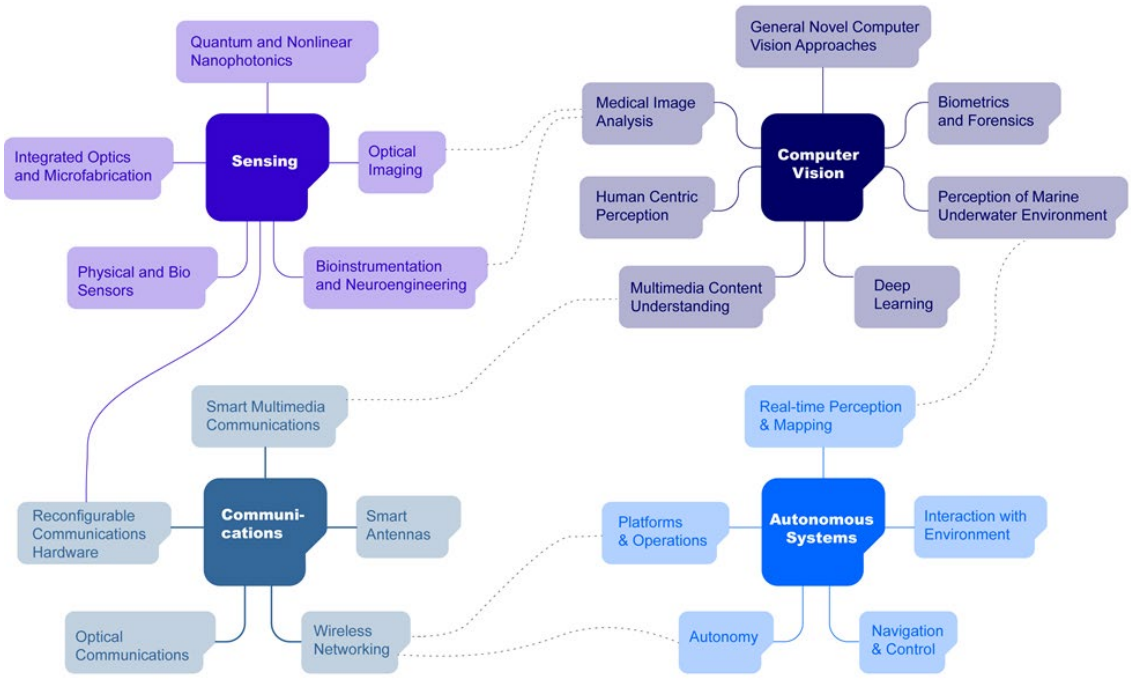


Figure 4.1.1 – Interaction between research topics and lines in Cluster NIS

4.1.2 Scientific outcomes in 2020

Sensing

The **Sensing** RL aims to design multi-parameter sensing systems for capturing relevant information. By the end of 2020 this RL consisted of 56 Core Researchers including 24 PhDs. During 2020, this RL published 51 articles in indexed journals (33 of them classified by Scopus as first quartile), and had 12 PhD theses ongoing (3 of them concluded). The 3 main scientific outcomes produced during 2020 were the following:

- **Optofluidics and Sensing**. The monolithic fabrication of an integrated device with femtosecond lasers for the excitation of whispery gallery modes through a suspended waveguide was demonstrated; the devices produced set the world state-of-the-art on silica machining and this solves the problems associated with the robustness of whispery gallery modes excited with fiber tapers. Waveguides operating in a broadband regime were also fabricated and were key to demonstrate the excitation of close-to-surface waveguides and plasmons, as well as its application in integrated optics sensing.
- **Optical Graphene Microphone.** Fabrication of graphene oxide thin films through dip coating technique was employed for the assembly of membranes in optical fibers for acoustic or pressure sensing. This deposition process allowed the development of ultrasonic sensors for broadband spectrum and were compared with a conventional microphone. The deposition technology is being adapted for the manufacture of graphene-based antennas in the GHz range. The study of graphene inks is also being explored for sensing applications.
- **Low power micro sensor human implementable.** For the first time in the Iberian Peninsula, a neurostimulator was implanted in epileptic patients with the contribution of partners at the Centro Hospitalar Universitário de São João. Afterwards, new techniques of systems synchronisation and signal processing for the development of new neurostimulation therapies were developed using very low power implantable sensor. International collaborations with the department of Neurology of Ludwig-Maximilian University of Munich in Germany and the Neurology Department of the University of Tampere had resulted in a scientific paper.

Communications

The Communications RL aims to create self-learning communications systems that can support different types of services and data in Immersive and Extreme Environments, taking advantage of state-of-the-art heuristics including artificial intelligence and machine learning. The focus is on solutions for the communications systems of the future, from the physical layer to the networking layer to the application layer, considering both terrestrial and maritime environments.

By the end of 2020 this RL consisted of 30 Core Researchers including 16 PhDs. During 2020, this RL published 17 articles in indexed journals (13 of them classified by Scopus as first quartile), and had 12 PhD theses ongoing (3 of them concluded). The 4 main scientific outcomes produced during 2020 were the following:

- **Placement and active queue management algorithms for aerial networks** that enable significant performance gains (higher throughput and lower delay) when compared to state-of-the-art counterparts.
- **New trace-driven ns-3 simulation models,** enabling the replication of experiments and the creation of wireless network digital twins by using information on signal-to-noise ratio, physical data rates, and wireless channel occupancy observed in the real-world.
- **Ubiquitous Framework for High-Quality Audiovisual Production**. An IoT-like approach capable of automating the operations carried out at professional audiovisual production studios.
- **Parallel Implementation of K-Means Algorithm on FPGA**. A fully parallel implementation of the K-means algorithm on FPGA to optimise the system's processing time, a key enabler for real-time applications.

Computer Vision

The **Computer Vision** RL aims to empower the next generation of intelligent systems with the capability of reasoning from visual data, approaching or even surpassing the human vision. The RL addresses both

fundamental and applied problems in computer vision, image processing, machine learning, and decision support systems anchored in the automatic analysis of visual data. The focus is on the fields of health, multimedia and robotics.

By the end of 2020 this RL consisted of 48 Core Researchers including 18 PhDs. During 2020 this RL published 23 articles in indexed journals (19 of them classified by Scopus as first quartile) and had 28 PhD theses ongoing (1 of them concluded). The 3 main scientific outcomes produced during 2020 were the following:

- **Understanding the decisions of CNNs**. A novel in-model joint architecture to explain the decision of CNN classifiers was proposed. This architecture outputs not only a class label, but also a visual explanation of such decision, and can be used with any classifier.
- **Uncertainty-aware deep learning-based approach for computer-aided diagnosis and grading.** A CAD grading system that supports the clinical decision and the assigned pathology grades by providing a medically interpretable explanation. This methodology was successively tested in grading Diabetic Retinopathy. A deep learning model for Covid-19 detection in X-ray images was also designed using a dataset containing the manual labels given by two radiologists, including intra and inter-observer variability, in 1.845 chest X-ray images.
- **Improved 3D visual information for underwater manipulation** based on the innovative hybrid imaging system for 2D/3D visual acquisitions for harsh underwater environments. New operational regimes and the capability to provide dense 3D measures for textureless scenarios were included.

Autonomous Systems

The Autonomous Systems RL addresses the development of innovative robotics solutions for operation in complex environments. Relevant examples are underwater environments and particularly deep-sea water. This research line also includes activities related to the development of key components of field going robotic platform addressing topics such as persistent operations, underwater robotic data and energy mules, operations in non-segregated space, or collaborative mapping and learning.

By the end of 2020 this RL consisted of 26 Core Researchers including 8 PhDs. During 2020, this RL published 10 articles in indexed journals (8 of them classified by Scopus as first quartile), and had 15 PhD theses ongoing. The 4 main scientific outcomes produced during 2020 were the following:

- **Autonomous navigation**. Deep learning algorithm for underwater visual odometry navigation. This algorithm fuses together visual and inertial data, using a recurrent neural network.
- **Underwater docking**. A multi-sensor system for underwater docking operations; this system combines short-range acoustic positioning with visual perception, allowing for a global solution of the relative localisation problem in underwater docking maneuvers.
- **Autonomous water sampler**. An autonomous sampler of the water column for estimation of sediment transport. Based on the real time estimation of sensor depth, and on the modelling of the deployment system, this sampler assures that the water sampler descends and ascend on the water column at constant rate, a requirement for transport sediment estimation.
- **Precise positioning.** Development and implementation of algorithms for precise positioning both above (RTK GPS) and under water (acoustic based). These algorithms enable the precise space referencing of data collected by robotics platforms, contributing to the production of accurate maps of surveyed areas.

4.2 POWER AND ENERGY

Coordinator: Luís Seca

Assistant to the Cluster Coordinator: David Rua

Centres: *CPES*

4.2.1 Presentation of the Cluster

The Power and Energy Cluster addresses INESC TEC scientific strategy in the Energy Domain, bringing complementary scientific competences to the relevant and high impact activity of the Centre for Power and Energy, that has its activity mainly focused on the Power System domain.

In fact, managing the Energy Systems of the future requires strong knowledge on Power System operation and planning, which are competences held by the researchers of CPES, that are the main anchor of this Cluster. However, digitalisation requires the inclusion of other competences, coming from other R&D Centres of INESC TEC, to develop new scientific knowledge applied to the domain, namely on the foreseen needs on advanced sensing, ICT, industrial systems and computational intelligence. These competences can foster a seamless integration of renewables and a truly decarbonisation of a system that needs to be resilient, reliable and both economically and environmentally sustainable.

For this, 3 Research Lines (RL) structure the evolution of the institution in the Power and Energy Domain, focusing on the domains that require synergies, in developments and breakthroughs, to support the objectives of the Cluster. The RL include competences from other research topics from the different Centres such as: competences coming from CEGI (in green), from LIAAD and HASLAB (in purple), from CTM and CAP (in grey) and from CPES (in dark yellow).

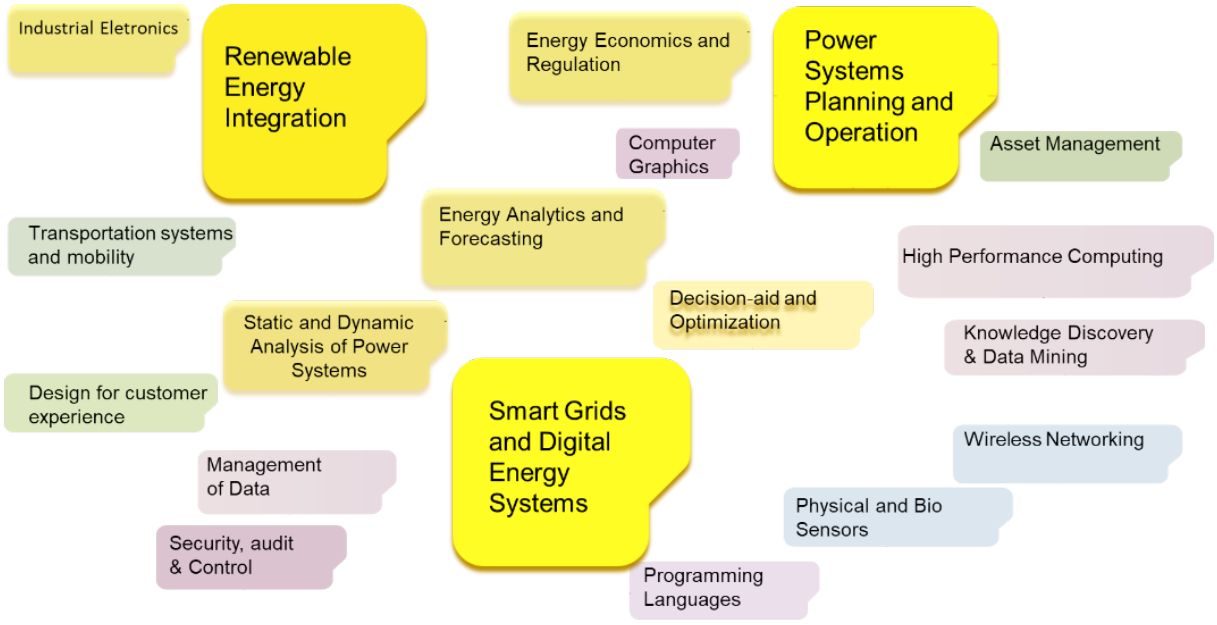


Figure 4.2.1 – Interaction between research topics and lines in Cluster PE

4.2.2 Cluster research lines

RL1 – Renewable Energy Integration

The full and enduring decarbonisation of the power system requires significant advances in the state-of-the-art and a combination of new: computational strategies; smart hardware for power conversion; and ambitious regulatory approaches. More concretely, the challenges associated to the variability of renewable based energy

sources, its distribution at different voltage levels over the grid and the fact that it is connected using power electronics inverters, are significant.

The presence of other actors, such as distributed storage, electric mobility and flexibility from demand (mainly due to IoT capability in industrial, office and residential buildings) brings a very important capacity to push the limits of this renewable energy integration, by damping the variability of the primary resource and providing a stable and resilient energy system.

The impact of this integration with other energy vectors, namely "green" hydrogen and ammonia, is of great importance. These can be produced, transported and distributed, constituting a complementary mean of increasing the share of renewable in the system, either to be later converted into electricity or, to be incorporated as a gas turbine fuel to support a low or reduced carbon electrical grid. This should be one of the major outbreaks in the coming years in this RL.

Main research challenges

- System operation and control under a massive connection of power electronics interfaced renewable generation;
- Development of advanced control strategies for a stable and resilient operation of the electrical system;
- Valorisation of demand side flexibility and articulation with other domains like transportation;
- Definition of new technical and business models to support cost-effective ancillary services to the system;
- Improve predictability of RES in future scenarios with hybrid power plants, storage and other green energy vectors (hydrogen, ammonia).

RL2 – Power and Energy Systems Planning and Operation

To support the decarbonisation of Society, mainly through electrification, several changes need to occur in the way the electrical system is planned and operated. In fact, the foreseen increase in new types of sources and resources in the coming years, namely solar photovoltaics and electric vehicles, is a challenge. On the one hand, large solar power plants and EV fast charging stations require that the electrical grid has the capacity to absorb and supply these larger units, involving network reinforcement and also predictive control, as this type of resources can benefit from high a correlation factor. On the other hand, distributed energy resources are also a matter of concern, as relatively high simultaneous power flows can occur in areas of the network that were not prepared to handle them. Self-consumption and energy communities can mitigate some of these effects but still require a highly sensor-intensive grid, that intelligent control and management for a safer and resilient network operation and planning.

Simultaneously, it is necessary to start developing tools to manage the operation of gas distribution grids incorporating renewable gases and addressing regulatory, planning and operational concerns.

This RL will develop techniques and tools to optimise the performance of the existing or foreseen power system in economic, technical and security of supply terms.

Main research challenges

- Application of artificial intelligence (AI) in system operation and planning, focused in human-machine interaction;
- Data visualisation, advanced training procedures for human operators (e.g. augment reality);
- Novel cost-benefit and multicriteria analysis methodologies for network planning with multiple options (flexibility, network reinforcement, smart grids functions);
- Scalability problems that require high-performance computing and distributed approaches with graphics processing units to close the gap (in terms of computational time) between planning and operational tools;

- Identification of new regulatory policies and control solutions for gas distribution grids with renewable gases towards an energy sector coupling approach, including improvement of security of supply in the power and energy system.

RL3 – Smart Grids and Digital Energy Systems

The Smart grids RL entails the continuous development of an intelligent operation of the electrical network as a means to support the integration of new distributed energy resources. This intelligence, driven by big data, advanced analytics and IoT technologies, enables a two-way flow of electricity and data with the capacity to detect, react and pro-act to changes in usage and multiple issues, assuring quality of service under a dynamic market-based operation of the electrical system.

Energy analytics is the main lever of this RL, as a smart grid requires IoT to support use cases in areas such as asset optimisation, predictive maintenance, self-healing and the optimisation of power quality while making sure demand for electricity is met in the most optimal way with energy savings and low environmental impact. The development of energy services, associated with end-user interaction, is also a very important result of this new operation paradigm, towards a generalised carbon neutrality and able to support a circular economy.

This RL is crucial to foster the development of an integrated energy system for a climate-neutral Europe and is clearly where some of the most significant progress will occur in the coming years.

Main research challenges

- Active participation of Distributed Energy Resources in new ancillary services
- Employ life cycle assessment techniques towards sustainable multi-energy articulation
- Exploitation of end-user flexibility
- Management of multi-energy carriers
- Cross-border exchange of energy and data
- Cybersecurity and IoT for critical infrastructures
- Cyber-physical energy systems

4.2.3 Scientific outcomes in 2020

The Cluster PE has its major scientific outcomes based on the scientific outcomes of CPES, as the majority of the researchers that develop scientific work in the domain have their activity in this Centre. However, there has been some development in the Research Line for Smart Grids and Digital Energy Systems coming from researchers from HASLab.

So, the most relevant scientific outcomes for the Cluster PE in 2020 are presented below.

RL1 – Renewable Energy Integration

- Development of a privacy-preserving protocol and data markets for renewable energy collaborative forecasting, considering different communication schemes (centralised, peer-to-peer, asynchronous communication). Papers in IEEE Transactions on Sustainable Energy and in International Journal of Forecasting. Patent request to EPO;
- Development of an agent-based model to simulate the MIBEL day-ahead market considering the presence of hydro generation, wind and solar PV units;
- Development of techniques to detect and isolate faults in passive and active components of DC/DC power converters. This algorithm, based on an inversion method, is able to detect automatically failures in DC/DC converters. Paper in Electric Power Systems Research;

- CPES Seed project to develop an innovative solution for provision of a virtual inertia in power inverters based on a controller of the voltage of the DC link capacitor, applied to photovoltaic systems.

RL2 – Power and Energy Systems Planning and Operation

- Deep learning approach (variational auto-encoders) to simulate load profiles of residential consumers under dynamic electricity tariffs and demand response signals. Internship of PhD student from EDF R&D. Code released in Github and method published in IEEE Access;
- Development of a methodology to monetise the benefits of the investments in the distribution system concerning the security of supply, the quality of service, the distribution losses and operational efficiency. The tool includes the estimation of the distribution grid quality indices evolution and assists the DSO on the medium and long-term planning decisions. Contract with E-Redes;
- CEGI and CPES developed and applied a data-driven methodology to predict distribution lines (overhead and subterranean) failure location in HV and MV networks operated by E-REDES, considering meteorological variables, geographical location, and physical characteristics (e.g. conductor material). Contract with E-Redes.

RL3 – Smart Grids and Digital Energy Systems

- Implementation of a cross-entropy optimisation method for smart schedule optimisation within domestic and tertiary buildings to be employed in distributed computational units (edge) and cloud-based systems;
- Building a polyglot layer to enable integrated interrogation of data stored in data sources with different NoSQL models through an extended relational model, thus being compatible with existing Low-Code development tools. The power grid can benefit from a holistic approach to query data from several database systems, where possibly each one addresses a distinct reality and thus deploy distinct data models types (relational, non-relational, graphs, etc). This explores the concept one query to several systems. One paper: Alonso, Ana Nunes, et al. "Building a Polyglot Data Access Layer for a Low-Code Application Development Platform." IFIP International Conference on Distributed Applications and Interoperable Systems. Springer, Cham, 2020;
- Analysis of the impact of the characteristics of message exchange phases in Byzantine fault-tolerant distributed settlement protocols, in particular, considering the use of cryptographic primitives, concluding that the approach to be followed in the construction of these protocols should include adaptation mechanisms. This work, currently an ongoing PhD thesis will be applied to the implementation of distributed Self-Healing mechanisms to increase distribution network resilience. One paper published in the IFIP International Conference on Distributed Applications and Interoperable Systems. Springer, Cham, 2020";
- Collaborative approach for data monetisation and improved extraction of value, while being supported in distributed management solutions for control and auditability such as blockchain. This concept is being explored for the monetisation of energy forecast data, benefiting from each other's data and collecting a profit based on data quality; 1 PhD Thesis being concluded;
- CPES and CEGI developed a first prototype of a local market platform for energy trading based on Ethereum blockchain technology with an innovative post-delivery local energy market design. INESC TEC Seed project P2PChain with CPES and CEGI. Paper: Mello, J. et al. "Power-to-Peer: a blockchain P2P post-delivery bilateral local energy market." EEM 2020;
- Development and validation with historical data of AI-based substation's alarm management software for reducing the cognitive load of distribution network operators, namely: 1) identification of anomalous behaviours regarding the performance of the protection functions associated with HV and MV line panels. 2) identification of similar events in HV line panels. Contract with E-Redes.

4.3 INDUSTRIAL AND SYSTEMS ENGINEERING

Coordinator: Bernardo Almada Lobo
Assistant to the Cluster Coordinator: Ricardo Zimmermann

Centres: *CEGI, CESE, CITE and CRIIS*

4.3.1 Presentation of the Cluster

The Cluster on Industrial and Systems Engineering (ISE) researches and innovates in systems and services applied to the management of value streams. It envisions to lead research in complex decision-making in end-to-end, customer-centric, supply chains across different industries (e.g., manufacturing, retail, health and mobility).

To improve business performance, foster innovation and productivity, and contribute to environmental and social sustainability, the intervention of this Cluster ranges from local optimisation of individual organisations to complex system optimisation of networks. Its activities cover the design, implementation and improvement of systems for decision support, the optimisation and management of human-centred automation, as well as the development of new approaches to innovation and technology management. Clearly, this Cluster aims at helping companies to fully embrace the fourth industrial revolution by leveraging digital transformation, advanced analytics and the integration of advanced manufacturing technologies and new business models. Customer-centric and real-time supply chain optimisation, as well as decentralised decision-making, will only be possible with highly flexible, realocable, adaptable and intelligent automation, control and robotics.

The main scientific driving forces of ISE include Customer-Driven and Human-Centric Industry and Services, Green & Energy/Resources Efficient Value Chain, as well as Flexible, Autonomous and Collaborative Production. Furthermore, the Digital transformation and Digitalisation, the IoT – Internet of Things, the Vertical and Horizontal Digitisation, together with Data and Knowledge Intensive Production and Virtualisation for Decision Making open new research avenues for the Cluster.

ISE has 5 Research Lines (RL) that are cross-fertilised to expand the space of its solutions: Operations Management, Operations Research & Management Science, Autonomous Systems, Technology-enabled Innovation, and Industrial Information Systems. Each RL is characterised by a set of research topics, each addressed by a group of researchers.

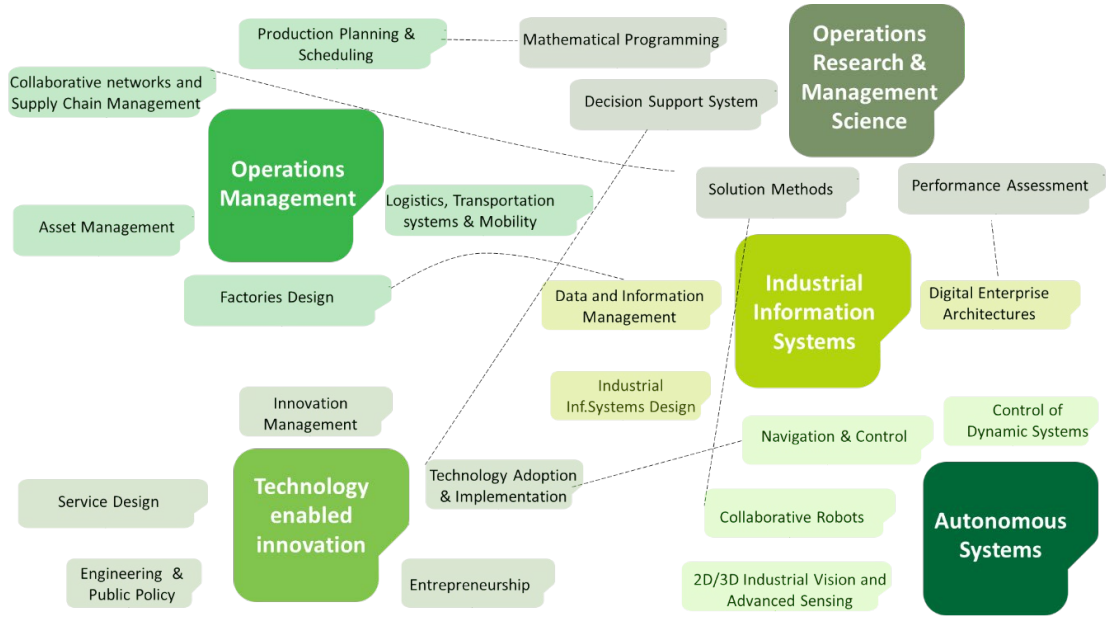


Figure 4.3.1 Interaction between research topics and lines in Cluster ISE

4.3.2 Scientific outcomes in 2020

RL1 – Operations Management (in manufacturing and services)

This research line aims to contribute to the design, control, plan, and improvement of all value adding processes that lead to more efficient or effective creation and delivery and management of goods and services, with a holistic and integrated view of responsive, sustainable and resilient operations and systems. This RL allows for the design of end-to-end supply chain processes, with an empowered end customer.

This RL published in 2020 18 articles in indexed journals (15 of them classified by Scopus as first quartile).

The four main scientific outcomes produced during 2020 were the following:

- **Production Planning and Scheduling**. (i) A real time scheduling engine integrated with an IIoT platform to monitor, detect and evaluate disturbances on plan execution, and suggest corrective measures; (ii) A standardised communication protocol of open-source reinforcement learning (RL) integrated with simulation models for decision support in in-house logistics systems.
- **Collaborative Networks and Supply Chain Management**. The balance of power dynamics between supply chain partners in the context of digital transformation of SMEs has been investigated in the winner project of the EurOMA Young Scholar Networking Grant.
- **Logistics, Transportation Systems and Mobility.** (i) Knowlogis was awarded the best digital project award in the Healthcare sector by Portugal Digital Awards; (ii) Novel models to estimate the emissions and other externalities of transport and mobility.
- **Asset Management**. Novel predictive and prescriptive models for asset management and reliability engineering to control the health status across the whole life cycle of the asset.

RL2 – Operations Research and Management Science (decision support in a digitised industry)

This research line aims to leverage the science of optimal decision-making (mathematical models and algorithms) under uncertainty, contributing to the methodology of operational research and to the practice of decision-making, especially in: supply chain management, production planning and scheduling and transportation/mobility.

During 2020, this RL published 19 articles in indexed journals (12 of them classified by Scopus as first quartile).

The four main scientific outcomes produced during 2020 were the following:

- **European project coordination** (Project TRUST-AI), selected for funding; the project builds on Genetic Programming.
- **Mathematical Programming-based heuristics**. New insights were obtained on how to deal with uncertainty and hybridise heuristics and mathematical programming (matheuristics). These approaches have been applied on emerging topics related to urban logistics (in particular “last mile”).
- **Visualisation techniques**. Novel semantic ontologies to recommend the adequate visualisation techniques for a given analytical task when analysing urban mobility data, with deep learning artificial neural networks.
- **Machine Learning meets Optimisation**. Advances have been made in the area of e-commerce, with several papers having been submitted.

RL3 – Autonomous Systems

This research line aims to support the design and implementation of innovative solutions within the areas of industrial robotics and intelligent systems, focusing on the development of cognitive, sensitive, human centred and safe robotic-based and automated systems.

During 2020, this RL published 11 articles in indexed journals (9 of them classified by Scopus as first quartile), and 19 papers in proceedings of international conferences.

The main four scientific outcomes produced during 2020 were the following:

- **Navigation, Localisation and Coordination of Mobile Robots.** A novel open-source Path Planning solution Aware of Robot's Centre of Mass for Steep Slope Vineyards.
- **2D/3D Industrial Vision and Advanced Sensing**. Development of an AI empowered flexible robot handling system, capable of generating grasp solutions, based on the digital model of both the part and the gripper and their contact forces.
- **Collaborative Robots**. (i) Deployment of a collaborative robotic coating cell. This industrial cell includes a programming by demonstration system, an advanced 3D sensing system, and an innovative safety sensor to allow for a symbiotic, safe and intuitive human-robot collaboration. (ii) An automated framework (AdaptPack studio) for agile development and simulation of robotic palletizing cells.

RL4 – Technology-enabled Innovation

This research line aims to study the emerging processes of planning, adopting and implementing digital technologies in industry and services, and to develop new concepts, theories and methods fostering new technology-based innovation and technology management processes as enablers of value co-creation. It also aims at contributing to public policies addressing the emerging challenges in industry and services.

During 2020, this RL published 17 articles in indexed journals (9 of them classified by Scopus as first quartile).

The main scientific outcomes produced during 2020 were the following:

- **Technology management and adoption**. Definition of skills and business models for the future manufacturing, as well as relevant industrial use cases.
- **Theory of service design**. (i) Co-creation and launch of the ServCollbab, a global initiative of service researchers to improve well-being; (ii) new results in advanced service design and innovation for healthcare transformation and technology startups; (iii) advanced the understanding of customer experience with technology enabled services.
- **Technology Entrepreneurship.** A novel reference framework for Software as a Service Business Model Creation.

RL5 – Industrial Information Systems

This research line aims to develop new concepts of information systems for industrial management addressing the challenges and opportunities of an industrial context characterised by data dependency and an intensive digital transformation, towards a sustainable industry transformation.

During 2020, this RL published 3 articles in indexed journals (2 of them classified by Scopus as first quartile), and 3 papers in proceedings of international conferences.

The two main scientific outcomes produced during 2020 on **Digital Platforms, Data-driven Architectures** and **Integration of Business Process Support** were as following:

- A first specification of a digital platform based on semantic-enabled architecture to manage product-service systems based in the concept of digital twin was achieved.
- Expansion of the OSPS (Open Scalable Production System) framework through the integration with robotic oriented cloud computing platforms (allowing for large scale testing and deployment of multi robot systems), namely the Amazon AWS RoboMaker, together with Manufacturing Execution System and Simulation and Decision Support Tools.

4.4 COMPUTER SCIENCE

Coordinator: Rui Oliveira
Assistant to the Cluster Coordinator: Ana Nunes Alonso

Centres: *CRACS, CSIG, HASLab, LIAAD*

4.4.1 Presentation of the Cluster

The mission of the Cluster is to increase the individual and collective recognition of INESC TEC in both fundamental and applied Computer Science research.

Computing became fully decentralised, mobile, increasingly autonomous, and ubiquitous reaching all appliances, devices and living beings. As a result, current information and communications systems present many hard and intricate challenges associated to scalability, security and criticality. The ever-increasing amounts of generated data embody a wealth of information that needs to be properly and timely mined and analysed. This challenges our capacity to filter, curate, store, process, query and visualise unprecedented volumes of data from diverse sources and formats. In addition, the economic value of the data, trade and state secrets, and individual rights require data manipulation to comply with demanding levels of privacy. Smarter and autonomous systems in critical realms such as utilities, health care, transportation and finance require dealing with new, and often unanticipated, sorts of risks that challenge the best practices of software engineering, network and information security and human-computer interaction.

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.

Through each of its Centres, the Cluster addresses diversified, heterogeneous and yet complementary research topics such as Artificial Intelligence, Cybersecurity, Computer Graphics and Virtual Environments, Information Management and Systems, Decision Support Methods, Parallel and Distributed Systems, and Software Engineering.

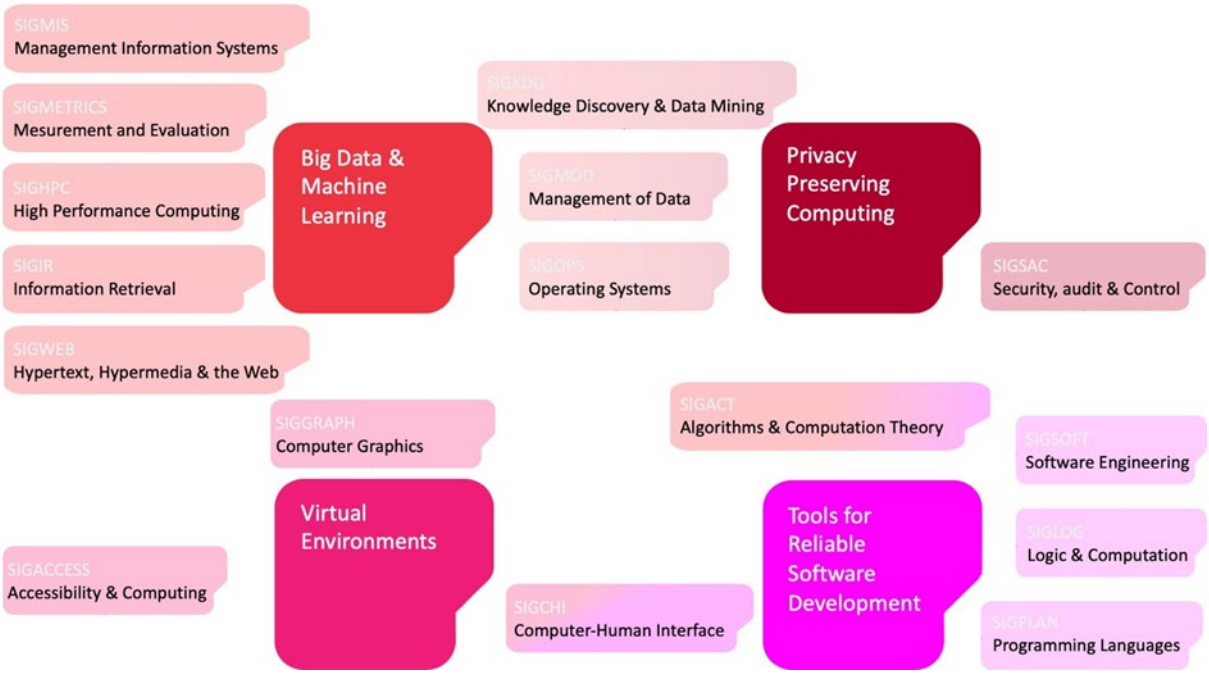


Figure 4.4.1 - Interaction between research topics and lines in Cluster CS

For 2020, the Computer Science Cluster kept its focus on four research lines with considerable critical mass and deemed strategic with regards to social and economic impact. These are:

- Big Data and Machine Learning
- Privacy Preserving Computing
- Tools for Reliable Software Development
- Virtual Environments

The interaction between these research topics and lines is pictured in Figure 4.4.1, above. 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, Earth and Ocean Observation, Industry, and Telecommunications.

4.4.2 Scientific outcomes in 2020

An overarching objective of the Cluster for 2020 was to increase the international visibility and notoriety of INESC TEC's computer science research. This has been pursued in several ways that, on each own, acknowledged our scientific competences and seniority.

INESC TEC has designed and developed the Portuguese digital contact tracing system for COVID-19, STAYAWAY COVID. As a partner of the Decentralised Privacy-Preserving Proximity Tracing consortium, INESC TEC contributed to the protocol underlying the Apple/Google Exposure Notification service and Huawei's Contact Shield.

INESC TEC co-chairs the Portuguese node of the Research Data Alliance (RDA), a third-party agreement in the context of the RDA-Europe 4.0 European project. The node fostered the engagement of Portuguese research communities in the RDA. Cristina Ribeiro was appointed by the INCoDe.2030 programme to coordinate the definition of the Portuguese Strategy for Open Data.

INESC TEC became involved in the European Network of Excellence on Artificial Intelligence through the H2020 flagship Project HumanEAI and in the ESFRI European Plate Observing System (EPOS, Sustainability Phase), through the Collaboratory for Geosciences (C4G), where it is assessing the readiness of the Thematic Core Services for Open Science.

The University of Porto, the Polytechnic of Porto and INESC TEC have organised the first Summer School on Machine Learning and Big Data with Quantum Computing, a huge success with about 2 000 participants.

Nuno Moniz and Arian Pasquali were the WSA Global Award winners in the "GOVERNMENT & CITIZEN ENGAGEMENT" with the app Meuparlamento.pt. João Gama, João Mendes Moreira and Luís Matias were announced as recipients of "The George N. Saridis Best Transactions Paper Award for Outstanding Research" for the year 2016. Roberto Vaz, Diamantino Freitas and António Coelho were awarded the 2020 International Award for Excellence for The Inclusive Museum Research Network. Luís Soares Barbosa was nominated Chair of the IFIP Technical Committee 1 - Foundations of Computer Science. The International Federation for Information Processing (IFIP) Technical Committee 1 is an international committee that aims at the development of the theory and computer science and of its bridges with other domains of knowledge and socially relevant applications. José Creissac Campos was elected Steering Committee chair of the ACM SIGCHI Engineering Interactive Computing Systems (EICS) conference, one of the most relevant international conferences devoted to all aspects of engineering usable and effective interactive computing systems. Rui Oliveira was elected Steering Committee chair of the IEEE Symposium on Reliable Distributed Systems, one of the most relevant and long-standing conferences devoted to distributed systems. Leonel Morgado was elected Vice President for Scientific Quality of the International Network Immersive Learning Research Network. Maximino Bessa has been elected to the Executive Commission of the Eurographics Association.

A continued effort has been to improve the average publication impact while increasingly targeting the very best venues. To the Cluster this means focusing on CORE A and A* conferences and Q1 journals. To this end, during 2020, the Cluster's researchers produced 59 (up from 46) Q1 journal papers, 16 (up from 9) CORE A and 5 (up

from 4) CORE A* conference papers. These figures were above 2019's. As a whole, in 2020, the Cluster's researchers published 114 papers in indexed journals and 147 (down from 163) papers in indexed conferences.

On the specific topics of the Cluster research lines we highlight the following outcomes. These were either published or made available to the community as software packages.

Big Data and Machine Learning

On the storage of big data, we highlight two papers: one published in the scientific journal ACM Computing Surveys, one of the journals with the greatest impact factor in the field of Computer Science, entitled "A Survey and Classification of Software-Defined Storage Systems", presenting different approaches to the Software-Defined Storage paradigm; and "GenoDedup: Similarity-Based Deduplication and Delta-Encoding for Genome Sequencing Data", presenting a new data deduplication solution that enables the storage and access to human genome information more quickly, and with lower associated storage costs, published in the scientific journal IEEE Transactions on Computers.

On large scale data processing, advances on a platform for computational offloading include the possibility of using soft real-time tasks and off-loading algorithms that take deadlines, execution time, local and total energy consumption into account.

A repository-agnostic security middleware for a federated research environment for immunogenetics, to foster data sharing and joint research towards the development of new therapeutics and vaccines, was implemented, providing a proof-of-concept implementation of a blockchain-based approach for the traceability of transformations used in the processing of human RNA data. Also, a software ecosystem for the real time processing of geospatial data streams was implemented and tested, along with tools and methods for the assisted curation, exploratory analysis and publishing of large scientific datasets.

On fake news detection, the following outcomes should be highlighted: a novel process to identify bots; the creation of a model to balance the need for information regarding volume and time; the development of ML models for tampered videos and photos; and the development of external modules for the widely used and open-source Autopsy tool.

Privacy-Preserving Computing

Advances in privacy-preserving data storage and processing include the development of a secure data analytics framework that enables the combination of different cryptographic primitives with hardware-based protected environments, namely for Machine Learning workloads, with the goal of protecting both data and models when using third-party infrastructures. A secure deduplication system that takes advantage of hardware-based protected environments has also been developed.

Tools for Reliable Software Development

We highlight the paper "The Last Mile: High-Assurance and High-Speed Cryptographic Implementations" presented at IEEE Symposium on Security and Privacy 2020, on an approach for building cryptographic implementations that are provably functionally correct, protected against side-channels, and as efficient as hand-written assembly, and the paper "Improving Performance and Energy Consumption in Embedded Systems via Binary Acceleration: A Survey", published in the ACM Computing Surveys journal, focusing on approaches for exploiting instruction-level parallelism through the automatic generation of specialised hardware from binary code, applicable to reconfigurable devices (FPGA).

A property-based testing framework for assessing the correctness of smart contracts in the Ethereum blockchain was developed.

Virtual Environments

We highlight the development of a fully immersive 3D authoring tool for industrial training, a joint project with Vestas that streamlines 3D authoring and enables its analysis through automated techniques. Recently published survey "Finding the Gaps about Uses of Immersive Learning Environments: A Survey of Surveys" is recommended by iLRN as a methodological go-to reference. In the MASSIVE lab we highlight the development of an innovative HDR image pipeline that enables object recognition in extreme lighting conditions, as the major outcome of project HDR4RTT, a project funded by the U.S. Office of Naval Research Global. The systematic review "Do

Multisensory Stimuli Benefit the Virtual Reality Experience? A Systematic Review" was published in IEEE Transactions on Visualization and Computer Graphics.

5 TEC4 INITIATIVES

5.1 Overview

A TEC4 ("TEChnologies FOR …") is an organisational approach 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 complementary dynamics and supports the full knowledge-to-value chain.

The short-term objectives of the TEC4 initiatives are the creation of innovative, knowledge based 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. Their long-term objectives 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.

Each TEC4 targets a specific market and induces cross-cluster multidisciplinary projects, promoting collaboration with business and producing solutions to be transferred to companies. Each has also a strategic agenda, according to their market domain, addressing three pillars: the stakeholders' perspective, a strategy and related technological roadmap and the R&D infrastructure evolution - to keep up with the state-of-the-art and support the roadmap.

The application areas addressed by the TEC4s are aligned with European, national and regional priority domains, developing and consolidating internal R&D competencies around socio-economic pillars. 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.

The performance of each TEC4 is measured mainly by the level of recognition and activity (namely direct contracts with the companies and other relevant stakeholders) in its market and the number of inter-Centre collaborations generated. The TEC4 are not involved in project development: once an opportunity is detected, negotiations occur with the relevant Centres and it is under these that the project is then managed and executed.

Typically, a TEC4 encompasses:

- A concrete market domain, represented by businesses and associations;
- A group of Centres with their multidisciplinary competences, dedicated to the challenges of that market domain;
- An 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 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 TEC4 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.

The current TEC4s organisation is composed by:

- ✓ Five established TEC4s:
  - TEC4AGRO-FOOD: agro-food and forestry
  - TEC4ENERGY: energy related activities and economy
  - TEC4HEALTH: health and well-being related activities and economy
  - TEC4INDUSTRY: production technologies, manufacturing, distribution, logistics and retail
  - TEC4SEA: sea activities and economy

- ✓ TECPARTNERSHIPS, dedicated mainly to promote and support business in all other sectors and to explore new market segments and incubate new potential TEC4's until they reach a qualified maturity level.

TEC4s are dynamic organisation models that need to be periodically evaluated and adapted to the economic landscape.

Sections 5.2 to 5.7 present a short description of the scope and objectives of the current TEC4 initiatives and the main outcomes of 2020's activity.

5.2 TEC4AGRO-FOOD

Business Developer: André Sá

5.2.1 TEC4AGRO-FOOD Presentation

TEC4AGRO-FOOD is INESC TEC's Initiative for Agro-Food and Forestry.

TEC4AGRO-FOOD's Mission is co-shaping the digital (r)evolution in Agro-Food and Forestry through research and technological development in Information and Communication Technologies and Electronics (ICT&E) and Robotics.

TEC4AGRO-FOOD's application areas are Smart (digitalisation) Precision ("right time, right amount, right place") Agriculture and Forestry, Food Security and Bioeconomy.

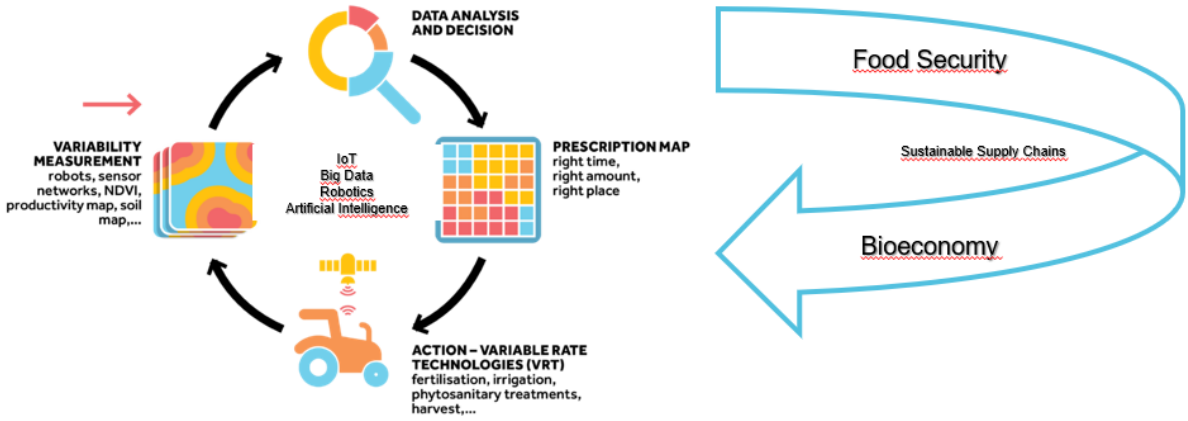


Figure 5.2.1 - Precision Agriculture/Forestry Action Cycle

TEC4AGRO-FOOD provides innovation services of Consultancy and Research and Technological Development in the mentioned application areas.

TEC4AGRO-FOOD has proven to be a very cross-cutting initiative regarding INESC TEC's R&D Centres, with the majority of them being involved in it, being CRIIS the most active one.

5.2.2 Main achievements in 2020

Following the strategy of full implementation of portfolio projects and redoubling efforts with companies and at international level, in 2020, TEC4AGRO-FOOD continued its consolidation as the main RTD national partner in the scope of ICT&E and Robotics for Agro-Food and Forestry. At the same time, at European level, TEC4AGRO-FOOD is entering in a sustainable manner the Research and Innovation Programmes, namely H2020. It should also be highlighted the increased visibility (press, events, etc.) and the contribution to the public policies (RIS3 and CoLABs).

TEC4AGRO-FOOD's main achievements in 2020 are presented below in chronological order:

- **Approval PRySM** - PRecision Sprayer Ground Robot (European; 93,2k€; CRIIS);
- **Approval AgRobIT** - Mowing Robot (European; 51,6k€; CRIIS);
- **Approval NOVATERRA** - Integrated novel strategies for reducing the use and impact of pesticides, towards sustainable Mediterranean vineyards and olive groves (European; 341,2k€; CRIIS);
- **Integration** of INESC TEC in the entities of the **Smart Specialisation Regional Platform Agroenvironmental Systems and Food (CCDR-N)**;
- **Approval rePLANt** - Implementation of collaborative strategies for integrated forest and fire management (ANI - Programa Mobilizador; 214,8k€; CESE, CRIIS, CEGI and CSIG);
- **Approval LL2FRESH** - LONG LIFE TO SAFE FRESH - What to start and accelerate? (European; 18,1k€; CITE);
- **Kick-off ROBOCARE** - Robotic Platforms for Smart Precision Protected Cultivation (Contract - Projetos de I&D Individual; Amorins Lda.; CRIIS);
- **Interview** first issue **AGRITERRA** magazine;
- **Organisation of Workshop INESC TEC - INIAV** *European Green Deal Call*;
- **Decision** of INESC TEC **to join SMART FARM COLAB** - Collaborative Laboratory for the Digital Innovation in Agriculture;
- **Approval and kick-off SCORPION - Cost effective robots for smart precision spraying (European; 531,7k€; CRIIS and CITE - INESC TEC Coordinator)**;
- **Approval Smart Farm 4.0** - Smart solutions for a sustainable, predictive and autonomous agriculture (ANI - Programa Mobilizador; 114,4k€; CRIIS and CAP);
- **Creation** of **Work Group Agro-Food & Forestry** (WG Agro) **INESC BRUSSELS HUB**;
- **Participation** in **Agroglobal 2020** (virtual);
- **Membership** as Managing Entity **InovTechAgro** - National Competence Centre for the Technological Innovation of the Agroforestry Sector;
- **"RTD Partner"** and key note speaker INESC TEC **AgroIN 2020**;
- **Approval SMARTAGEING** - Decision Support System for The Ageing of White Port Wine (ANI - Projetos em Copromoção; 26,4k€; CRIIS);
- **End of AGRINUPES** - Integrated monitoring and control of water, nutrients and plant protection products towards a sustainable agricultural sector (FCT - ERA-NET Cofund WaterWorks2015; CRIIS and CAP);
- **Approval INCAFO** - Identification of Vine Variety Through Leaf (ANI - Projetos em Copromoção: 150,3k€; CRIIS and CSIG);
- **Integration CoLAB BOARD** (Strategic Board) of the **CoLAB VINES&WINES (ADVID)**.

5.3 TEC4ENERGY

Coordinator: João Peças Lopes
Business Developer: Nuno Campos

5.3.1 TEC4ENERGY Presentation

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 now to the natural gas sector, and encompassing from industry to transportation, buildings and energy efficiency.

The main driver of TEC4ENERGY initiative is the need to respond to decarbonisation of the society and economy. Within this framework TEC4ENERGY initiative responds to the Societal Challenges and Innovation Strategies for Smart Specialisation defined by EU policies: the energy sector will be heavily digitalised, decentralised, under a user centric and market-based approach, involving a large-scale integration of renewable power sources, requiring the conceptualisation and development of disruptive solutions.

TEC4ENERGY offers several innovation services to the energy ecosystem as:

- Energy Conversion and Power Electronic Converters
- Optimisation of Electrical Network Operation
- Power Systems Expansion Planning
- Large Scale Integration of RES and DER in Power Systems
- Energy Efficiency
- Managing Electric Mobility Grid Integration
- Energy Management Systems
- Electricity Markets and Regulation
- Asset Management and Predictive Maintenance for Power System Components
- Power System Digitalisation (Smart Metering, IoT, Big Data and Cybersecurity)
- Advanced Sensing for Power System Operation
- Operation of natural gas distribution grids with injection of renewable gases
- Laboratory Services for Smart Grid Solutions Testing

The R&D Centres that have a closer involvement with TEC4ENERGY are:

- CAP (Networked Intelligent Systems Cluster)
- CEGI (Industrial and Systems Engineering Cluster)
- CESE (Industrial and Systems Engineering Cluster)
- CPES (Power and Energy Cluster)
- CRAS (Networked Intelligent Systems Cluster)
- CSIG (Computer Science Cluster)
- CTM (Networked Intelligent Systems Cluster)
- HASLab (Computer Science Cluster)
- LIAAD (Computer Science Cluster)

5.3.2 Main achievements in 2020

TEC4ENERGY aimed to identify new potential projects with the industry and the society, through a multidisciplinary scientific-based approach to overcome the limitations that stakeholders found in the existing market solutions, conveying these projects for further development to the Centres closer to the technological requirements. TEC4ENERGY therefore intended to impact INESC TEC activity by fostering the generation of new contract programs and projects, namely the ones involving the Portuguese industry, joining in this response different Centres of the institution. TEC4ENERGY has also established contacts with key stakeholders in the Energy arena promoting the development of projects that involve several Centres within INESC TEC.

Taking into consideration the main achievements in the energy sector, and despite the SARS-CoV-2 pandemic, 2020 was a consistent year in what regards to new flagship projects. One can refer namely the European Horizon 2020 projects EUniversal, ATTEST and OneNet, in a total revenue of 1.7 M€, and the materialisation of two important national “PT2020 Mobilizadores” projects, CITYCATALIST and BATERIAS2030, with an accumulated revenue of 500 k€.

TEC4ENERGY has made a considerable effort in the national panorama, to contribute to the energy transition, to the society decarbonisation and to the digitisation of the national business framework, in the energy sector, through direct R&D contracts and proposals. In 2020, TEC4ENERGY submitted 15 project proposals for direct contracts with the industry (11 of which successfully approved, and 1 still waiting for decision) These proposals amounted to about 790 k€ and covered a variety of topics ranging from integration of renewable generation in islands, consultancy for energy transition of natural gas fired power plants, development of studies for the integration of Electric Vehicles in electrical distribution grids, advanced management of gas network with incorporation of renewable gases, definition of technical requirements for solar PV power plant auctions and consultancy for the Development and Investment Plan of the Portuguese TSO. The 11 approved projects led to an income of more than 500 k€.

TEC4ENERGY demonstrated in 2020 the capability to develop a network of contacts that led to strengthen the portfolio of clients and to an increase of the sources of revenue for INESC TEC. TEC4ENERGY has also a variety of different stakeholders and partners, some of which with a long-term relationship as EDP, EDA, EEM, EFACEC, REN, and other partners, with a more recent but promising one as CapWatt, GALP Power, Portgas, Tejo Energia, Finerge, IKEA, Dream Message and TrustEnergy.

5.4 TEC4HEALTH

Coordinator: Miguel Coimbra
Business Developer: Carlos A. Ferreira

5.4.1 TEC4HEALTH Presentation

The Mission of TEC4HEALTH is to induce a market pull drive into R&D, targeting all the value chain actors and processes in the healthcare and well-being sectors. For accomplishing this, TEC4HEALTH aims to explore the activities within the health sector where technology needs and roadmaps indicate a high potential for applying INESC TEC's competences, resulting into successful projects, contracts, and technology transfers.

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

From a technology transfer perspective, health technologies have already been quite successful within INESC TEC (3 recent spin-offs, ~50% of INESC TEC's patent portfolio). Mapping the experience of INESC TEC with current worldwide health challenges led to the identification of three key TEC4HEALTH challenges to address in the next 5 years: cancer (lung, breast, colorectal, pancreatic, skin, stomach, ovary, uteri and thyroid), disease prevention/screening (chronic and pandemic diseases) and neuro diseases (epilepsy, depression, Parkinson, Alzheimer and autism). INESC TEC's innovation services in artificial intelligence, biomedical instrumentation, information systems, health management and medical robotics make it a very attractive research institute for any type of partner working in these health challenges.

The Centres with scientific and technological competences more aligned with TEC4HEALTH challenges are: CAP (Applied Photonics), C-BER (Biomedical Engineering Research), CEGI (Management and Industrial Engineering), CRACS (Advancing Computing Systems), CRIIS (Intelligent Systems and Industrial Robotics), CSIG (Information Systems and Computer Graphics), CTM (Telecommunications and Multimedia) and LIAAD (Artificial Intelligence and Decision Support).

5.4.2 Main achievements in 2020

With the creation of the new TEC4 structure at the end of 2019, 2020 was mainly a year of internal and external development. Externally, it is also possible to group achievements from the point of view of presence at events or improvement of institutional relations / new partnerships.

Internal:

- **Participation in the WG of Health Technologies of the INESC Brussels Hub:** the main highlights are a characterisation report of the 5 INESCs, the INESC capacity on health technologies Workshop and the presentation to the EU-Life cluster;
- Collaboration in the preparation of the 1st edition of the **magazine Science & Society** - Data Science, Artificial Intelligence and Health;
- Establishment and scheduling of regular meetings with **points of contact (PoC) in all Centres** to discuss potential projects in health technologies;
- **Support in** H2020, FCT **applications and projects** to mitigate the effects caused by the COVID-19 pandemic.

Events/Clusters:

- **Representing INESC TEC:** (Re)utilização de dados em saúde (FMUP), EIT Health RIS Hub Univ. Porto events (online), HCP events (online), IEEE EMBC (online) and EUGLOH events.
- **Presenting/networking:** HIMMS (fair - online), MEDICA (fair - online) and B2B Health Innovation Market.

- **As member:** (Health Cluster Portugal) Collaboration in the Smart Health Network, sharing ideas about current trends and preparing projects with relevant ecosystem partners + Digital Innovation Hub application; (EARTO) Presentation of our impact and projects in the health and COVID-19 groups; (CCDR-N) Health and life sciences representation.

Partnerships:

- **Companies (highlight of new strong connections):** Siemens Healthineers (possibility to create a Think Tank + PoC in Portugal), Glintt (for wearables, artificial intelligence and logistics areas), Promptly (preparation of projects), INEGI (relaunch collaboration on health projects) and Retmarker (good relationship for future submissions in retinal image analysis);
- **Hospitals:** Increase of the collaboration network in more hospitals, namely with the growth / preparation of more projects with IPO Porto, Hospital Santo António and Hospital Vila Nova de Gaia e Espinho, and new partnerships in hospitals in the South / Lisbon, as is the case of Hospital Garcia da Horta and Hospital Egas Moniz. The largest private hospitals were approached (Luz, CUF and Lusíadas), creating a good relationship with Lusíadas for the future.

Considering that 2020 has become mainly a year of promotion and growth and it was somehow affected by the COVID-19 pandemic, a positive balance is assumed.

5.5 TEC4INDUSTRY

Coordinator: Américo Azevedo
Business Developer: António Almeida

5.5.1 TEC4INDUSTRY Presentation

The MISSION of TEC4INDUSTRY is to foster transformation for an innovative, collaborative, human-centred and sustainable industry. The TEC4INDUSTRY positioning in the market is completely aligned with INESC TEC purpose and track record, focused on streamlining the interface between the academia and industry as well as drive sectors innovation through cross-fertilisation.

TEC4INDUSTRY aims to monitor scientific results in the range TRL 1-9, induce a market pull drive into R&D, promote applied research leading to products, processes and services (TRL 5-9) and generate knowledge and solutions capable to be transferred to the retail and manufacturing Industries, covering end-to-end supply chain actors. It should be noted that we identify a continuous activity under the scope of TEC4INDUSTRY. This bridging with companies from different industry sectors represents the core activities of INESC TEC, since its creation, and has been established based on different mechanisms: from advanced consultancy services to contract based R&D or even strategic & innovation partnerships, promoted both at a national and European level.

This added value service to the market has been anchored in a history of successes, materialised in effective technology and knowledge transfer to companies. Important partnerships with companies from the shoe industry (e.g. Kyaia), the distinct consultancy projects targeted to support companies along their digital transformation (e.g. GALP) or even the promotion and execution of innovate European projects, where INESC TEC has been involving Portuguese companies from the different sectors (e.g. automotive and wood industries) are examples of activities that TEC4INDUSTRY will continue to pursue and leverage.

5.5.2 Main achievements in 2020

To promote TEC4INDUSTRY vision and mission, two major clusters of objectives were defined: **internal oriented objectives** to improve articulation with the Clusters and research Centres, and **externally oriented objectives** to promote and disseminate INESC TEC expertise and services in the Portuguese industry.

TEC4INDUSTRY internal-oriented activities

In 2020, a series of actions were conducted to define the working methodology with the different research Centres, directly or indirectly related to the TEC4INDUSTRY. Defined the Points of Contact from each Centre to the TEC4INDUSTRY, TEC4Clusters event was organised and promoted. The main objective was to describe the match between the industry needs and the research Centres knowledge, expertise, and future roadmap. Moreover, the intelligence report for the Portuguese industry, including extractive, transformative, retail, and advanced production systems industries, were considered. To streamline the connection between INESC TEC and industrial companies, the TEC4INDUSTRY supported the creation and definition of the vision, mission, and exploitation plan for the new iiLab (industry and innovation lab).

TEC4INDUSTRY external-oriented activities

TEC4INDUSTRY also conducted a series of actions in order to promote the INESC TEC services in the Portuguese Industry as well as at a European level.

Industry 4.0 Advanced Training

Different projects were deployed by the TEC4INDUSTRY in the advanced training field. At the beginning of the year, it launched the first TEC4INDUSTRY Masterclass related to immersive technologies in the iiLab infrastructure. Different CEOs, directors, and heads of engineering had the chance to interact with INESC TEC experts and experience AR/VR technologies. During the first semester, the TEC4INDUSTRY released the i4.0 fundamentals online course in partnership with COTEC. Until the end of 2020, this online course had more than 700 attendees from different companies and sectors and resulted in a paper in the education science journal.

This year, it was also promoted and provided the advanced training program in industry 4.0 in partnership with INEGI. Finally, with the support from TEC4INDUSTRY, INESC TEC submitted a proposal to CLAMTEX European project to provide training services to clusters in digital transformation subjects.

European Projects

At European level, the TEC4INDUSTRY was very active in European project proposal setup and submission and the EIT Manufacturing, in connection with different Centres. Related to the EIT-Manufacturing, the TEC4INDUSTRY performed as Business Owner in various Education projects from EIT Manufacturing, submitted a successful Cross-Kick EIT Human Capital proposal involving different INESC TEC research Centres, and supported the submission of 3 proposals for maturity assessment in the Portuguese market. In terms of European projects, the TEC4INDUSTRY supported and promoted participation in 5 proposals, leading one in the FoF-09 call. Moreover, it supported the submission of 1 proposal in the H2020 COVID call and 3 proposals in the GREEN DEAL call in collaboration with TEC4SEA and TEC4ENERGY. Finally, the TEC4INDUSTRY promoted proposal submission in the open call domain, with one already accepted in the Market 4.0 European project.

National Projects

At a national level, TEC4INDUSTRY also provided an important contribution to promote R&D projects with national companies. In partnership with BOSCH, a strategic proposal was submitted in the digital twin domain. Moreover, 3 FCT, 1 SIAC and 2 P2020 projects were submitted in partnership with national companies and industrial associations, including VW Autoeuropa and industrial associations from Oliveira de Azemeis and Santa Maria da Feira. Also, four different service proposals were submitted to Jerónimo Martins, ProGROW, EGOI and VW Autoeuropa in logistics, AI and Voice-to-Text domains.

INESC TEC Promotion

In terms of INESC TEC services promotion, TEC4INDUSTRY participated in preparing the MoU with India in the industry digitalisation domain. Moreover, it promoted the participation in the COTEC Innovation Summit, in the Portugal Digital Awards 2020, together with TEC4PARTNERSHIPS, and the preparation of the EMAF 2020 (postponed to 2021). Also, TEC4INDUSTRY was main speaker and promoted the Webinar AEP “A Crise Global a resposta europeia a situação portuguesa e o papel do Norte”, the AED Days 2020, the EIT Manufacturing Hub Webinar series, the webinar AIMMAP – Business Intelligence na Indústria, and the webinar PBS – Digital Operations and Digital Supply Chain. Finally, TEC4INDUSTRY participated in the Focus Group MOBINOV & Sector Metalomecânico Aveiro and supported the setup of INESC TEC portfolio in Portal da Inovação, from ANI.

New Companies Leads

2020 was a fruitful year in terms of leads creation, with interaction with more than 30 companies, such as VW Autoeuropa, Navigator, Microsoft Portugal, KIT-AR, OLI Sistemas Sanitários, Smurfit KAPPA Portugal, B-Simple, SPMS, Flexdream, E-GOI, SELT, Cartonagem Trindade, Sysadvance, FARFETCH, RICO, MOLDIT, HUF Portugal, SABESP – Saneamento e Águas de S. Paulo, AR-Experts, Continental Engineering Services, CELOPAS, Jerónimo Martins, FUNFRAP, SONAE MC, SONAE Capital, Worten, SONAE Arauco, PROGROW, Fluidotronica, AMORIM and OpenLine Group.

5.6 TEC4SEA

Coordinator: Eduardo Silva
Business Developer: Carlos Pinho
Communication, dissemination and continuous engagement: Ana Paula Lima

5.6.1 TEC4SEA Presentation

TEC4SEA is the INESC TEC initiative that brings together R&D&I Institutions, businesses and associations, increasing synergies and critical mass to address real world challenges related with the Sea Economy, raising up a north based Ocean Engineering Excellence Network capable of stimulating industries, that will act as the leading international counterpart.

The Centres involved in TEC4SEA projects during 2020 were the following: CAP - Applied Photonics; CEGI - Management and Industrial Engineering; CESE - Enterprise Systems Engineering; CPES - Power and Energy Systems; CRAS - Robotics and Autonomous Systems; CRIIS - Industrial Robotics and Intelligent Systems; CSIG - Information Systems and Computer Graphics and CTM - Telecommunications and Multimedia.

INESC TEC clearly contributes to worldwide R&D&I for the Sea Economy. The multidisciplinary application-oriented solutions addressed by TEC4SEA cover a wide range of both established (e.g., aquaculture, fishing and Ports) and emerging industries (e.g., autonomous ships, seabed mining and offshore renewable energies). It also contributes to the emergence and strengthening of new services and ecosystems in increasingly relevant areas, such as ocean health maintenance activities, by contributing to monitoring activities of biogeochemical variables, oil spill mitigation, among others.

Aiming at bringing the autonomous and digital worlds to a sustainable Sea Economy, TEC4SEA promotes the following innovation services for the Blue Sectors:

- Development of optical and biosensors (for physical, chemical and bio parameters)
- Broadband communications solutions
- Heterogeneous data integration and management
- Development of customized visualisation tools, virtual and augmented reality solutions
- Offshore RES & DER integration
- Multiple energy vectors integration
- Digital Twin and logistic optimisation solutions
- Conception, development and optimisation of mission oriented robotic platforms
- Customised processing solutions and on-board processing optimisation
- Perception solutions for unstructured environments, 3D mapping and data fusion
- Optimisation of underwater positioning systems and navigation algorithms

5.6.2 Main achievements in 2020

The pandemic situation jeopardised the milestones and objectives proposed for 2020, both the “internal” (with impact in the core teams of INESC TEC) and “external” (with impact in stakeholders outside INESC TEC) ambition. Almost all the activities were performed remotely which adds flexibility and higher productivity at the cost of some communication gaps and less social interaction so important in networking activities. Nevertheless, we may say that TEC4SEA managed to achieve most of the goals set for 2020, especially the internal ones, as listed below:

Internal:

- Creation and consolidation of a work team bridging and articulating the Centres and the TEC4SEA towards common objectives, actions and initiatives;
- "Inter-TEC4" collaborations in several initiatives and projects in diverse domains, namely: TEC4PARTNERSHIPS (defence and space domain); TEC4ENERGY (offshore renewable energies) and TEC4INDUSTRY (processing and logistics);
- Creation of a Sea Economy awareness report with the landscape characterisation that impacts INESC TEC activities. INESC TEC's positioning and strategy analysis was also started;
- Development of an action plan for the Green Deal (H2020) and start of its implementation, aligned with Horizon Europe (and EITs).

External:

- Joined the consortium (Fórum Oceano, INESC TEC, Wavec, +Atlantic, CEIIA) that is preparing the creation of an entity to assume the assets, the dynamisation and valorisation of Aguçadoura's test zone. The model was fine-tuned, several high-level presentations were made at the governmental level and the financial sustainability analysis was started;
- The relation with core players was strengthened, namely with: Fórum Oceano, CIIMAR, Air Centre, United Nations, Instituto Hidrográfico, Portuguese Navy, CEIIA, CETMAR, IPMA, CoLAB B2E and +Atlantic (with whom INESC TEC started the process of association);
- Several new contacts, with research institutions and industries, to define synergies and identify possible collaborations were made in the context of H2020. Moreover, international relations were strengthened, namely with partners in Europe, South Korea, USA and India;
- Consolidation of the network of contacts, strengthening and disseminating our initiatives and promoting INESC TEC name (Oceans'20 Singapore, Oceans'20 Gulf Coast, UN World Ocean Day 2020, EU Sustainable Energy Week 2020, Sea Tech Week 2020, Business2Sea 2020, 7th Atlantic Stakeholder Platform Conference, Air Centre Networking Fridays, among others);
- The Participation in Business2Sea 2020 had a more active component - it included the presentation of the work carried out in collaboration with CETMAR at the Workshop on cross-border cooperation: "Proposal for the creation of a cross-border test site as a technological driver for the Euro-region Galicia and North of Portugal" as well as pitches of the Grow project and MarRISK - 10 years RAIA;
- Organisation and participation in the virtual workshops "InTheBlack" and "New Challenges in the Mineral Raw Materials Industry: Safety, Digitalization, Technology & Innovation", both with more than 100 registrations;
- Diligence and support to position a Portuguese company as POC of Pesco HarmsPro, in articulation with TEC4PARTNERSHIPS;
- Signature of a collaboration protocol with Subsea Mechatronics;
- Collaboration with Air Center and the Archaeological Museum of São Miguel de Odrinhas in the kick-off of the project that aims to characterise the archaeological site of Alto da Vigia, Sintra with the participation of the Minister Manuel Heitor;
- Collaboration in the Portuguese Recovery and Resilience Agenda related with the Sea sectors;
- Participation in consultation meetings of agents in various sectors of the Economy of the Sea (Fish and Biotechnology, Large Emerging Assets), towards the new ENEI;
- Identification of financing opportunities, strategy definition, articulation with INESC TEC Centres and external stakeholders and support for several project submissions: 2 Co-promotion, 1 ESA Ports of the Future, 8 Green Deal, 1 XKIC - representing a total INESC TEC budget of ~ 9M€;
- INESC TEC was recognised with the "Scientia Mare Award" from PwC at the Webinar "Excellens Mare".

5.7 TECPARTNERSHIPS

Business Developers: Augustin Olivier, António Gaspar, José Nina de Andrade

5.7.1 TECPARTNERSHIPS Presentation

Our mission is to promote and support market activity in all other sectors (not covered by the previous TEC4), to explore new sectors of activity in the market where technology needs and roadmaps indicate a high potential for applying INESC TEC's skills and research lines and also to provide global coordination and support to all TEC4 initiatives, including common dissemination and management tools.

The working methodology to explore new application/market areas is structured in three steps and, in 2020, the following activities were developed:

1. **Study phase**

The objective is to analyse target market segments with their players (technological and end users partners and competitors) evaluating if INESC TEC can bring a recognised value in line with the institution's research lines. The successfully outcome of this phase will be an approved market strategic plan.

Defence: Participation in the AED Portuguese Cluster, in order to evaluate market and establish industrial contacts. Membership of the AEDCP Board. Focus on fostering participation in PESCO and EDIDP and gathering information regarding upcoming EDF. Participation in EARTO Security and Defence WG to establish international contacts. Creation of internal mailing list.

Space: Same as above for AEDCP. Focus on ESA opportunities and emerging Portuguese Space Agency and national strategy, as well as the upcoming Space Co-Programmed Partnership under Horizon Europe. Participation in EARTO Space WG to establish international contacts. Creation of internal mailing list.

Aeronautics: Same as above for AEDCP. Focus on disruptive technological opportunities, like urban air mobility and hydrogen/hybrid based mobility, as well as upcoming EU Clean Sky 3 initiative. Creation of internal mailing list.

Public Administration: Identification of potential funding programmes and reference documents.

Mobility: Identification of opportunities in regional mobility markets, particularly in the area of Intelligent Transport Systems. Identification of opportunities involving port administrations.

2. **Startup phase:**

The objective is to implement the market strategic plan, offering INESC TEC portfolio of services addressing the sector and promoting the institution as a relevant technology player. The successfully outcome of this phase will be the creation of multidisciplinary and inter-Centre scientific team, integration into sectoral networks and project volume.

Internet Market: Reviewing this sector of activity in terms of market positioning. Targeting the most interesting market segments and review institution's research lines.

Financial sector: Currently in a restructuring period due to the entry of new players and the need to digitise by exploiting the data belonging to them.

Construction sector: Low productivity sector, lagging behind digitisation, which is expected to have a relevant impact from its increase.

3. **Consolidation phase:**

This phase must ensure the existence of consolidated scientific multidisciplinary inter-Centre teams, integration into sectoral networks with recognition as a relevant actor and continuous project activity.

In 2020, no new sector was identified as suitable for the launch of a dedicated TEC4 initiative.

5.7.2 Main achievements in 2020

The COVID-19 pandemic restricted most human contact activities during 2020. In the first half of the year, enterprises were focused mainly in how to respond to the new market situation and their availability to discuss new R&D propositions was very low. For this reason, meetings, workshops and fair planned participations such as QSP Summit, were postponed. Considering the situation, this period was mainly dedicated to produce market strategic plans documents to Building, Finance and Internet sectors.

In order to disseminate INESC TEC activities related with these new sectors, 34 online meetings were promoted with enterprises and associations, and it is possible to highlight the participation as a speaker in 4 webinars and an interview given to "Les Echos" (economic French newspaper).

In the ASD sectors, 17 meetings were held during International Aerospace Days 2020 and 4 during AED Days 2020, were INESC TEC was also present with a virtual stand and in two panels.

To promote internationalisation, INESC TEC obtained the Research Tax Credit « agreement CIR » (Crédit Impôt Recherche) by French MESR (Ministère de l'Enseignement Supérieur et de la Recherche). This certification allows clients working with INESC TEC to deduce R&D investments from their corporate taxes. In the internationalisation context, the participation in EIT Digital and EARTO Defence and Security WG and Space WG must also be highlighted.

The Market Strategic Plans of Building, Finance and Internet describe: Value chain, services and products providers, main sector clusters and associations, market trends, national and European policies, challenges identification, innovation user cases, INESC TEC SWOT, related research lines and innovation services, value proposition CANVAS and a strategic action plan.

Internet Market
9 Flyers to present INESC TEC skills were produced, as well as a video about competencies for the new market "Internet market".

Building
The project REV@CONSTRUCTION, led by Teixeira Duarte, was approved with a 470.278€ budget for INESC TEC and the first BUILT COLAB meetings were promoted.

Finance
Contracts were approved with NAU21, related with assurance fraud detection, valued 203.000 €, and with MONTEPIO, addressing Data Governance Policy and Control, valued 65.000 €.

Aeronautics
PT2020 Mobilizador project, entitled FLY.PT, addressing urban air mobility, was approved with a 251.000 € budget for INESC TEC.

Space
PORT XXI, ESA project, for the creation of new port environmental monitoring services, was approved, valued 52.000 €.

NEWSAT, an International Partnerships project involving MIT, for the design of new satellites, particularly mission definition, was approved, valued 265.827 €.

Defence
Support of security clearance certification process for an EDIDP approved project, PANDORA.

Mobility
Contract with Quadrilátero Urbano, addressing intelligent mobility systems, was approved, valued 59.500 €.

INTERNAL PROCESSES AND SUPPORTING TOOLS
TECPARTNERSHIPS team also led the following activities related with internal (to the TEC4 structure) processes and supporting tools:

- CRM - Identification of requirements (new survey), available software evaluation and mock-up demo;
- Website - Identification of industrial relevant contents, such as competences and contacts;
- Internal business processes - Optimisation of several internal business processes related to TEC4 activities.

6 RESEARCH AND DEVELOPMENT CENTRES

6.1 CTM - CENTRE FOR TELECOMMUNICATIONS AND MULTIMEDIA

Coordinators: Jaime Cardoso and Filipe Ribeiro

6.1.1 Presentation of the Centre

The Centre for Telecommunications and Multimedia (CTM) consists of more than 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 specialises 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.

In 2020, CTM accomplished its mission, within the Cluster NIS, 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). CTM contributed to the research in new sensors, low power or nanoscale, to enable the envisioned "electrosphere of sensors". The Centre has also 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 provided the means to make sense of the acquired data; the semantic knowledge built from the integration of the network of sensors allows acting over the environment as well as over the content.

6.1.2 Research outcomes in 2020

The main broad research achievements obtained by **CTM in 2020** were the following:

- More than 35 articles published in relevant scientific journals, the majority of them in journals classified by SCOPUS as "1st Quartile" and "2nd Quartile";
- Five awards to CTM Researchers in the 2020 FCT Individual Call for PhD Scholarships;
- More than 40 successfully defended Master Theses;
- One scientific output identified by the European Commission Innovation Radar as an innovation with significant potential.

The main achievements obtained by the **OET Area in 2020** were the following:

- **Rail-to-rail timing signals generation using thin-film transistors**. We have shown for the first time on-chip rail-to-rail timing signals generation with InGaZnO thin-film circuits suitable for a sensor matrix in an X-ray radiation sensing system;
- **Parallel Implementation of K-Means Algorithm on FPGA**. We proposed a fully parallel implementation of the K-means algorithm on FPGA to optimise the system's processing time, a key enabler for real-time applications;

The main research achievements obtained by the **WiN Area in 2020** were the following:

- **Placement and active queue management algorithms for aerial networks** that enable significant performance gains (higher throughput, lower delay) when compared to state-of-the-art counterparts;
- **New trace-driven ns-3 simulation models** enabling the replication of experiments and the creation of wireless network digital twins by using information on signal-to-noise ratio, physical data rates, and wireless channel occupancy observed in the real-world;

The main research achievements obtained by the **MCT Area in 2020** were the following:

- A Semantic and context-aware metadata-based approach for automatic content creation;
- Ubiquitous Framework for High-Quality Audiovisual Production. An IoT-like approach capable of automating the operations carried out at professional audiovisual production studios.

The main research achievements obtained by the **IPPR Area in 2020** were the following:

- **Identifying relationships between imaging phenotypes and lung cancer-related mutation status**. We proposed a novel machine learning model to predict the mutation status from tomography scans and clinical data and identify the most important features for that characterisation;
- **Understanding the decisions of CNNs**. We proposed a novel in-model joint architecture to explain the decision of CNN classifiers. This architecture outputs not only a class label, but also a visual explanation of such decision, and can be used with any classifier.

6.1.3 Innovation outcomes in 2020

The main broad innovation achievements obtained by **CTM in 2020** were the following:

- CTM researchers organised two advanced training courses; the events took place in Porto;
- The CTM Summer internships, to give the students the opportunity of conducting a short-term R&D project framed around a research team of CTM;

The innovation achievements obtained by the **OET Area in 2020** were the following:

- **NFC antenna for constrained industrial environments.** We designed and implemented, in partnership with a multinational company, an Near Field Communications (NFC) reader antenna suitable to operate in a size-constrained industrial environment, together with a suitable matching network to ensure reliable performance during operation;
- **Novel BLE indoor localisation solution for asset tracking**. In partnership with a telecommunications company, a novel Bluetooth Low Energy (BLE) based wireless repeater solution was designed and implemented, spanning from PCB design up to firmware development.

The main innovation achievements obtained by the **WiN Area in 2020** were the following:

- **Network Infrastructure Monitoring Approach for Remote Cork Manufacturing**, in partnership with multinational company for monitoring communications between the Open Platform Communications (OPC) server and the Programmable Logic Controllers (PLCs) in the shop floor, using innovative network monitoring techniques and analysis;
- **Wi-Fi-based narrowband and broadband wireless communications for utilities**. Study developed in partnership with an electric utility for assessing the suitability of the Wi-Fi technology for supporting smart metering and related applications within the use cases of an electric utility;

The main innovation achievements obtained by the **MCT Area in 2020** were the following:

- **Graph-based non-linear navigation in multimedia archives.** An interactive and intuitive approach for archive browsing and navigation based on the concept of a network of objects and relations;
- **Computer Vision for content annotation in a Broadcasting environment. A timecode-based solution for person identification in broadcasted content.**

The main innovation achievements obtained by the **IPPR Area in 2020** were the following:

- **Computer Vision for Heart Rate Extraction in the neonatal intensive care units.** We proposed a regular consumer camera-based framework for continuous and contactless extraction of the heart rate in newborn subjects and the real-world conditions of a Neonatal Intensive Care Unit;
- **Algorithm for generating fingerprint templates.** We proposed an algorithm for generating minutiae templates for fingerprints. With this algorithm, we obtained a MINEX III certification by NIST. This

certification is a test used to establish that template generation and correspondence algorithms comply with the US government's Personal Identity Verification (PIV) program.

6.1.4 Activity Overview

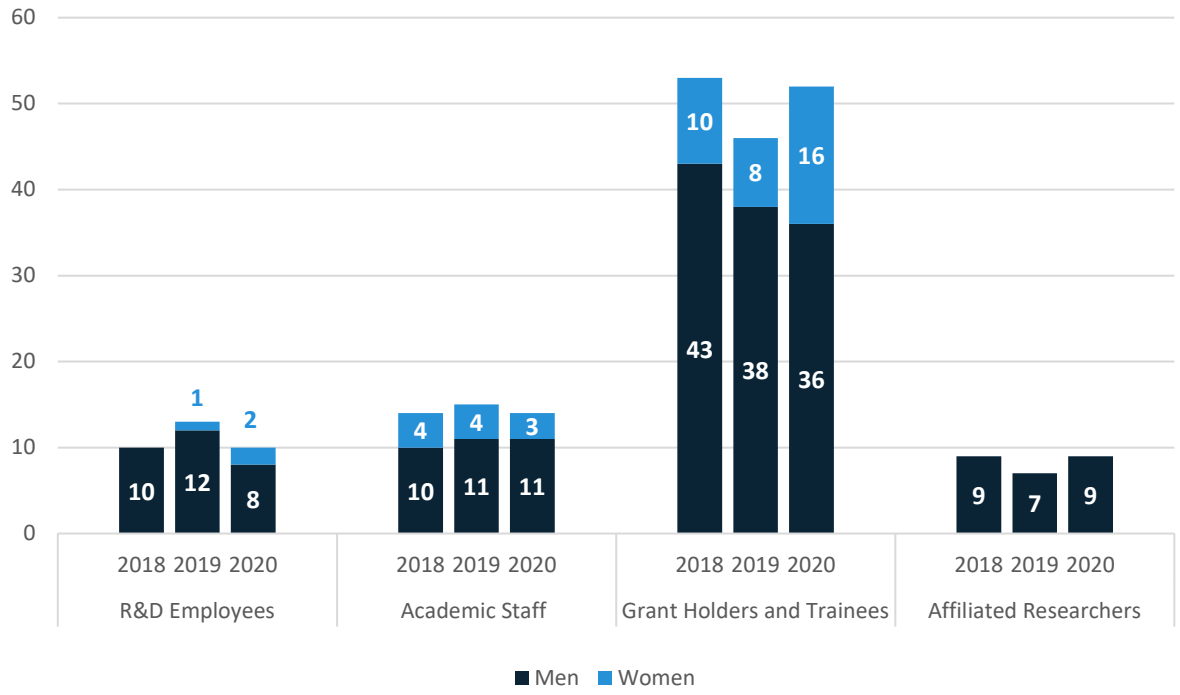


Figure 6.1.1 - CTM - Research team evolution

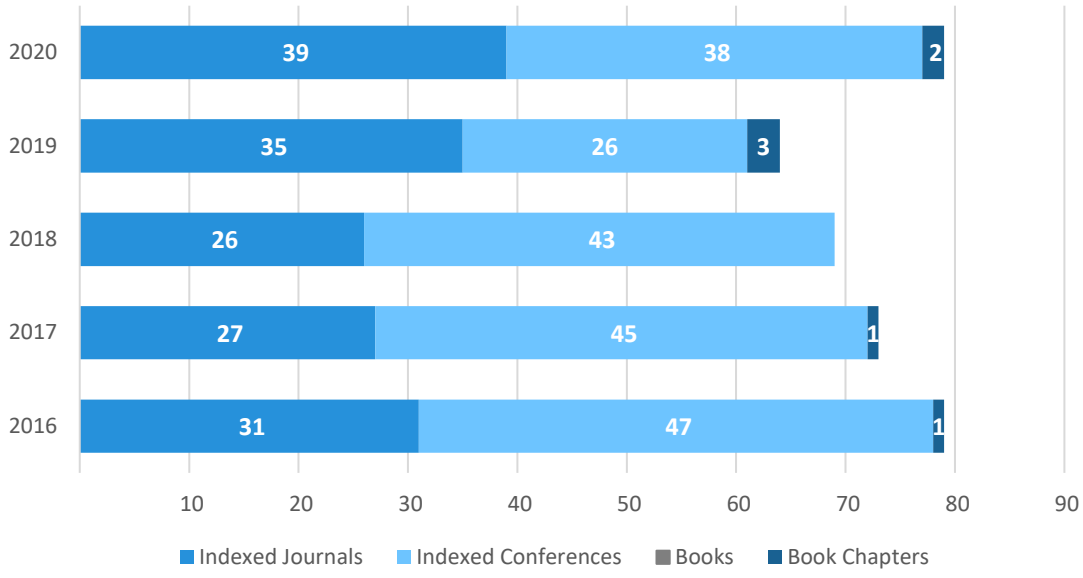


Figure 6.1.2 CTM - Evolution of publications by members of the Centre

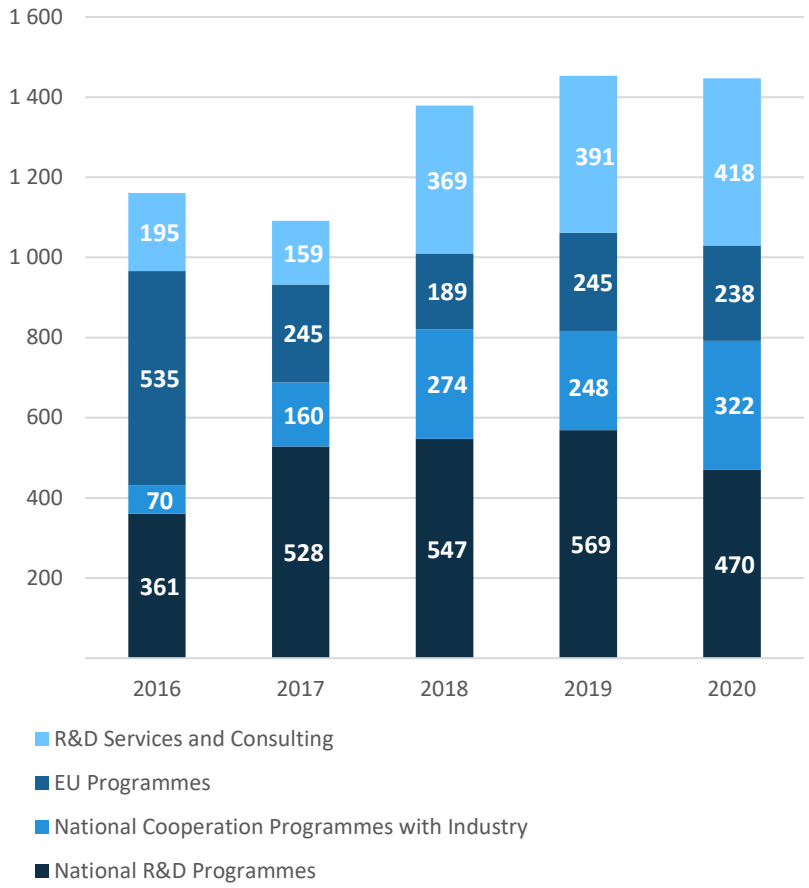


Figure 6.1.3 - CTM - Project funding evolution (k€)

6.2 CAP - CENTRE FOR APPLIED PHOTONICS

Coordinators: Paulo Marques and Ireneu Dias

6.2.1 Presentation of the Centre

CAP accomplishes its mission within the Cluster NIS by directing its activities towards 4 main areas of research: integrated optics and microfabrication, advanced optical imaging, optical sensors, comprising chemical/biosensors and physical sensors, and quantum optical engineering. This organisation is non-hermetic and the development of solutions implies multidisciplinarity and cooperative work from the different fields of the available expertise.

Of particular importance is the insertion of the Centre and its dissemination activities within the universe of the DFA (Department of Physics and Astronomy of the Faculty of Sciences of the University of Porto) that hosts the Research Centre. In particular, CAP members (professors and invited professors) are involved in the experimental teaching on optics and microfabrication, and were involved in the creation and continuous maintenance and upgrade of the physical infrastructure to support these activities (advanced optics lab and cleanroom) supporting 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.

6.2.2 Research outcomes in 2020

Integrated Optics and Microfabrication

Optofluidics. The monolithic fabrication of an integrated device with femtosecond lasers for the excitation of whispery gallery modes through a suspended waveguide (all of this within a microfluidic channel) was demonstrated. The devices produced set the world state-of-the-art on silica machining and this solves the problems associated with the robustness of whispery gallery modes excited with fiber tapers.

3D Fabrication. The fabrication of polymeric structures by multiphoton photopolymerisation was demonstrated; the smallest dimension achieved was a suspended polymer bridge with 268nm. Other 3D forms such as lens, cubes, prisms and woodpiles were fabricated.

Integrated Optics and Fiber gratings. The fabrication of waveguides operating in a broadband regime were achieved. These were key to demonstrate excitation of close-to-surface waveguides and plasmons excitation and its application in integrated optics sensing (bubble resonators). Fabrication of long period gratings working at the turning around point (TAP) was demonstrated; enhanced versions were demonstrated with recourse to thin films deposited on the optical fiber.

Physical sensors

Raman Spectroscopy. The fiber Raman endoscope was characterised and is currently being tested in terms of performance. Several biological tissues with neoplasias, including with calcium hydroxyapatite, provided by *Universidade de Évora,* have been tested using the conventional Raman spectrometer. Graphene microphone. In terms of graphene applications, different sensors have been developed and a microphone for large bandwidth was developed. Several fiber-based interferometers using the Vernier effect were fabricated and tested. Two world records were established comprising giant sensitivities for strain and refractive index measurements.

Bio sensors

Using Fiber Laser Technology, new laser pulse shapes (long, pulse, multiple peak, ramp) were designed and tested in the context of Laser induced Breakdown Spectroscopy applications, which show the capability to cope with the typical challenges of this technique (strong dependence on water content, plasma heterogeneity, other) opening the opportunity to establish its application in new contexts (bio-applications, underwater).

A new approach for coupling optical bubble micro-resonators was developed relaying on sub-surface waveguides implemented by direct fs laser writing. Bubbles have the highest Q factor, but remain challenging to excite and interrogate. This new approach solves a critical technological problem, enabling sensitive biosensors.

Development of new LPFG biosensor systems with innovative sensing layers and coating methods, using Molecularly imprinted polymers, PEVA and other polymer based sensitive layers, for the detection of biogenic amines and other relevant molecular analytes. Upgrade of a sputtering deposition system to produce high quality thin films for the development of sensing structures.

Quantum Optical Engineering

This research line is centred in the current trends in applied photonics associated with the miniaturisation of devices into scales of tens to hundreds of nanometers, in combination with other domains such as material sciences and quantum information theory, exploring quantum and nonlinear effects. These activities can be summarised as follows:

- Explore new concepts in optical sensing based on nano-plamonics and nano-structured optical material (metamaterials) using numerical simulations (development of Hydrogen sensors);
- Development of optical and quantum analogues for physical simulation using computer simulations, initially developed to simulate the propagation of light in nonlinear optical media, were adapted to emulate the dynamics and determine stationary solutions of the dynamical equations of alternative gravitational theories;
- Develop and improve a numerical toolbox based on supercomputing to simulate light-matter interaction at the microscopic and quantum levels. Improved codes to investigate the propagation of an optical pulse in a four-level atomic system in the electromagnetically induced transparency regime have been developed. By demonstrating that linear and nonlinear optical properties can be externally controlled and tailored by a continuous-wave control laser beam and an assisting incoherent pump field, it is shown how these media can provide an excellent framework to experimentally explore pulse dynamics in the presence of non-conservative terms, either gain or loss. These research results complement the previous towards the development of quantum analogue computing and have stimulated a sublime of research towards the development of quantum artificial intelligence based on the concept of reservoir computing.

6.2.3 Innovation outcomes in 2020

- Improved numerical models and codes for light-matter interaction in regimes out of equilibrium, with emphasis on solver of Generalized Nonlinear Schrödinger equation;
- A new method for improved detection and identification of molecular analytes using optical tweezers and intelligent scattering analysis amplified by nanoimprinted polymers. Preliminary results obtained in buffer and human serum solutions are encouraging;
- A prototype for the detection of biogenic amines in fresh food and their products was developed including a kit for sampling processing, which can have important applications in real time food quality control and public health;
- A low-cost optical interrogation system to read long period fibre gratings and SPR based fibre sensing probes was developed, relying in cost-effective tunable lasers and advanced signal processing. Envisaged application include in-situ environmental monitoring, and incorporation in critical infrastructures (e.g. marine windemils);
- A process for silica machining using femtosecond laser writing allowing the demonstration of whispery gallery modes excitation within a microfluidic channel;
- A system and method for the characterisation of a coated part using LIBS. Innovative application in the cork industry.

6.2.4 Activity Overview

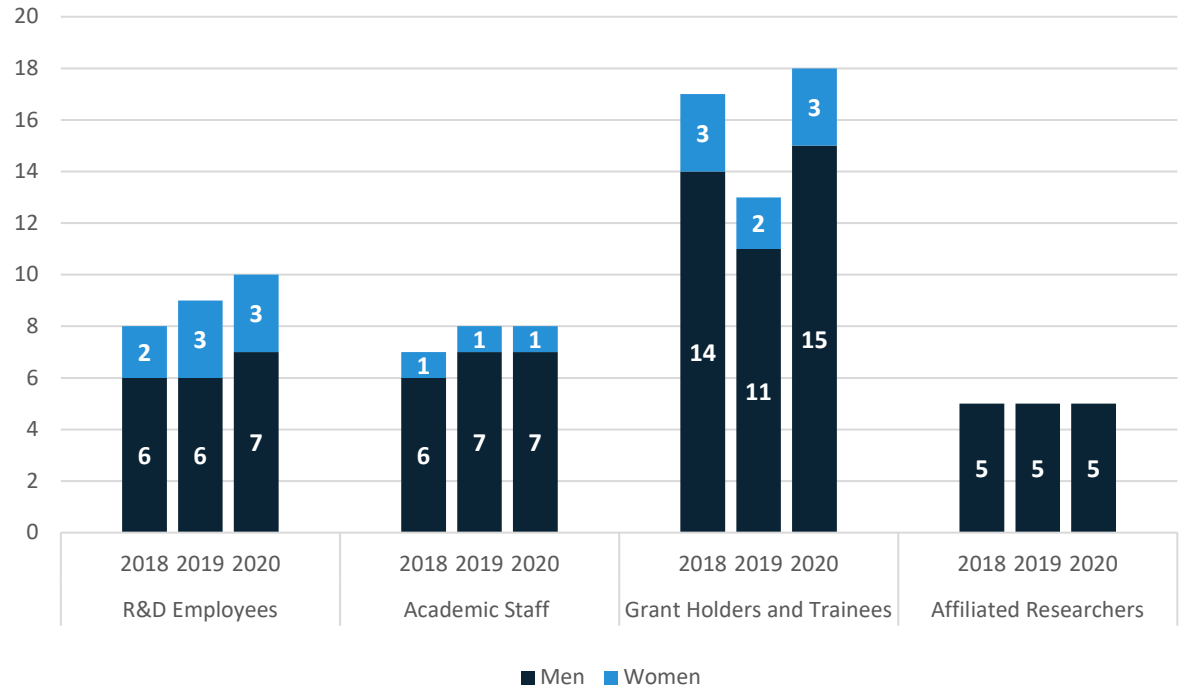


Figure 6.2.1 - CAP - Research team evolution

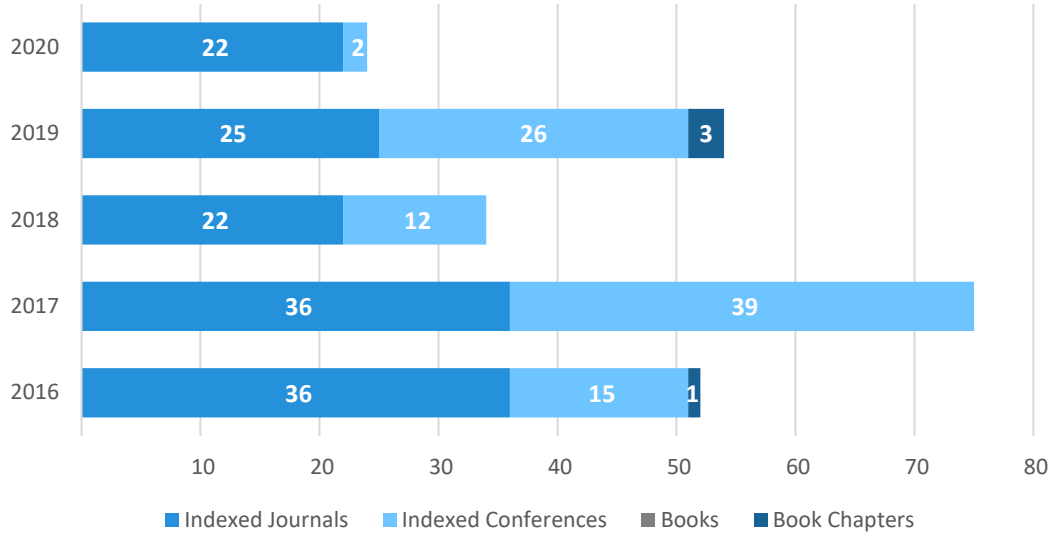


Figure 6.2.2 - CAP - Evolution of publications by members of the Centre

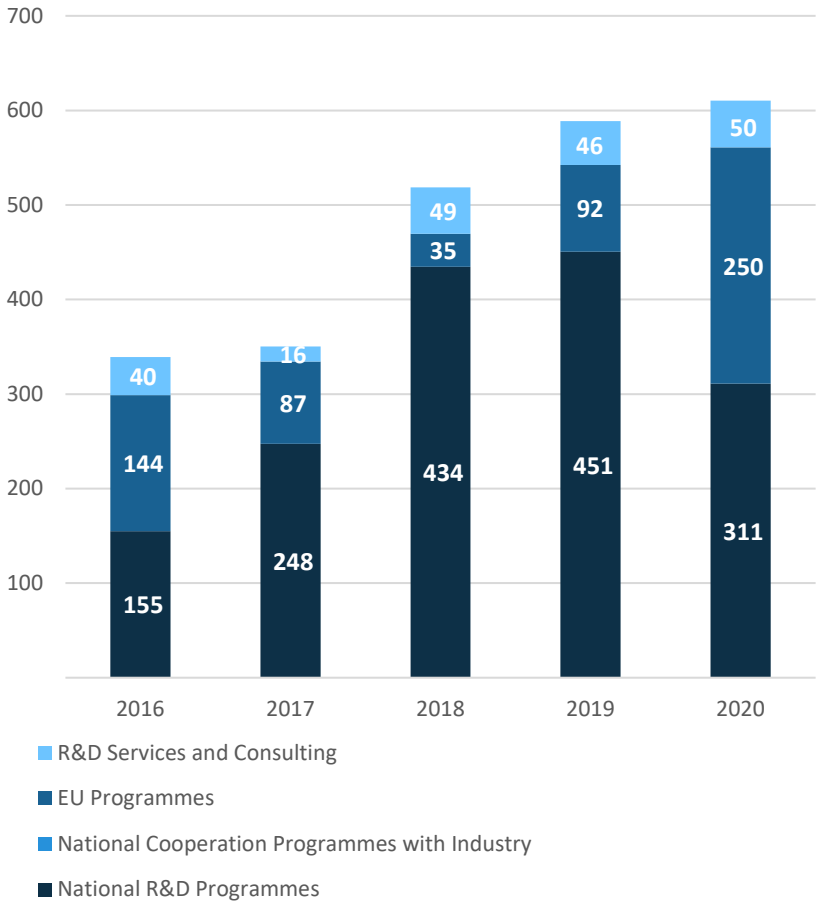


Figure 6.2.3 - CAP - Project funding evolution (k€)

6.3 CRAS - CENTRE FOR ROBOTICS AND AUTONOMOUS SYSTEMS

Coordinators: Aníbal Matos and José Miguel Almeida

6.3.1 Presentation of the Centre

The Centre for Robotics and Autonomous Systems (CRAS) aggregates more than 60 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 and exploration; long term deployments and autonomy; sensing, mapping, and intervention; multiple platform operations.

CRAS activities are mainly positioned within RL 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, environmental monitoring, deep sea exploration and infrastructure inspection.

6.3.2 Research outcomes in 2020

In 2020 CRAS researchers published 10 papers in recognised scientific journals, the majority of them in 1st or 2nd quartile journals. Three Individual PhD Scholarships were awarded to CRAS researchers in the 2020 FCT Call for PhD Scholarships and two PhD scholarships in the Open International Call for AIR Centre PhD Scholarship Programme. The actual scientific production (mainly papers in international journals and conferences) was considerably below the planned figures. The major cause was the lock-down due to the COVID 19 pandemic that greatly reduced the field going activity that is, in many cases, required to validate results for publication. The main research achievements during 2020 were the following:

- Development of a high precision underwater short-range acoustic positioning system for close range maneuvers with underwater robots;
- Development of a multi sensor system for underwater docking operations; this system combines short-range acoustic positioning with visual perception;
- Development of a guidance strategy for docking and undocking operations for underwater robotics systems;
- Development of the capabilities for automatic detection of floating marine debris with machine learning methods using hyperspectral imaging systems;
- Development of a spectral library for marine litter identification and classification;
- Development of unsupervised deep learning methods for identification of unseen objects based on similar clustered samples for application in forestry and oceanic environments;
- Development of multi-sensor 3D motion estimation representations for underwater unmanned system navigation and localisation;
- Development of MARA AUV prototype - a robotic underwater system for confine spaces exploration;
- Development of the IRIS underwater Robot - Robotic underwater system for lost fishing gear recover;
- Project SAIL on space-atmosphere-ocean interactions in the marine boundary layer provided new and very relevant atmospheric observations over the Atlantic during the navy's circumnavigation expedition. An innovative monitoring system was designed and installed on board the ship, enabling the acquisition of a unique set of observations on the electrical properties of the atmosphere. The resulting dataset of detailed atmospheric observations generated great interest from the international scientific community and is currently being organised and prepared for publication.

6.3.3 Innovation outcomes in 2020

In 2020, CRAS organised a new edition of IN THE BLACK. This online edition focused on "The safety of people and the planet through the application of technology" contributed to generate renewed momentum to the EIT Raw Materials Community and also to strengthen connections between KIC Partners. During 2020 CRAS had a strong field activity, demonstrating results of research projects. The most important events were the following:

- The SAIL campaign performed from January to May 2020 on board the ship NRP Sagres, in the framework of its circumnavigation expedition. The field activity included the set-up of a complete atmospheric monitoring system on board the ship - including electric field, radiation and ions monitoring systems – as well as field work on sea from January to May 2020, with at least one person from CRAS continuously on duty on board;
- ESA plastic field trials were performed in Azores, Faial Island during 2 weeks in September 2020. The main objective was to collect a dataset of floating marine debris for the development of automatic algorithms for detecting marine litter concentrations based on hyperspectral imaging systems;
- Mine-Heritage field work in Mine-Heritage Site 2: Fojo das Pombas Mine, Valongo, during the last week of July, first week of August (2020).

The major Innovation outcomes during 2020 were the following:

- Development of an autonomous system to sample the water column at constant rate for estimation of sediment transport;
- Development of a semi-autonomous remotely operated vehicle of mapping sediments in hydro-power plants. The prototype will operate at the Santo António Hydropower plant near Porto Velho, Brazil;
- Upgrade of MARESEYE underwater vision system;
- An innovative oceanographic monitoring system was designed and built for the SAIL campaign. The system was devised to be towed from the tall ship Sagres in order to be able to perform ocean observations during its circum-navigation trip. The tow ship combined state-of-art instrumentation and an innovative design enabling its operation from a large ship, and provided valuable information on ocean parameters such as temperature, salinity, dissolved oxygen, chlorophyll or turbidity;
- Improve underwater Cameras-SLS system for 1500m depth;
- Development of an ultra-compact variable buoyancy system for buoyancy trimming in AUVs;
- Up-scaling of the UX1 robot - UX1Neo prototype;
- The establishment of UGR - Spinoff of UNEXMIN project.

6.3.4 Activity Overview

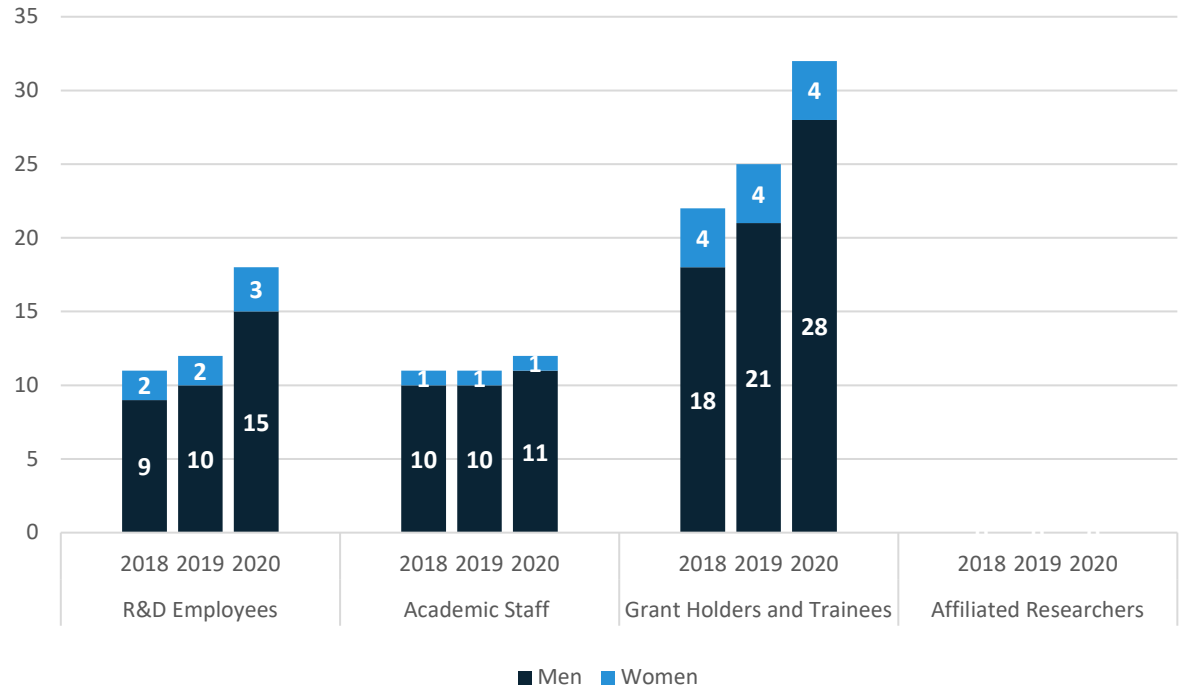


Figure 6.3.1 CRAS - Research team evolution

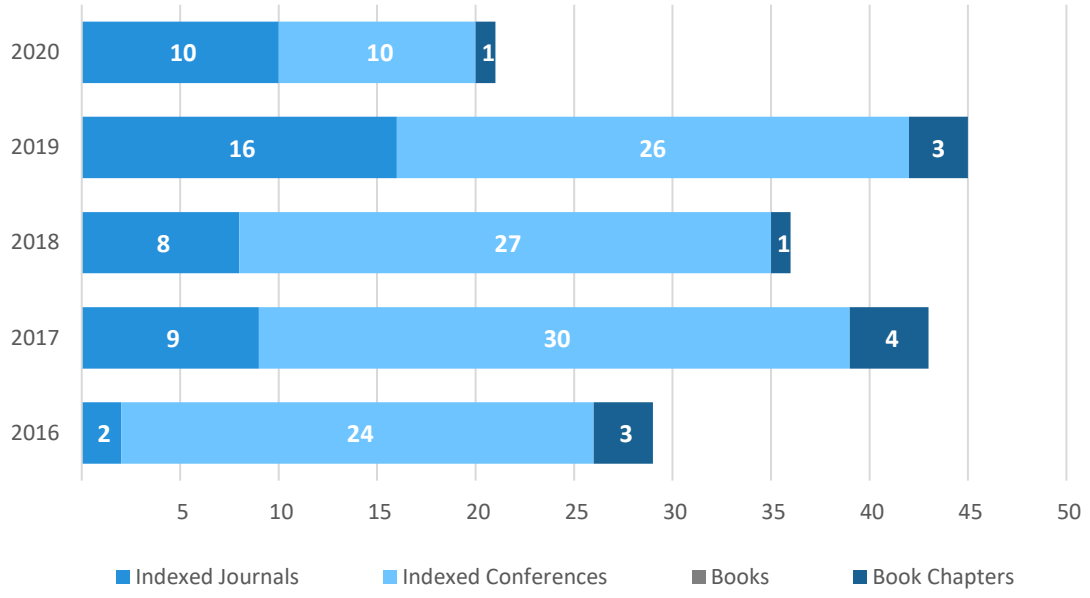


Figure 6.3.2 - CRAS - Evolution of publications by members of the Centre

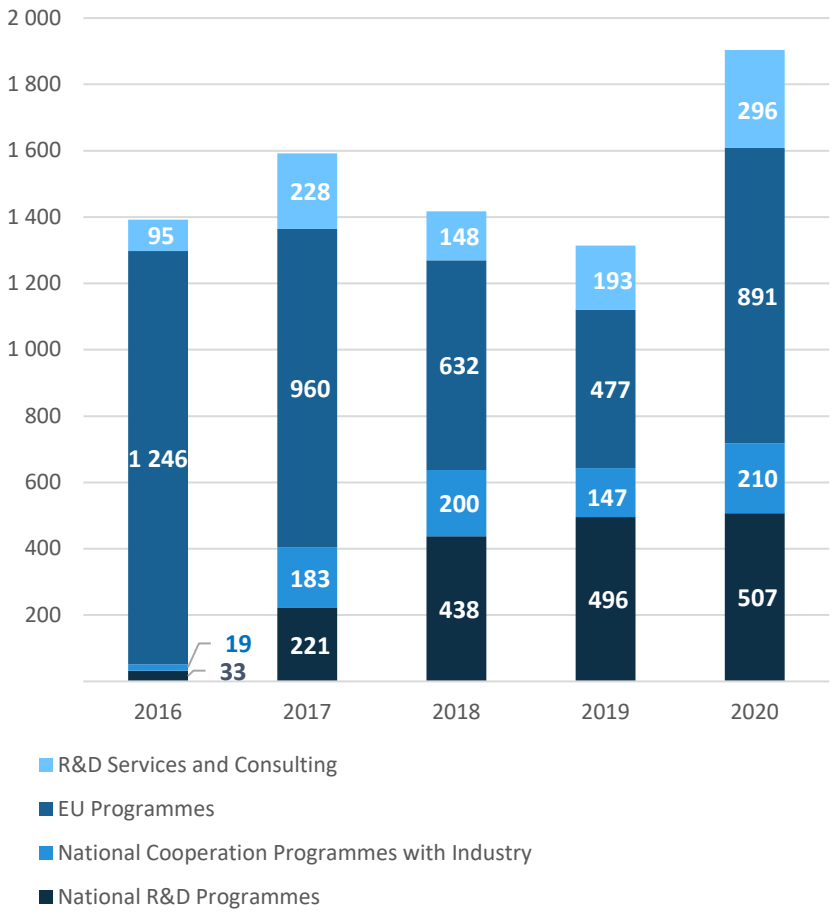


Figure 6.3.3 - CRAS - Project funding evolution (k€)

6.4 C-BER - CENTRE FOR BIOMEDICAL ENGINEERING RESEARCH

Coordinator: João Paulo Cunha

Assistant to the Centre Coordination: Duarte Dias

6.4.1 Presentation of the Centre

The Centre for Biomedical Engineering Research (C-BER) main objective 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 strategic 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 internal synergies and strategic partnerships with other Centres of INESC TEC, clinical partners, research institutes, medtech companies & startups and foster international cooperation.

6.4.2 Research outcomes in 2020

During this atypical pandemic year, C-BER was capable to maintain its scientific publication level in high standards with a total of 23 indexed international high-impact journals (16 in quartile Q1 and 2 in Q2).

Furthermore, the Centre has achieved other high-impact outcomes such as:

- **Covid-19:** in the project CRX-AI4COVID, it was developed a deep learning model for Covid-19 detection in X-ray images. The strong support and interaction with two radiologists was achieved, resulting in 1.845 chest X-ray images with manual labels, including intra- and inter-observer variability;
- **Project SCREEN-DR:** the project ended in December 2020 from which new deep learning methods were developed mainly focussed on the retinal image quality detection and also in the detection and referral of Diabetic Retinopathy;
- **High number of citations:** four papers from C-BER had more than 100 citations in the period of 2017-2019. These papers are in the area of medical image analysis and wearable devices;
- **New research projects:** the strong impact in research led to the approval of 2 new FCT projects. CAGE project that is focused on Computer Assisted Gastric Cancer Diagnosis and also the THOR project that aims to detect Covid-19 using Computer Vision and Point-of-Care Ultrasound imaging;
- **1st Multimodal epilepsy monitoring Unit:** C-BER was the first research centre worldwide to achieve a full monitoring system of epilepsy patients. Until now we had been the pioneers in the 3Dvideo-EEG for epilepsy seizures support diagnosis, and this year, at Centro Hospitalar Universitário de São João, we were the first worldwide to achieve a 3Dvideo-EEG plus deep brain activity using the new Medtronic Percept™ PC neurostimulator device with the BrainSense™ technology.

6.4.3 Innovation outcomes in 2020

PATENTS

In 2020, we were able to leverage the high standards in innovation reached in 2019 and also to maintain the strong contribution of innovations with the disclosures of new inventions. In 2019 we had 6 patent families and in 2020 these patents had 8 applications for internationalisation and we also filled two new patents, closing 2020 with a total of 8 patent families. Furthermore, we have also registered the copyrights of a software application and the first INESC TEC design patent. This was only possible due to the high interaction with SAL and the continuous support from them.

The new patents are the following:

- Computer-Implemented Method, System and Computer Program Product for Detecting a Retinal Condition from Eye Fundus Images (filled in 2020 in Portugal and Europe);
- *Peça ou artigo de vestuário sensorizado, método de operação e seus usos* (P856.1 PP 2020.01.26 - filled in 2020 in Portugal).

START-UPS

Besides this, we have been very active in the creation and launch of spin-offs and, in 2020, we were able to secure funding for C-BER second spin-off - inSignals Neurotech. Portugal Ventures will fund the trials of the inSignals Neurotech multi-center evaluation study of the developed neurotechnology. This will launch this start-up into the market and to support that a License agreement is already being prepared that will include one of the patent families, the software application registered and the design patent. SAL is supporting the Centre in this task. Next year, a program contract will be established with the start-up in order to support it in this task.

iLoF (Intelligent Lab on Fiber), the start-up funded in 2019 is growing and has received more funding round in a total of more than 1.5M€ besides the 2M€ raised last year. We have been supporting their activity during the full 2020. A program contract between C-BER and the company was established to support both research and development activities and also strategic decision related with projects participation. C-BER and iLoF participation together in a project funded by FCT and were partners in a H2020 project proposal. Next year we aim to design the second program contract with iLoF to pursuit this partnership and support them in their journey. We are also preparing the license agreement jointly with SAL.

WeSENSS (Wearable SENSors for Safety) was also very active in the first 3 months of the year, with the preparation of a pilot proposal for GALP. The multinational company was closing the first funding round of the spin-off to perform a pilot in one of their infrastructures. Unfortunately, the pandemic situation led to the cancellation of this funding. The strong interaction with EQS was also explored in this year leading to a stronger partnership that we hope will bring short-term funds. Conversations with Grosvenor and Portugal Ventures investors also took place at the end of this year and are still ongoing.

6.4.4 Activity Overview

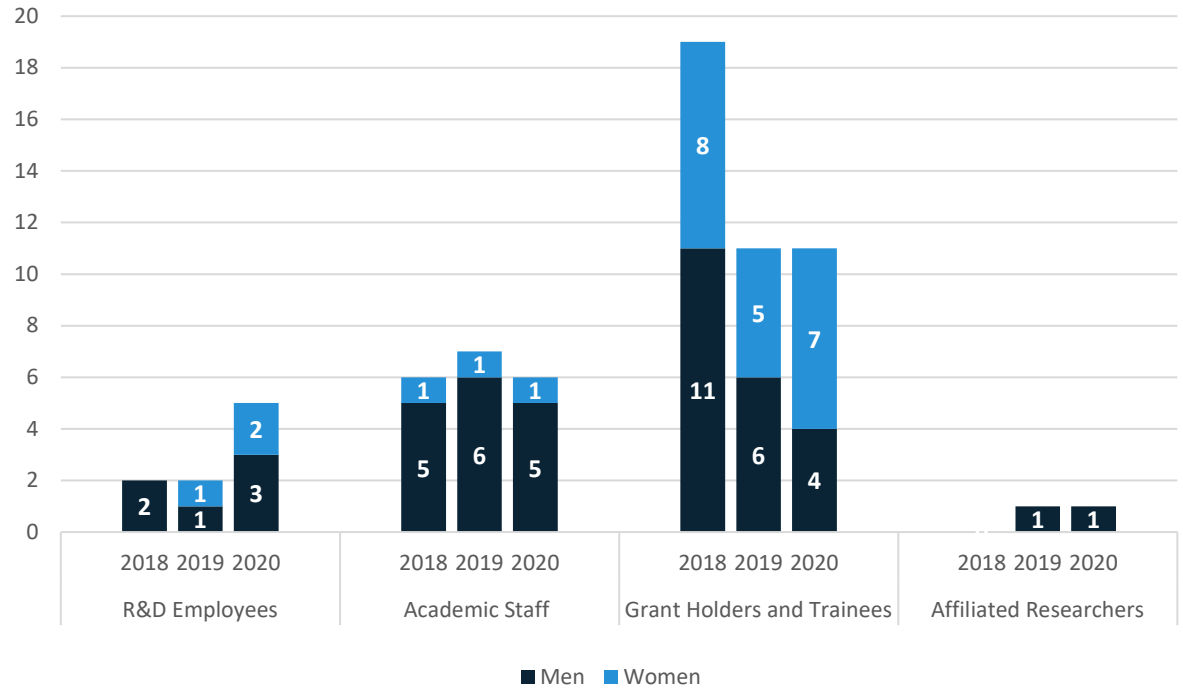


Figure 6.4.1 - C-BER - Research team evolution

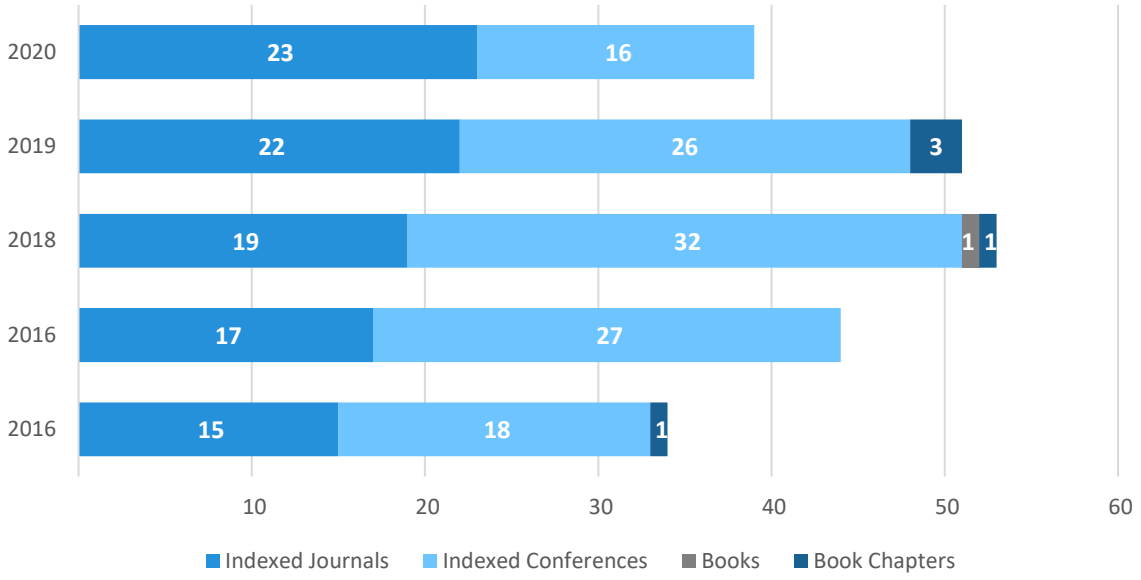


Figure 6.4.2 - C-BER - Evolution of publications by members of the Centre

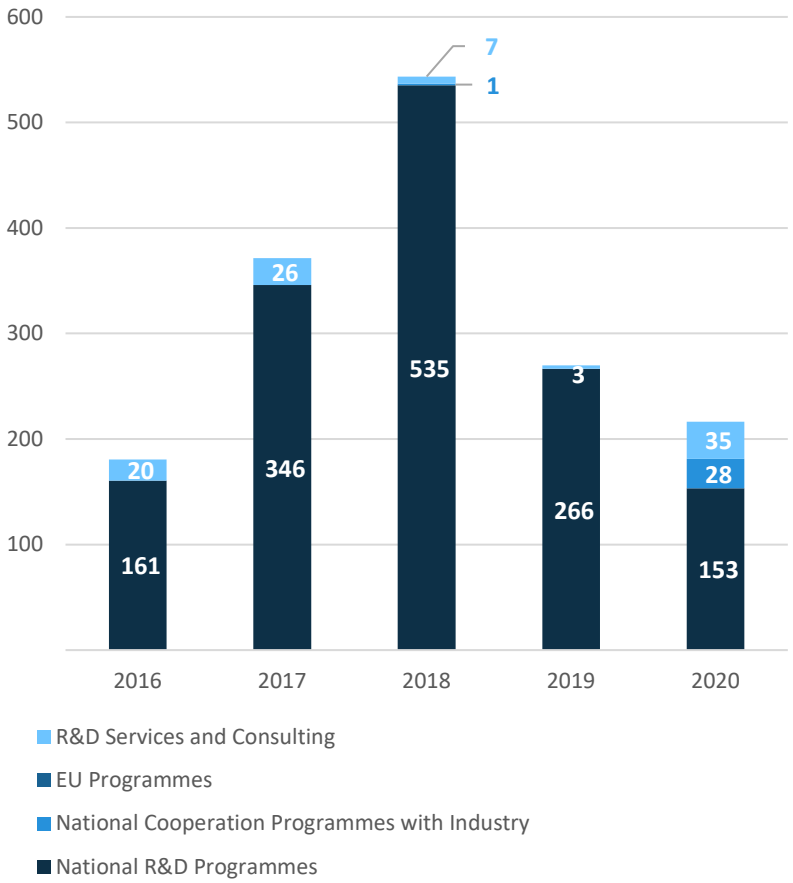


Figure 6.4.3 - C-BER - Project funding evolution (k€)

6.5 CPES - CENTRE FOR POWER AND ENERGY SYSTEMS

Coordinators: Manuel Matos and Ricardo Bessa

Assistant to the Centre Coordination: Jorge Pereira

6.5.1 Presentation of the Centre

The Centre for Power and Energy Systems (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.

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

The Centre is an international 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 (in 2020, it coordinated three European projects) and granted direct contracts with national and international companies, with a robust track record in technology transfer and consulting. In recent years, researchers of CPES received the IEEE PES Renewable Energy Excellence Award and a recognition award from CIGRE. Other researchers won repeatedly the IEEE PES competitions in meta-heuristics applications to power systems. Several post-graduate students have successively won the Portugal best MSc thesis prize awarded by the Portuguese TSO and other prizes to MSc and PhD theses. In 2016, INESC TEC won the recognition of best innovation partner of EDP.

6.5.2 Research outcomes in 2020

- Organisation of the PSCC 2020, Power System Computation Conference, 420 participants;
- Development of a privacy-preserving protocol and data markets for renewable energy collaborative forecasting, considering different communication schemes (centralised, peer-to-peer, asynchronous communication). Papers in IEEE Transactions on Sustainable Energy and in International Journal of Forecasting. Patent request to EPO;
- Deep learning approach (variational auto-encoders) to simulate load profiles of residential consumers under dynamic electricity tariffs and demand response signals. Joint project with EDF R&D. Code released in Github and method published in IEEE Access;
- Development of a methodology to monetise the benefits of the investments in the distribution system concerning the security of supply, the quality of service, the distribution losses and operational efficiency. The tool includes the estimation of the distribution grid quality indices evolution and assists the DSO on the medium and long-term planning decisions;
- Development of a simulation model to evaluate the total generation cost in Portugal considering the payments to the Special Regime (feed-in tariff) and to the Ordinary Regime Generators;
- Development of an Agent Based Model to simulate the MIBEL day-ahead market considering the presence of hydro generation, wind and solar PV units.

6.5.3 Innovation outcomes in 2020

- Characterisation and model identification of a distribution network (HV, MV and LV). Network simulation and identification of system weaknesses (voltage drops, large losses, overloaded lines and transformers). Synthesis of measures for problems mitigation, particularly for the reduction of technical losses, including economic evaluation and cost/benefit analysis. Application to Angola network;

- Assessment of demand side management contribution to the long-term adequacy of supply of the Portuguese generating system. Contract with DGEG;
- Development of an application to assist the DSO in the medium and long-term planning decisions by monetising the benefits of investments in the distribution system concerning the security of supply, the quality of service, the distribution losses and operational efficiency. Contract with E-Redes;
- Development and application of a data-driven methodology to predict distribution lines (overhead and subterranean) failure location in HV and MV networks operated by E-REDES, considering meteorological variables, geographical location, and physical characteristics (e.g. conductor material);
- Development of software module for battery energy storage systems predictive optimisation applied to hybrid parks and microgrids, transferred to EFACEC in the context of project national funded project FLEXERGY;
- Development and validation with historical data of AI-based substation's alarm management software for reducing the cognitive load of distribution network operators, namely: 1) identification of anomalous behaviours regarding the performance of the protection functions associated with HV and MV line panels. 2) identification of similar events in HV line panels. Contract with E-Redes;
- Design and implementation of the second generation of a home energy management system (HEMS) within the InteGrid project. The new version is capable of determining the flexibility within a household, represented under a single battery formulation, for modular clustering and privacy design implementation;
- Strategies to optimise the simultaneous participation of multi-energy aggregators in day-ahead electricity (energy and reserves), gas and carbon (EU ETS) markets;
- Accomplishment of Flexibility HUB - Flexibility coordination tool at the distribution grid to foster DSO/TSO interaction – Deliverable D7.5 EU-SYSFLEX;
- Development of Hydro-Flexibility Matrix in the framework of XFLEX Hydro Horizon 2020 Project;
- New developments and model calibration with 2019 MIBEL data to reach a fully operative market simulator for operation and investment decisions with energy and reserve constraints. Upgrade of CEVESA market simulation software;
- First prototype (P2PChain) of a local market platform for energy trading based on Ethereum blockchain technology with an innovative post-delivery local energy market design. INESC TEC seed project.

6.5.4 Activity Overview

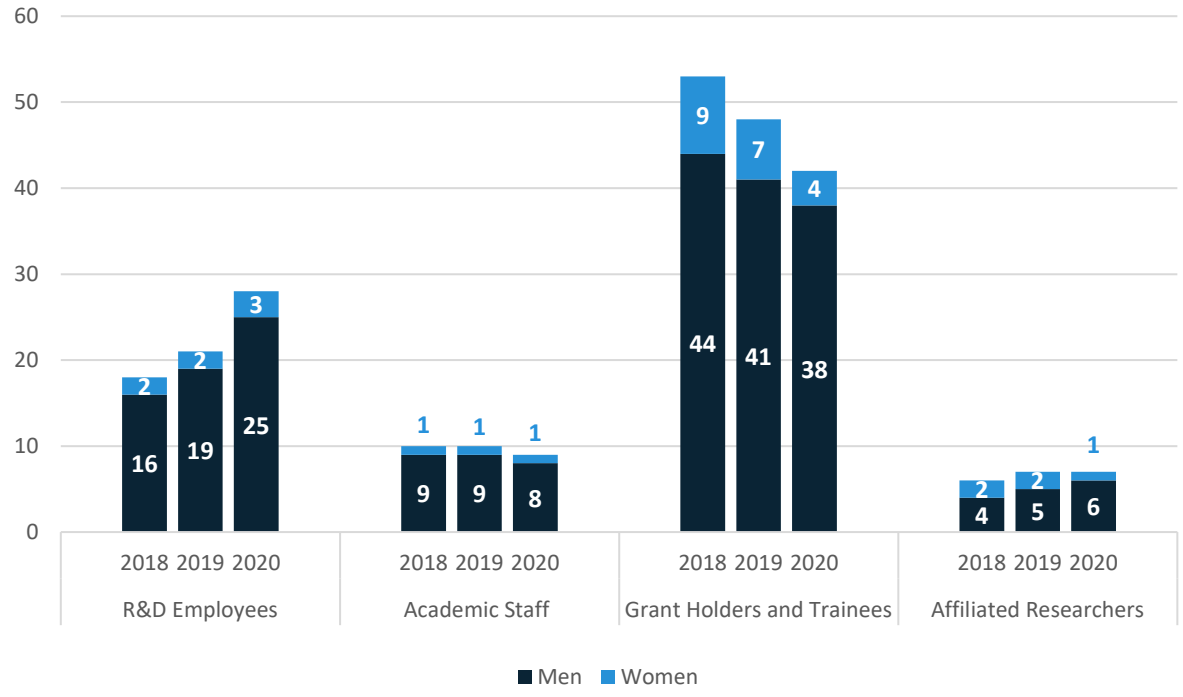


Figure 6.5.1 - CPES - Research team evolution

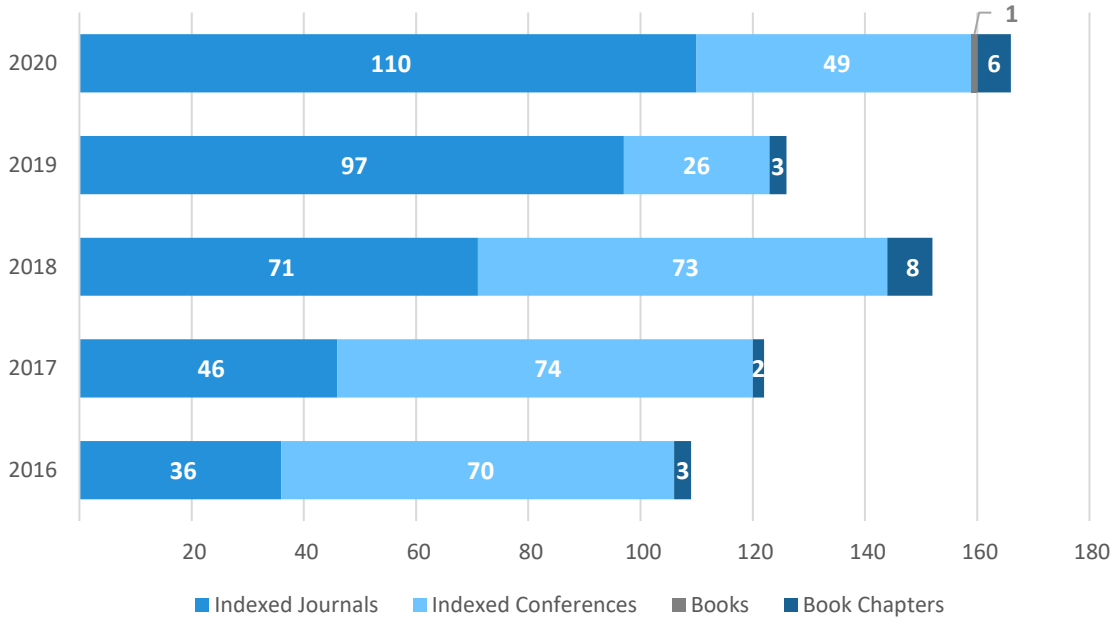


Figure 6.5.2 - CPES - Evolution of publications by members of the Centre

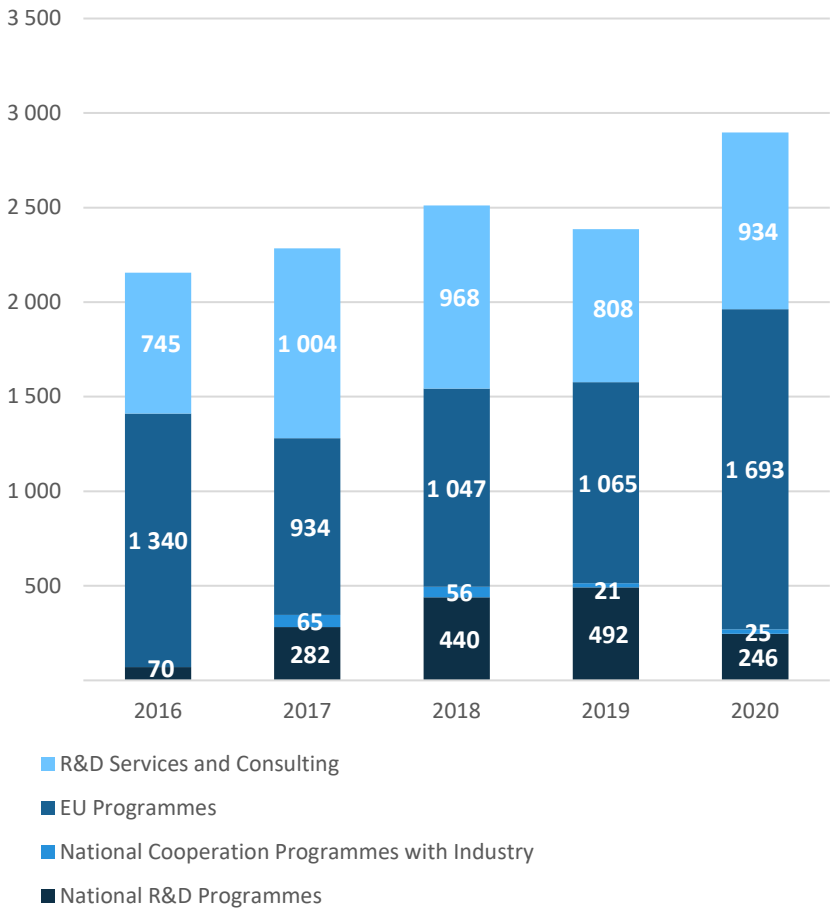


Figure 6.5.3 - CPES - Project funding evolution (k€)

6.6 CESE - CENTRE FOR ENTERPRISE SYSTEMS ENGINEERING

Coordinators: António Lucas Soares and Rui Rebelo

6.6.1 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 accomplishes its mission, within the Cluster ISE – Industrial and Systems Engineering, by undertaking multi-disciplinary, system-oriented research and technology development for the strategic and operational management of industrial enterprises and networks. Research at CESE is organised along the following lines: responsive, sustainable and resilient manufacturing systems, collaborative networks and digital value chains as socio-technical systems, digital architectures for data-driven manufacturing, decision support in a digital manufacturing context, mobility for the circular economy, and technology adoption and management for inclusive manufacturing. It uses the knowledge generated in research to provide high value-added and innovative niche services to the industrial enterprises, such as Production Systems Management, Logistics Systems, Digital platforms for networks and supply chains, and Digitalisation and Industry 4.0 roadmapping.

6.6.2 Research outcomes in 2020

RL1. Responsive, sustainable and resilient manufacturing systems. The field of planning and scheduling produced several outcomes: an integrated planning and scheduling solution for natural cork stoppers production, acting as a decision support system with order promise characterised by degrees of confidence; a planning and scheduling system for the production of injected shoes considering demand forecasts and process complexity; a real time scheduling engine integrated with an IIoT platform to monitor, detect and evaluate disturbances on plan execution, and suggest corrective measures. The usage of reinforcement learning (RL) for decision support in in-house logistics systems continued to be studied, namely, the usage of open-source RL frameworks integrated with simulation models. An outcome of this study was a standardised communication protocol between RL frameworks and logistics simulation models.

RL2. Collaborative networks and digital value chains as socio-technical systems. The relationship between supply chains and innovation continued to be researched in 2020. The effect of the fit between supply and demand uncertainty and supply chain responsiveness on business and innovation performance were investigated, as well as how the fit between innovation capabilities and supply chain strategies affects performance. These outputs contribute to the adoption of collaborative values chains by companies in order to increase their competitiveness. Additionally, the balance of power dynamics between supply chain partners in the context of digital transformation of SMEs has been investigated in the winner project of the EurOMA Young Scholar Networking Grant.

RL3. Digital architectures for data-driven manufacturing. A first specification of a digital platform (DP) to manage product-service systems based in the concept of digital twin (DT) was achieved. The DP, developed in the scope of the Transformer 4.0 project, is based in a semantic-enabled architecture where multiple instances of DT will be managed. The Advanced Plant Model, a 3D model of a manufacturing area consolidated with production schedules was demonstrated and validated in two use cases of H2020 Scalable 4.0. The validation included the integration with CRIIS robotic manipulators through the OSPS architecture (Open Scalable Production System). Integration of advanced robotics, Manufacturing Execution System and Simulation and Decision Support Tools was achieved via OSPS in an IIoT-based architecture.

RL4. Decision support in a digital manufacturing context. Several outcomes were achieved linked to decision support in manufacturing systems. Four optimisation-simulation platforms were created, each with a specific purpose and area of application: assembly line balancing in the aerospace industry (FASTEN project), production scheduling in the textile industry (PRODUTECH project), resource allocation in engine manufacturing and layout design in the automobile components industry (both in ScalABLE 4.0, also producing a relevant paper). Within the STOSS project, the design and initial development of a Web-based decision support system for Sectorisation Problems (SP) was developed, to address areas such as administration, commerce and services. The DSS covers Basic SP, Resectorisation P and Dynamic SP, by resorting to various multicriteria solutions methods conveniently selected for the particular P.

RL5. Managing Transport, Logistics and Mobility for the Circular Economy. Models for the estimation of emissions and other externalities of transport and mobility were developed in 2020. Several aspects of urban logistics (in particular, for the "last mile") were object of research, through the development of mathematical programming models and meta-heuristics, and the exploration of collaborative solutions and new business models. In another research direction, work was pursued in the assessment and optimisation of sustainable forest wood supply chains, particularly addressing the integrated planning of inbound and outbound logistics and collaborative transportation planning problems. Moreover, in 2020, CESE launched a formal discussion with several other Centres to set-up common initiatives aiming at structuring and aligning research and innovation in the areas of transportation, logistics and mobility.

RL6. Technology adoption and management for inclusive manufacturing. CESE participated in European educational projects (M-NEST-I and M-NEST-RIS) in order to improve its competencies in designing and implementing innovative learning modules to tackle the challenges faced by industrial companies in their digitalisation efforts. CESE has been actively involved in ConnectedFactories2 H2020 project, particularly in the definition of skills and business models for the future manufacturing, as well as relevant industrial use cases. Furthermore, the links between ConnectedFactories2 consortium and the Digital Manufacturing Platform have allowed to gather relevant information on other digitalisation projects and cases, as well as open calls and potential partnerships.

6.6.3 Innovation outcomes in 2020

In the area of logistics systems, and in the scope of the 3DLOG project, a digital platform to coordinate and manage a volunteer collaborative network responsible for printing and delivering 3d printed visors to hospital was developed. The platform enabled the network managers to access all the current information about orders and its production and was also responsible for the optimisation of the routes to be followed when handling deliveries, minimising the distances covered. Also in this area, a decision-support system, based on simulation, was developed for an intermodal terminal (the Interporto Padova Spa, in Italy). The system was used to support the dimensioning of the number of logistic units for the container handling.

In the advanced training area, some training programmes (eg. Immersive Reality in the Context of Industry 4.0: Impact on People and Organisation; Advanced Program in Industry 4.0) were conducted at the iiLab, with the aim of providing business professionals with knowledge of the technologies and their applications to meet the challenge of digitalisation.

In the beginning of 2020, CESE presented a proposal to GALP to develop the roadmap for the following stage of their production digital transformation. Building on the two previous project stages, the roadmap would define the actions to increase digital maturity in production. The proposal was pre-approved, but due the COVID-19 pandemic the development plans (and GALP's production itself) were halted. Nevertheless, CESE adapted its maturity assessment and roadmapping tools to SMEs and implemented them in several companies throughout 2020. CESE improved its digital maturity assessment tools and applying it to several SMEs (DigTrafoRIS), and defined the technologies needed for the future supply chains (NEXT-NET).

Overarching the several innovation areas, CESE was actively involved in the definition of TEC4SEA strategy as well as participating in TEC4AGRO-FOOD activities.

6.6.4 Activity Overview

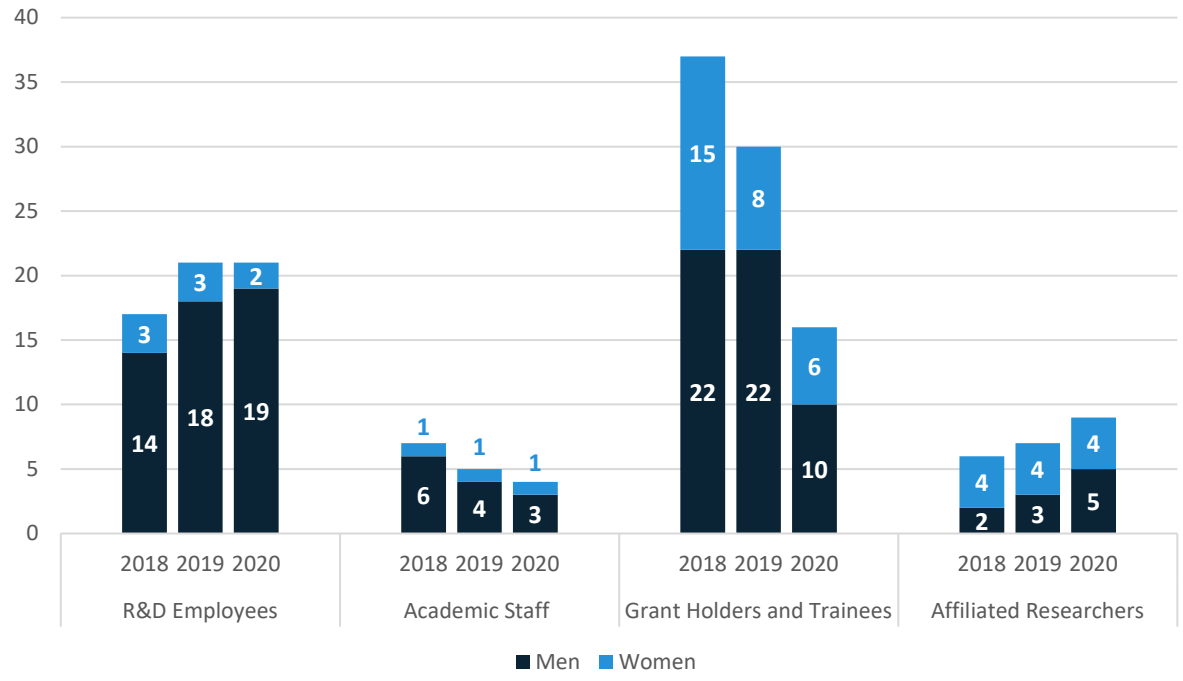


Figure 6.6.1 - CESE - Research team evolution

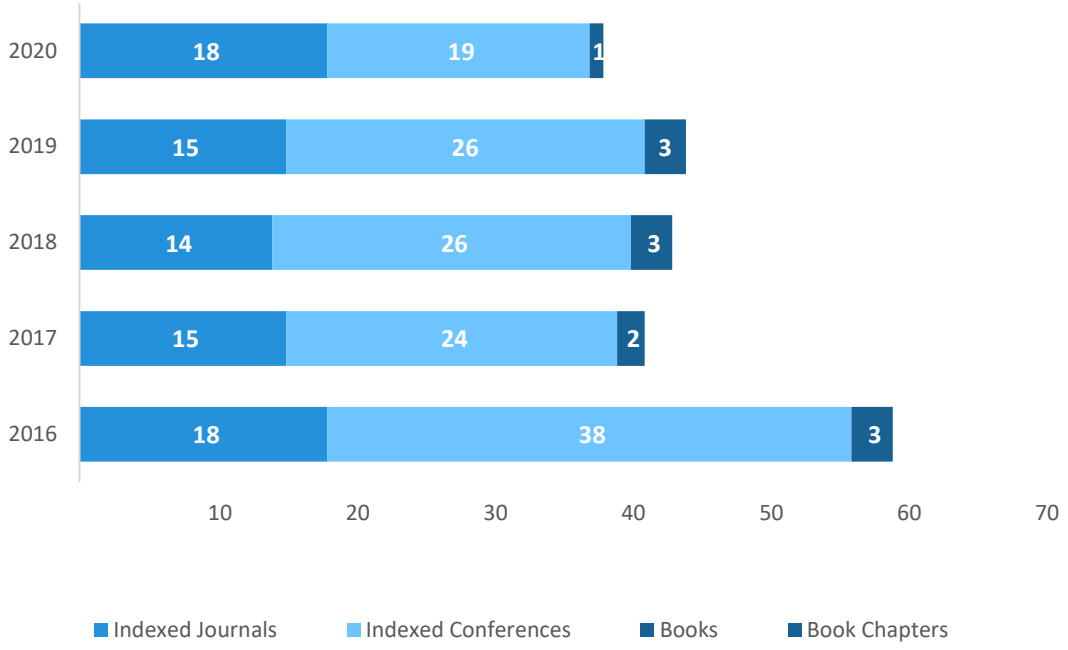


Figure 6.6.2 - CESE - Evolution of publications by members of the Centre

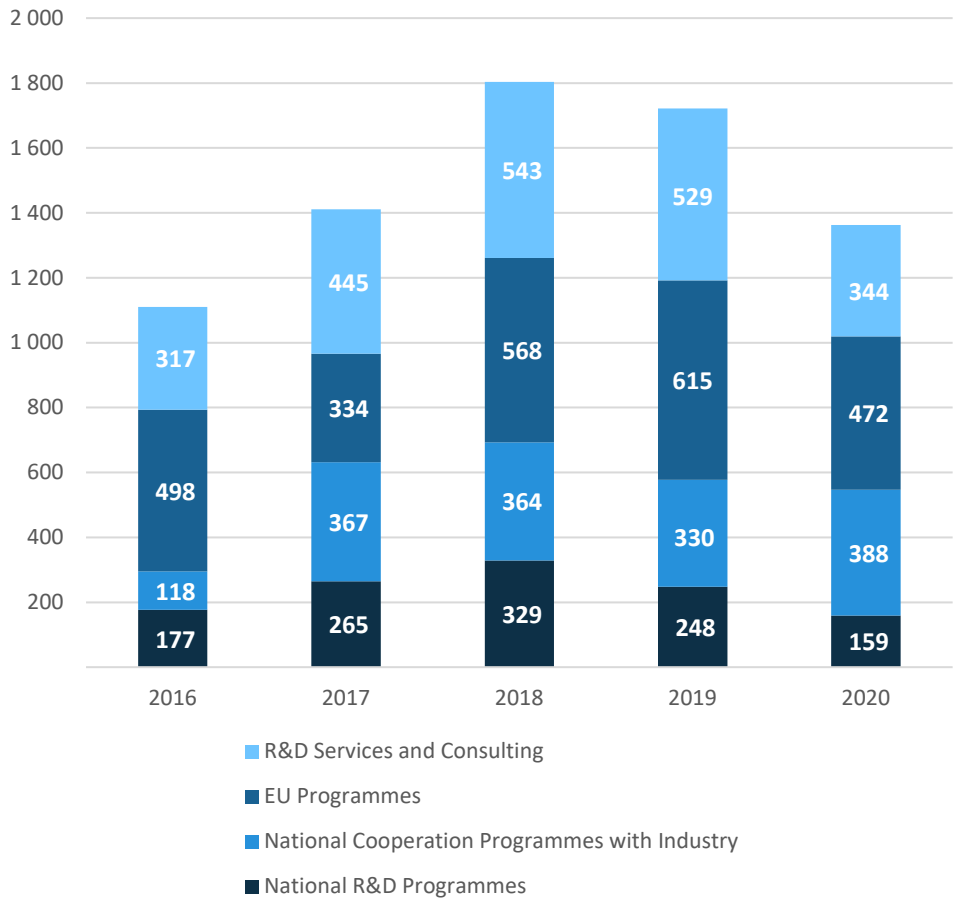


Figure 6.6.3 - CESE - Project funding evolution (k€)

6.7 CRIIS - CENTRE FOR ROBOTICS IN INDUSTRY AND INTELLIGENT SYSTEMS

Coordinators: António Paulo Moreira and Germano Veiga

6.7.1 Presentation of the Centre

The Centre for Robotics in Industry and Intelligent Systems 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.

6.7.2 Research outcomes in 2020

The main research outcomes are provided along the main research lines.

RL1. Navigation, Localisation and Coordination of Mobile Robots.

On this line an open-source Path Planning Aware of Robot's Center of Mass for Steep Slope Vineyards solution, called AgRoB-PP was made open-source with the support of ROSIN initiative. Motivated by the innovation line INOV2, six relevant peer reviewed publications were published in indexed journals related to the topics of localisation and path planning in steep slope vineyards.

RL3. 2D/3D Industrial Vision and Advanced Sensing

In the 2D/3D Industrial Vision Systems and Advanced Sensing, the most significant developments were related to: (1) extending the current modular and reconfigurable 3D Robot Perception Framework to deal with the problem of picking objects in cluttered scenes. To overcome this challenge the integration of this framework with an AI based methodology, applied to 2D images, was explored in order to segment the object position in the scene. (2) tackling the novel challenge of automating the bin picking process for entangled objects, which resulted in the publication of one article. (3) first steps on the development of an AI empowered flexible robot handling system, capable of generating grasp solutions, based on the digital model of both the part and the gripper and their contact forces.

RL4. Human Robot Interfacing and Augmented Reality

CRIIS has continued the developments on improving the projected spatial augmented reality system, developed in 2019. These new developments aimed to: (1) increase the maturity level of the technology and its user interfaces, (2) increase its range of industrial applications, namely, to support human operators both in the construction of silos for the food industry, and also on construction and maintenance of ships at the shipbuilding industry.

RL5. Future Industrial Robotics and Collaborative Robots

Aligned within the scope of this research line, CRIIS has deployed a collaborative robotic coating cell. This industrial cell includes a programming by demonstration system (6DMimic), an advanced 3D sensing system, and an innovative safety sensor to allow for a symbiotic, safe and intuitive human-robot collaboration. This research resulted in two papers focused on the integration of an IMU sensor to the current 6D MIMIC solution, allowing it to deal with marker's occlusion. Associated to the future industrial robotics, an optimised technique to deal with automatic planning and design of robotic systems was designed and tested. The results were also published. Moreover, an automated framework for agile development and simulation of robotic palletizing cells was developed, the AdaptPack studio. Two articles were also published. Finally worth of mentioning the development of a force-based sensing methodology, to enable industrial robots to perform high precision assembly tasks.

RL6. Vertical Integration, IoT, Industry 4.0

The main research outcome of the RL6 in 2020 was the expansion of the OSPS framework through the integration with robotic oriented cloud computing platforms, namely the Amazon AWS RoboMaker. The use of cloud computing platforms for the large scale testing and deployment of multi robot systems, is one of the upcoming challenges for the wide spread use of robotic systems. Still to be published for the scientific community, this work was already recognised as pioneer by Amazon, opening interesting perspectives for INESC TEC in the field.

6.7.3 Innovation outcomes in 2020

Major innovation outcomes in 2020 were achieved along innovation lines INOV.1, INOV.2 and INOV.3

INOV1. Flexible Production using Robotics

The main innovations activities were: (1) the semi-industrialisation and technology transfer of the results from the ScalABLE project, targeting the deployment of highly flexible collaborative robotic systems in full production; (2) the development and further exploitation of a Plug'n'Produce technology for bridging the gap between robots (based on ROS) and automation equipment (based on CODESYS softPLC), the ROS-Codesys bridge. The development of this solution has started under the ScalABLE4.0 project and was improved under the ROBIN initiative (associated to the H2020 Robin project). The solution was successfully released to the community under the ROS Industrial umbrella.

INOV2. Inspection, Control and Embedded Systems

In the Inspection domain, the main innovation achievements relate to the development of a machine vision inspection system for detecting non-conformities on metallic parts produced as a result of injection and machining production processes. A full machine vision system was developed, including the data acquisition hardware, image processing, feature extraction, and sample classification. Two main feature extraction approaches were implemented – textural descriptors (Haralick's features and local binary patterns) and defect segmentation with shape descriptors of the considered trails. Supervised classifiers were employed, specifically K-nearest Neighbors (KNN), Multilayer Perceptron (MLP) and Support Vector Machine (SVM).

INOV3. New challenges in Robotics

In an attempt to support institutions seriously affected by the COVID-19 pandemic such as hospitals, CRIIS designed a fast response with the development of a low cost and easy to assemble ventilator with a self-inflating bag – PNEUMA, and an autonomous Robot for Surface Disinfection at Health Care Facilities – RADAR. Following the news that reported the lack of ventilators, PNEUMA emerged as an add-on device that automates the self-inflating bag to help patients breathing. In order to prevent the virus dissemination, RADAR arises as a mobile robotic system with UV-C lights to disinfect areas, including a novel people detection system to ensure their safety. A partnership between CRIIS and the company DCSI was accomplished culminating in the system commercialisation by the latter. Succeeding this last development, a new iteration began with the project RDH4COVID, where a mobile robot transports UV-C disinfection systems around a given space. Furthermore, tests have been made to check the possibility of performing physiotherapy treatments using collaborative robots, with good results. These tests were the basis for the submission of a project proposal to the FCT 2021 call for projects.

6.7.4 Activity Overview

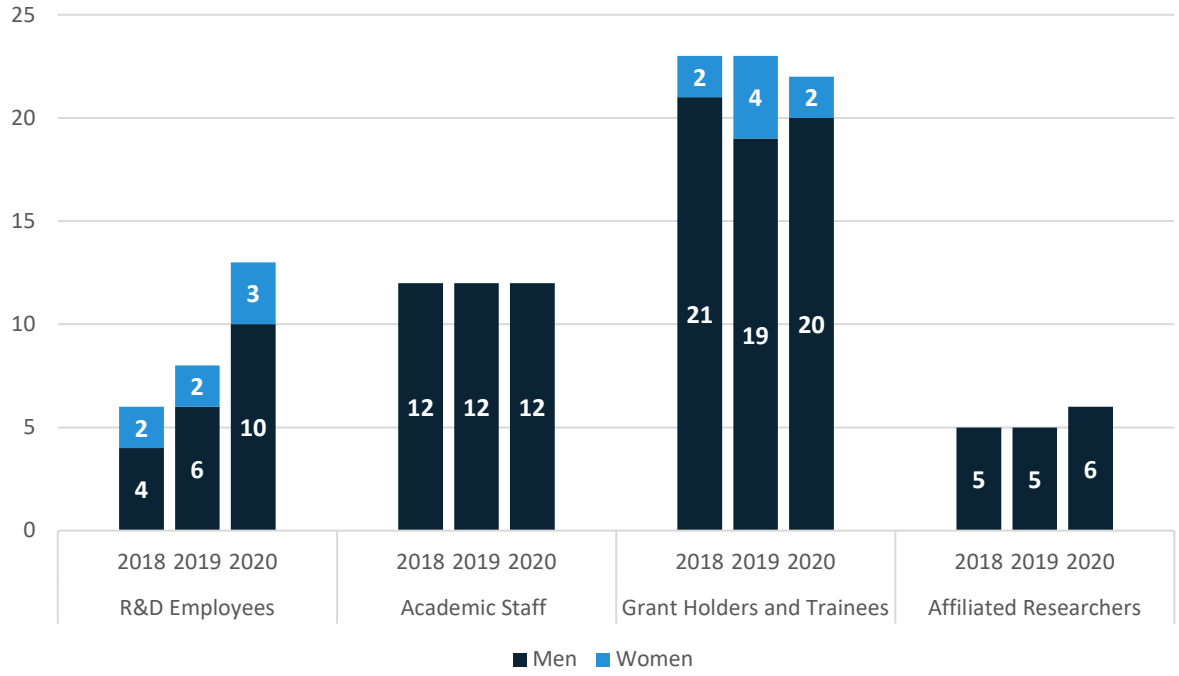


Figure 6.7.1 - CRIIS - Research team evolution

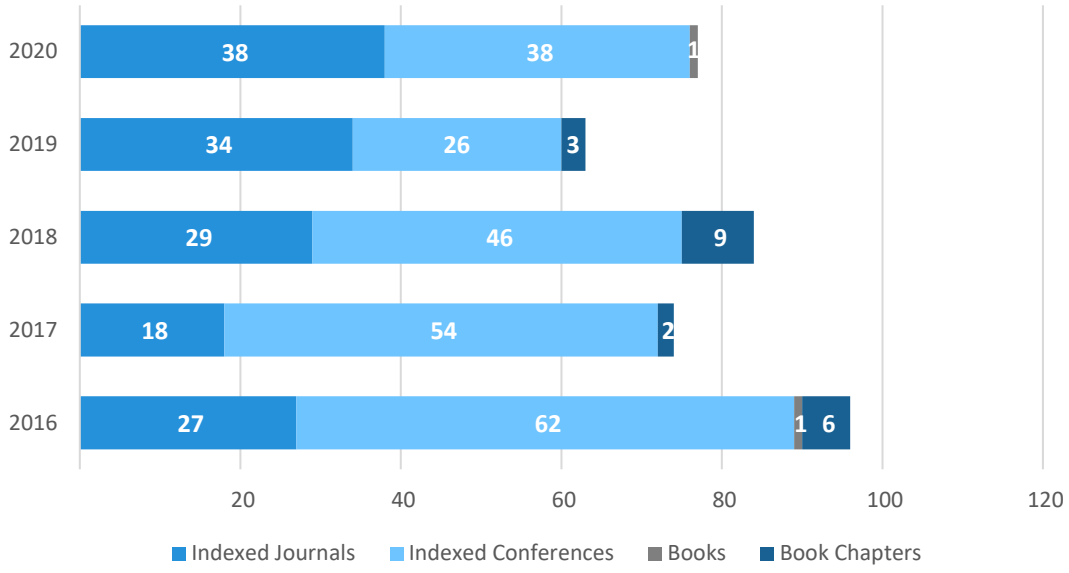


Figure 6.7.2 - CRIIS - Evolution of publications by members of the Centre

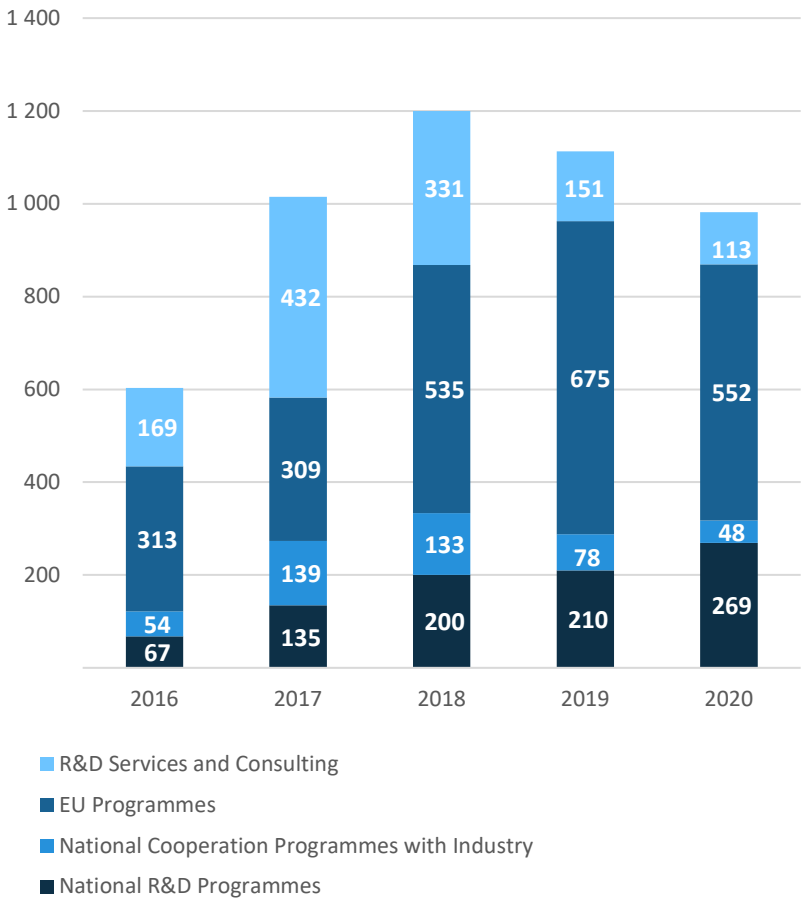


Figure 6.7.3 - CRIIS - Project funding evolution (k€)

6.8 CEGI – CENTRE FOR INDUSTRIAL ENGINEERING AND MANAGEMENT

Coordinators: Ana Viana and Pedro Amorim

6.8.1 Presentation of the Centre

CEGI integrates the Cluster Industrial and Systems Engineering (ISE). This Research Group (RG) is an international reference in business analytics through decision support systems for service and operations management, contributing also in data science, service science, and other emerging topics (e.g., blockchain and asset management).

Operations Research 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. A few years ago, a group of CEGI researchers was finalist of the "Wagner Prize award", for Excellence in Operations Research Practice, by The Institute for Operations Research and the Management Sciences.

Within the domain of business analytics, the goal of the RG is to conveniently extract knowledge from data that can be leveraged to increase, for example, revenues of a business. In terms of descriptive and predictive analytics, 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. Regarding prescriptive analytics the RG is particularly focused on addressing challenges related to dynamic optimisation under uncertainty. A new challenge, also associated to the increasing quantity of available data, is to couple Machine Learning and Optimisation, in order to make more supported and informed decisions.

Core areas of application/innovation of CEGI include Retail/Industry, Mobility and Healthcare, with significant contributions also in the Energy Sector through a strengthened collaboration with CPES. CEGI includes the Portuguese delegate to the European Union Horizon 2020 committee on Smart, Green and Integrated Transport.

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.

6.8.2 Research outcomes in 2020

Planned activities and actions for 2020 where considerably hindered by the COVID pandemics, in particular in what regards participation in conferences and short-medium term scientific missions. Still, the results obtained are frankly positive.

RL1. Operations Research / Management Science

In 2020 the RG continued to advance the state of the art in terms of methods and models of operations research / management science in its several domains of interest (e.g., health, retail, and industry), consistently publishing in highly ranked journals. A great deal of research was focused on robust models, capable of conveniently handling uncertainty. A major achievement was to successfully lead an European Project proposal, that was selected for funding. Although the Centre had previously participated in some European Projects, Project TRUST-AI is the first one that is led by CEGI. This project has also connections to the RL2 has it builds on Genetic Programming.

RL2. Data Science / Data Mining

The RG performs research in the various domains of the vast research field of data science, data mining and visualisation, mainly with an application perspective. This includes individual methods and techniques in knowledge acquisition and representation, and their application in the construction of recommendation systems.

In 2020, the RG worked on semantic ontologies to recommend the adequate visualisation techniques for a given analytical task when analysing urban mobility data. In particular, deep learning artificial neural networks were used to estimate the demand of bus passengers and to estimate social exclusion based on the maximum distance that someone has to walk to reach the public transport (Sobral, et al., Expert Systems with Applications, 2020).

RL3. Service Science / Design

In 2020, the RG advanced service design and innovation in key service contexts, namely by leveraging service design for healthcare transformation (Patrício et al., Journal of Service Management, 2020); and using service design as an innovation approach in technology startups (Korper et al., Creativity and Innovation Management, 2020). The RG also advanced the understanding of customer experience with technology enabled services, namely with smart services, and multi-channel services, and gerontechnologies. Furthermore, Lia Patrício was involved in the creation and launch of the ServCollbab, a global initiative of service researchers to improve well-being (Fisk et al., Journal of Service Management, 2020).

RL4. Emerging topics (Blockchain, Asset Management, Machine Learning and Optimisation)

Asset management is now consolidating and taking a prominent position within the RG. It is expected to be one of CEGI's key research areas in an horizon of 5 years. The Centre maintains its collaboration with CPES, jointly participating in European and National projects, namely with project XFLEX.

Regarding the blockchain technology, in a project funded by FCT and in joint partnership with Carnegie Mellon University, Doublechain, we studied the impact the blockchain may have on supply chains, in particular in fostering procurement bargaining. We developed a fully functioning proof of concept in Ethereum to illustrate how buyers can make syndicated purchases in a decentralised way. We were also able to publish these results on IEEE Transactions on Engineering Management.

The topic of Machine learning and Optimisation has also been in the research chart of CEGI. Advances have been made in the area of e-commerce, with several papers having been submitted for publication. The topic will also be addressed in project GreenShoes, "Moblizador" in the area of shoe industry.

6.8.3 Innovation outcomes in 2020

Technology transfer of the Centre has been mainly directed to three areas of activity: Energy, Retail/Industry and the Healthcare sector.

INOV1. ENERGY

In 2020, the Centre participated in several European projects within this domain (XFLEX, INTEGRID, and POCITYF). In XFLEX, INESC TEC team is responsible to create a health index for the hydropower system to monitor the effects of the newly designed flexible power services. This is being integrated in a smart control to leverage enhanced variable- and fixed-speed turbine systems, as well as a battery-turbine hybrid. In the Integrid project the INESC TEC team is in charge of creating a condition prognosis tool to make individual and status dependent maintenance possible for dry transformers in medium/low voltage substations.

INOV2. RETAIL AND INDUSTRY

In project Transformer 4.0, initiated in 2020, optimisation and artificial intelligence-based techniques are being developed to extract knowledge from historical data, and multi-disciplinary engineering processes designed to maximise knowledge sharing and effective learning in the power transformers design.

INOV3. HEALTHCARE

CEGI had three flagship-projects in 2020. Project MINE4HEALTH, running in collaboration with LIAAD, aims at leveraging the sheer amount of data present in this oncology hospital. Project BEST_ORDER rises a new paradigm in pharmaceutical distribution, providing a service where the distributor collaborates with the pharmacies at managing their stocks. Finally, project Knowlogis was awarded the best digital project award in the Healthcare sector by Portugal Digital Awards.

6.8.4 Activity Overview

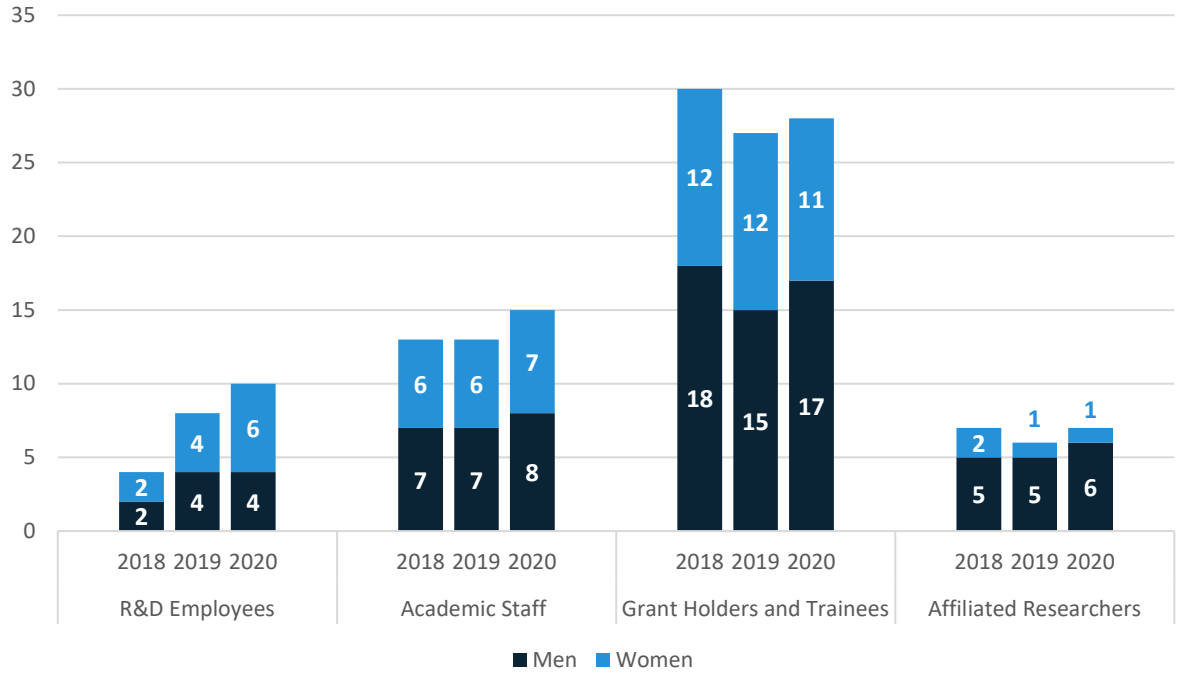


Figure 6.8.1 - CEGI - Research team evolution

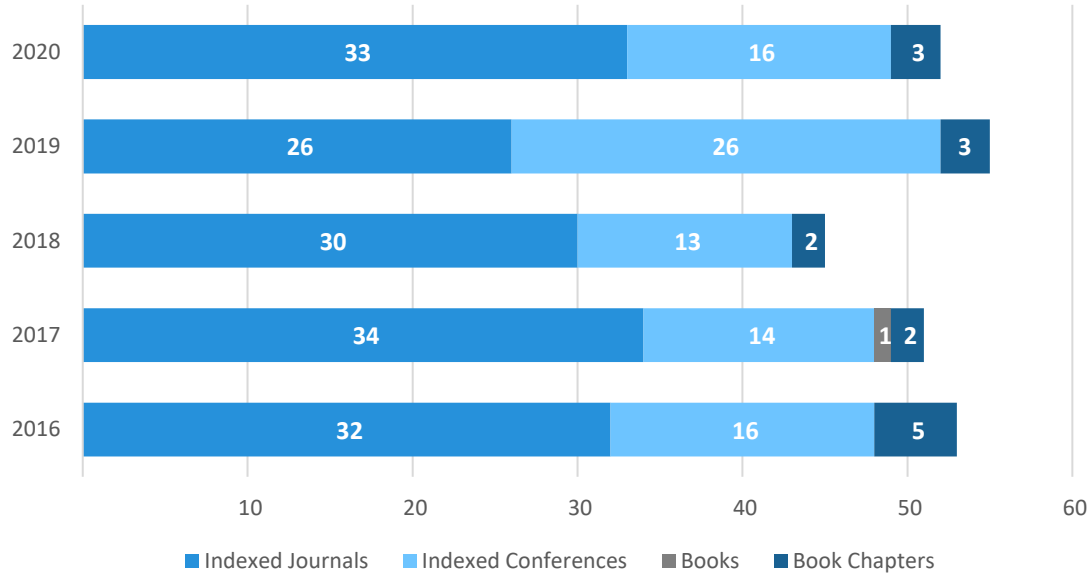


Figure 6.8.2 - CEGI - Evolution of publications by members of the Centre

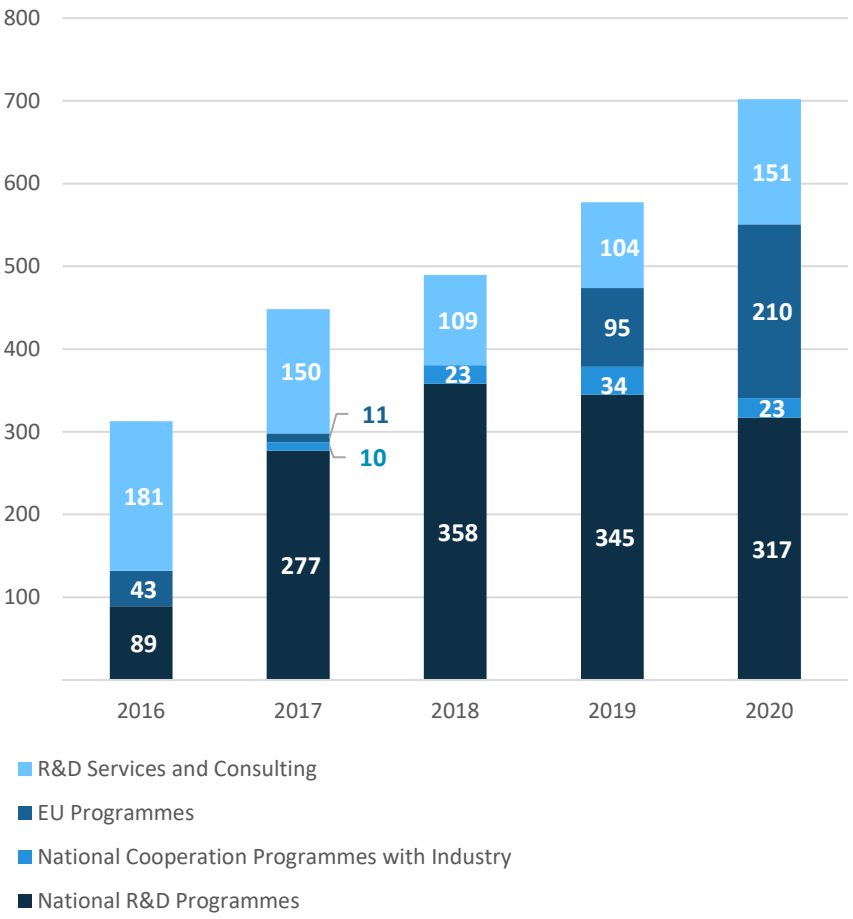


Figure 6.8.3 - CEGI - Project funding evolution (k€)

6.9 CITE – CENTRE FOR INNOVATION, TECHNOLOGY AND ENTREPRENEURSHIP

Coordinator: Alexandra Lobo Xavier

6.9.1 Presentation of the Centre

The Centre for Innovation, Technology & Entrepreneurship (CITE) aims at contributing to a sustainable and resilient economy by carrying out interdisciplinary R&D, advanced consulting and executive education in the fields of: Innovation Management (RL1); Technology Management and Policy (RL2) and Technology Entrepreneurship (RL3) fostering a cross-cutting approach to all INESC TEC's Clusters, and for Private and Public organisations. Formed by a multidisciplinary team from engineering, economy, humanities and business management, CITE gives comprehensive support to organisations to put emerging technologies in the center of their strategic innovation decisions.

To foster an entrepreneurship mindset in research communities and society, CITE operates the Laboratory for Technological Entrepreneurship of INESC TEC (LET-In), that offers training, mentoring, coaching, technological and business consultancy, supporting the development of technology-based entrepreneurial projects related to the institution's core technological areas.

6.9.2 Research outcomes in 2020

CITE reinforced its active participation in National and International Technical Committees for Innovation Management, CT169 and ISO TC 279. A researcher from the Centre was nominated as a national expert for the Working Group responsible for the development of the ISO56008 - Guidance standard on innovation operation measurements and metrics; in CT169, CITE integrates the WG for the review of the NP4457:2007 according to ISO 56002:2019 – Innovation Management Systems – Guidance (RL1).

From Maser Research, two main outcomes in the area of new framework developments have been achieved (i) a reference framework for Software as a Service Business Model Creation (RL3) and (ii) A model to describe how innovation happens in Social Networks (RL1, RL2).

A senior researcher at CITE is the principal editor and takes part of the board of The Journal of Innovation Management. The journal in 2020 was indexed by IBSS: International Bibliography of the Social Sciences (RL1, RL2, RL3).

In 2020, CITE submitted 2 proposals for FCT projects: (i) Use and effects of the technologies that support teaching-learning-assessment process in Portuguese schools: Pre and post COVID-19 (proposal led by a CITE member); (ii) Enhancing the benefits and societal impact of university-industry R&D collaborations. Although not approved, the proposals contribute for the strengthening of important partnerships and they will be resubmitted in the next call (RL2).

CITE signed a research contract with the company EurA to carry out a study about lessons learned and to recommend practices for improving business partnerships, resulting in a case study report about partnerships created within an European Commission program. The study is coordinated by a CITE researcher and the team has been reinforced with a new PhD student (RL2).

A CITE member has participated in the mobiliser program, CHIC, studying possible business models to take advantage of the business opportunities enabled by technology developed in the project, particularly the digitalisation of a Portuguese Cinema Archive. This participation resulted in a paper (RL2, RL3).

In 2020, CITE strengthened its partition in the Committee of The International Conference on Entrepreneurship Education 2020 (http://conf-ee.com/) which had over 100 participants (RL3).

In order to reinforce the cooperation with international research groups, CITE participated in EIP_AHA, by co-coordinating the WG C2: Independent living solutions, and participating in WG D4: Age-friendly environments. CITE also participates in the Thematic Network on Smart Healthy Age-Friendly Environments (RL1, RL2, RL3).

6.9.3 Innovation outcomes in 2020

Since 2015, CITE hosts EASME projects, EEN-Portugal and EEN-INNOVATION JOURNEY. In 2020 the project achieved the following outcomes: (i) 30 Portuguese companies received direct support through innovation advisory services; and 19 companies benefited from innovation management audits followed by the development of a strategic innovation roadmap; 4 SME Instrument project proposals have also been coached by CITE researchers; (ii) in partnership with Grosvenor Investments, two online events were organised: a pitch session, where 7 projects were presented to the investment fund, including 4 spin-offs from INESC TEC; and an open master class focused on Sustainability with a total of 32 participants; (iii) CITE co-organised several international events: we highlight the ATS Forum 2020 an event organised by the Portuguese company CONTROLAR with the support of the EEN partners and other relevant Stakeholders in the Portuguese automotive sector; 4 international brokerage events with a participation of 27 Portuguese; (iv) CITE participated in the Sectorial Group of Mobility (RL1, RL2).

During 2020, CITE reinforced entrepreneurship activities: (i) the DIVA project launched its second call, which received 255 applications and the available 1.38 million euros were invested in 68 projects for new solutions with application in the agri-food sector. Portugal was awarded with 4 more projects, for a total of 14 projects representing 20 SMEs and 265k€ of investment; (ii) the contract with EIT manufacturing to develop the EIT Jumpstart local training, focused on business model development and pitch training where 4 projects participated, with a final win at KIC Health; (ii) the contract with SmartAgrihub, to develop LL2FRESH proposal, a 3 months co-creation programme developed with COTHN, which counted with the participation of 7 technological-based projects in response to the challenge of increasing the shelf life of food products; (iii) as an Ignition Partner of Portugal Ventures, CITE was actively involved in the application of Insignals Neurotech to the Call INNOV-ID, having received an investment of 100k€

6.9.4 Activity Overview

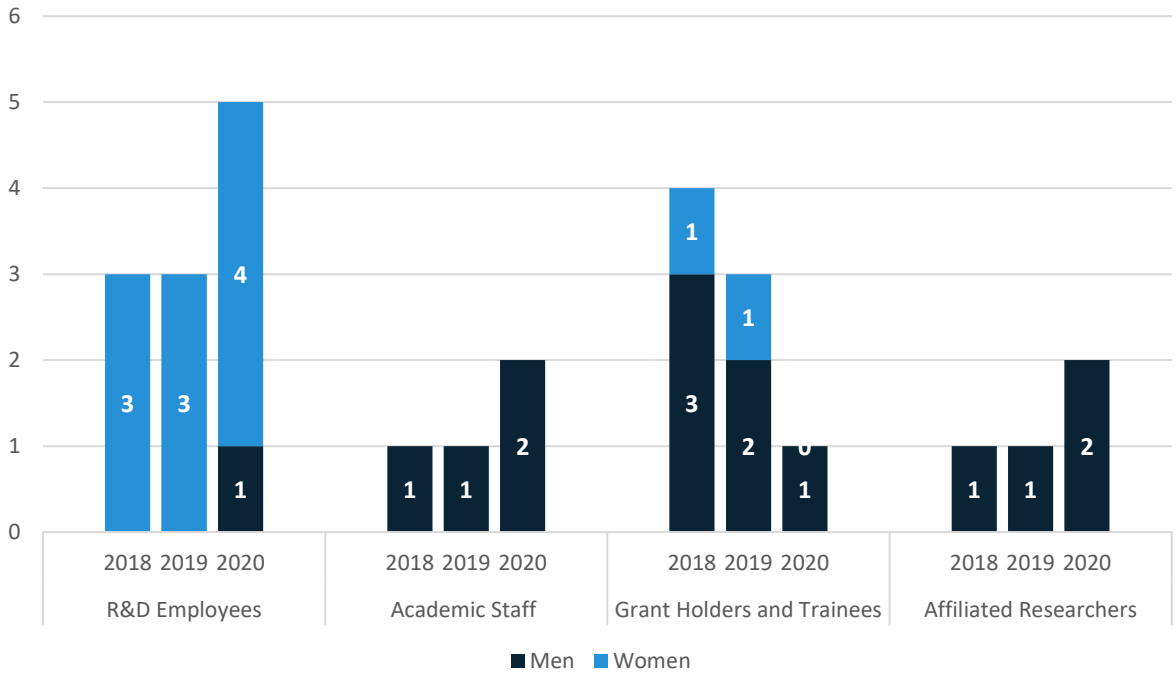


Figure 6.9.1 - CITE - Research team evolution

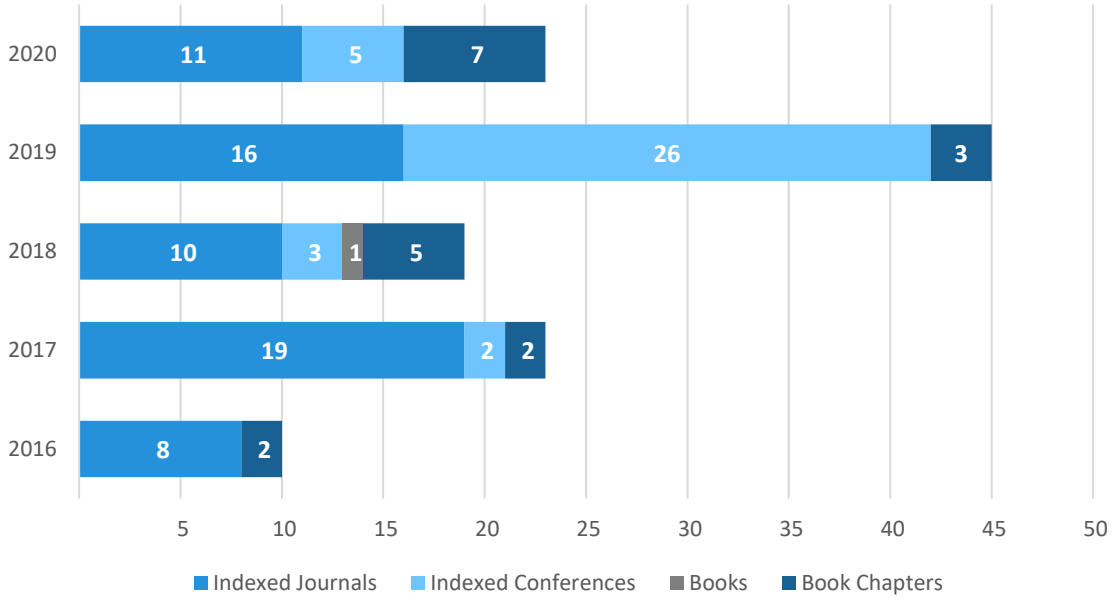


Figure 6.9.3 - CITE - Evolution of publications by members of the Centre

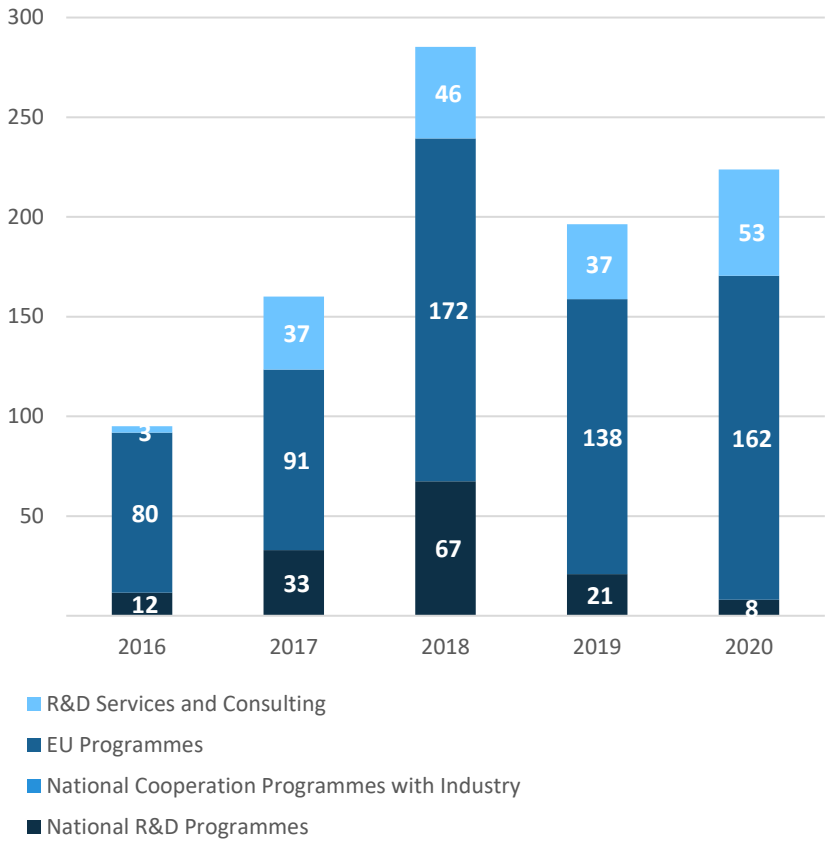


Figure 6.9.2 - CITE - Project funding evolution (k€)

6.10 CSIG – CENTRE FOR INFORMATION SYSTEMS AND COMPUTER GRAPHICS

Coordinators: Ademar Aguiar, Artur Rocha and Hugo Paredes

6.10.1 Presentation of the Centre

The mission of CSIG is to pursue high quality research, consultancy and technology transfer, strongly linked to industrial consortia, in five key research 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 has a large expertise on addressing complex engineering problems in the following key application areas: Platforms and Methods for Earth and Ocean Observation Science; Platforms and Methods for Personalized Health Research; Public Administration; and Mobility and Transport. The Centre is also committed to train young researchers and professionals. CSIG researchers originate from University of Porto, Polytechnic of Porto, University of *Trás-os-Montes e Alto Douro*, *Universidade Aberta* and University of Minho.

6.10.2 Research outcomes in 2020

Software Engineering (ES)

Software engineering contributions spread several research topics and projects. In the iReceptor Plus (H2020), the key contributions were the configuring the overall development process, secure layered architecture, and a blockchain-based architecture for tracing data transformations. The PhD thesis *"Engineering Software for the Cloud: A Pattern Language"* was distinguished with a *"Cum Laude"*. From the research contributions, we highlight those for Software Engineering Education, Software Testing, Distributed Architectures and Live Software Development.

Accessibility and Assistive Technologies (AAT)

The engagement and adherence strategies embedded on a personalised application for supervised physical activity on the peripheral arterial disease is under study in the WalkingPAD project, with the kick-off of 18 months clinical trials. The research is supported by the roadmap presented at HICSS-54. Advancements on the use of iconographic solutions for tech-inclusion of people with special need were achieved. Moreover, contributions to the navigation and spatial orientation of blind users were systematic reviewed and published in a reference universal access journal. Digital accessibility of online educational platforms was evaluated by identifying barriers for blind users' interaction.

Information Management and Information Systems (IMIS)

In the EPISA project, we continued developing an ontology for archival records, analysing the best storage alternatives for the knowledge graph management platform and started developing its prototype. User studies with professional archivists were conducted to evaluate interfaces. INESC TEC co-chaired the Portuguese node of the Research Data Alliance (RDA), a third-party agreement in the context of the RDA-Europe 4.0 European project. The node fostered the engagement of Portuguese research communities in the RDA. Cristina Ribeiro was appointed by the INCoDe.2030 as the coordinator of the group in charge of the definition of the Portuguese Strategy for Open Data, which delivered the document "*Estratégia Nacional de Dados Abertos*".

Special Purpose Computing Systems/Embedded Systems (SPeCS)

In PEPCC project the generation of accelerator circuits from binary instruction traces for several instruction set architectures, including ARM, RISC-V and MicroBlaze was explored. In CONTEXTWA project the performance of OpenCL code compiled for FPGAs for different coding techniques and performed an exploration via a case study of the k-means algorithm. A simple, energy/computationally efficient, and real-time feasible schemes to maintain at runtime a maximum number of training instances stored by kNN was developed. Source-to-source compilation research contributions for several languages were archived, namely in compilers for C/C++ (Clava), Java (Kadabra) and MATLAB (MATISSE).

Platforms and Methods for Personalized Health Research (PM4PHR)

PM4PHR has 3 active H2020 projects. RECAP Preterm consolidated a network of 14 federated nodes, constituting a privacy-preserving health research environment, abiding by the FAIR principles, including 20 European cohorts with duly curated data of children and adults born preterm. EUCAN-Connect created a new distribution of the aforementioned research environment (CORAL), along with training materials. iReceptor Plus conceptualised and implemented a repository-agnostic security middleware for a federated research environment for immunogenetics. Furthermore, it provided a proof-of-concept implementation of a block-chain based approach for the traceability of transformations used in the processing of human RNA data. The team has been involved in the standardisation initiatives of the AIRR community and in the conceptualisation of visualisation tools for immunogenetic data. Inno4Vac an Innovative Medicines Initiative project in the same line of iReceptor Plus was approved to start in 2022.

Platforms and Methods for Earth and Ocean Observation Science (PM4EOOS)

Under H2020 MELOA, it was prototyped and tested a software ecosystem for the real time processing of geospatial data streams, along with tools and methods for the assisted curation and exploratory analysis and publishing of large scientific datasets. In MarRISK project, a platform incorporating the semantic interoperability of data from IoT platforms was extended and the extraction of climate change indicators prototyped. The group is engaged with activities in Collaboratory for Geosiences (C4G), and in the respective ESFRI European Plate Observing System (EPOS, Sustainability Phase), where it is assessing the readiness of the Thematic Core Services for Open Science.

Computer Graphics and Virtual Environments (CG&VE)

The area has consolidated its contribution in the Industry 4.0, where the active role in the ILRN research network was key. We designed and developed a virtual reality training tool for an international company, namely the authoring and training tool in an immersive environment. A gamification framework and platform were also developed for the Feedback project (H2020), to achieve energy savings by promoting behaviour change. Project PAINTER has been exploring how cooperative work can be done in mixed reality environments aiming the development of a new tool for several application areas. A LITHME Cost Action was initiated to research how, in the near future, senses will be thoroughly augmented by wearable devices that will intermediate what we see, hear and speak in real time.

6.10.3 Innovation outcomes in 2020

Public Administration

The focus was on the application of the OGC standards for decision support in climate change adaptations for viticulture, and on the Digital Twin concept applied to port management and its need for a robust geospatial infrastructure. CSIG team participated in the organisation of an online workshop regarding the challenges to decision-making in vitiviniculture to the face of climate change.

Mobility and Transport

Emerging application area aiming at applying the Centre's know-how and experience to specific problems in Mobility as a Service (MaaS), Open Data Platforms for Transportation Services, Single-mode Transport Information Systems, Transport Decarbonisation and Connected and Autonomous Vehicles (CAVs).

Platforms and Methods for Personalized Health Research

Digital Framework for E-health Research (DIFFER), resulting from previous European Health Research projects, was formally constituted as a consortium between INESC TEC and the Vrije Universiteit Amsterdam. Moodbuster Science, an adaptive health research platform for healthcare interventions is currently used as a digital "test tube" for mental health interventions in the scope of several national and international research projects.

6.10.4 Activity Overview

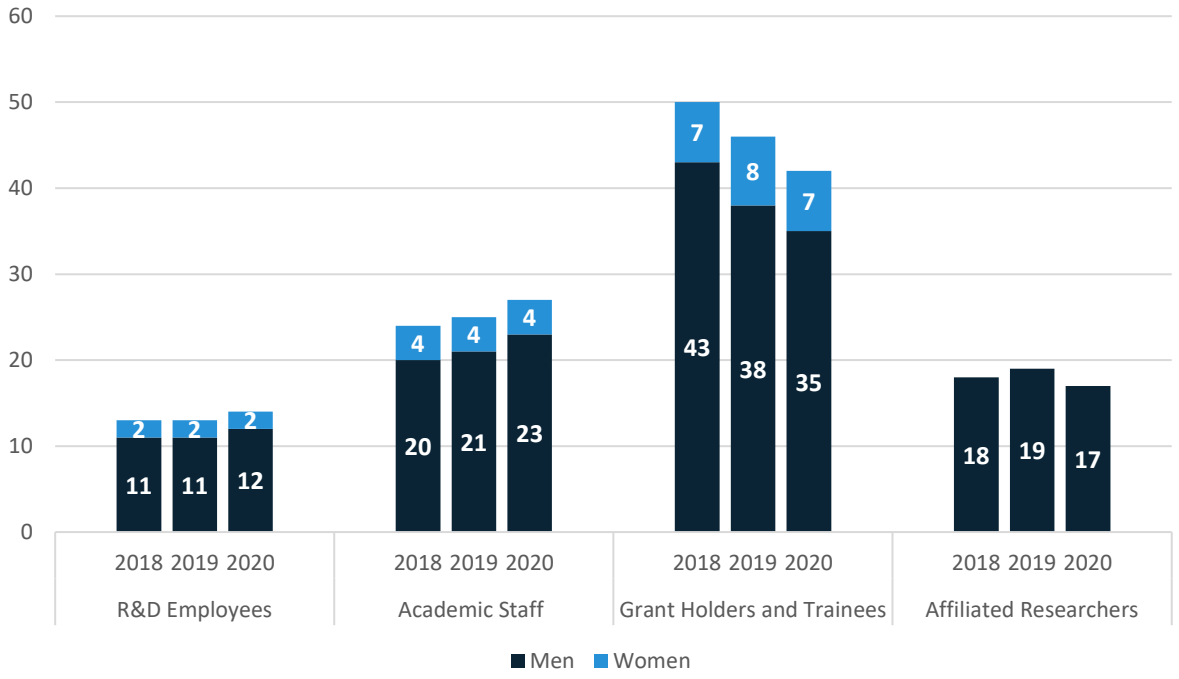


Figure 6.10.1 - CSIG - Research team evolution

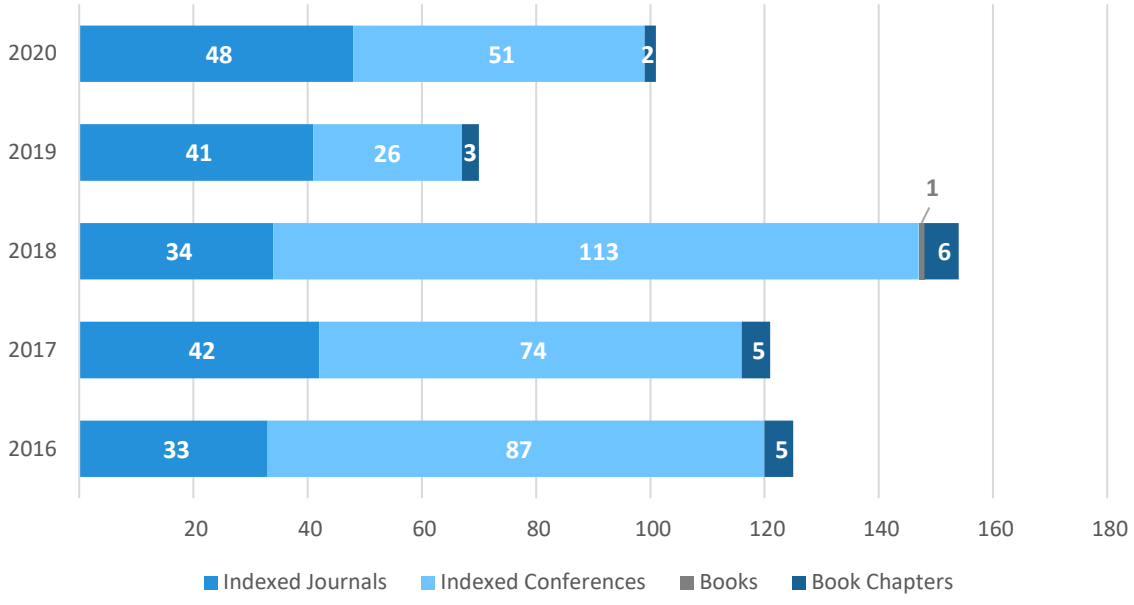


Figure 6.10.2 - CSIG - Evolution of publications by members of the Centre

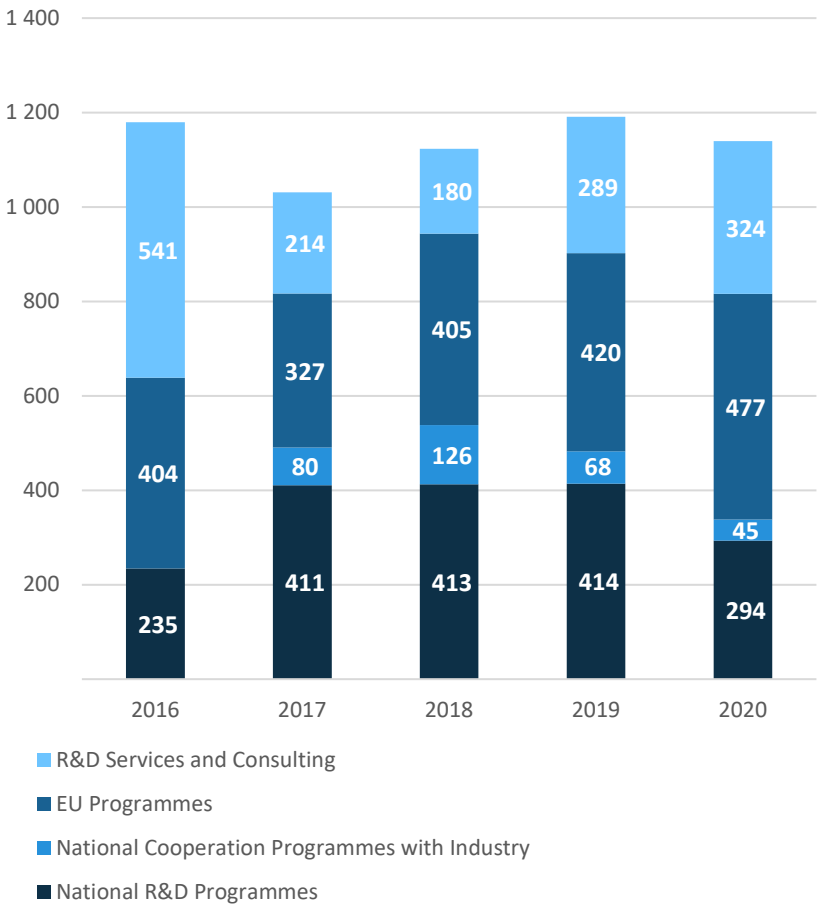


Figure 6.10.3 - CSIG - Project funding evolution (k€)

6.11 LIAAD – ARTIFICIAL INTELLIGENCE AND DECISION SUPPORT LABORATORY

Coordinator: Alípio Jorge

6.11.1 Presentation of the Centre

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

LIAAD aims to produce high quality cutting-edge research in the international forefront of our research areas and promoting transfer of knowledge and technology. This Centre has been working in the area of Machine Learning and Data Science since 1991. 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 and e-government, motivating our investment in different approaches to modeling. Currently, the growing awareness of the impact of Artificial Intelligence (and in particular of Machine Learning) in our lives demands a finer attention to bringing the human to the AI loop. 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, offering diverse modeling and methodological solutions, as well as bringing more transparency and meaning to Artificial Intelligence.

The scientific foundations of LIAAD are machine learning, statistics, optimisation and mathematics. By the end of 2020, LIAAD had a total of 132 members, with 33 core researchers and 25 grant holders and trainees. 24 of the researchers were Academic staff mostly from the University of Porto.

6.11.2 Research outcomes in 2020

The most active area of research is Machine Learning (ML), which includes the lines of **Large Scale ML**, **Auto ML** and **User Modeling and Natural Language Processing**. These lines accounted for 29 of the 53 journal papers published. Other strong areas are **Modeling and Optimisation** (12 papers) and **Mathematical Modeling** (5 papers).

The European **Network of Excellence on Artificial Intelligence** has started in 2020, following the H2020 flagship **Project HumanEAI**. LIAAD is involved and leads micro-projects on semantic recommendation, AutoML and causal reasoning among other AI areas.

The research on Narrative Extraction brings together a team of researchers on **Natural Language Processing** with publications at ECIR and EMNLP. We organised Text2Story2020, a workshop with 70 online participants and AI4Narratives at IJCAI. In **User Modeling**, we lead the organisation of the ORSUM workshop at RecSys (Online Recommender Systems and User Modeling) and launched a special issue with the UMUAI journal. Nuno Moniz and Arian Pasquali were the **WSA global Award winner** in the "GOVERNMENT & CITIZEN ENGAGEMENT" with the app Meuparlamento.pt which had won the Arquivo.pt 2019 prize.

In **Large Scale ML** LIAAD organised new editions of the Data Streams track at ACM SAC 2020, the IoT Stream for Predictive Maintenance workshop at ECMLPKDD 2020 and the SoGood workshop (data mining for **social good**), also at ECML/PKDD. João Gama, João Mendes Moreira and former member Luís Moreira Matias received the announcement of "The George N. Saridis **Best Transactions Paper Award for Outstanding Research**" from 2016. We started the organisation of DSAA 2021, a conference on Data Science and Advanced Analytics. We started our participation in the CMU-Portugal project AIDA on edge AI and **federated machine learning**. The project H2020 ChistEra project XPdM on **Explainable Predictive Maintenance** started.

The line of **Mathematical modeling** kept the good level of activity with an ongoing FCT project and several journal publications.

The line of **Modeling and Optimisation** also has an ongoing FCT project (FAST-Manufacturing) and contributed with 12 journal publications.

In **Complex Data Analysis/Machine Learning**, the **European project** Fin-Tech pursued in taking Data Analysis and Machine Learning to the financial regulators (CMVM in Portugal).

The main achievements in 2020 were:

- Participation in one of the 4 European Excellence Networks on AI (ICT-48);
- Organisation of international events increasing networking;
- Publications and special issues in top journals and conferences;
- Participation in the board of scientific societies;
- Interaction with the scientific community through the dissemination of demos, software packages, datasets and other resources.

6.11.3 Innovation outcomes in 2020

Our activity in knowledge transfer projects has increased in the area of Machine Learning.

- We have used anomaly detection methods in one international investment bank (Natixis);
- We pursued with the dissemination of machine learning and statistics with a course for the Portuguese financial regulator CMVM;
- We are developing models for credit scoring in micro finance, based on network features, for a Portuguese company (Pelican) acting in the African market;
- We applied AutoML and metalearning research in a project with Outsystems, who develops a low-code platform;
- Natural Language Processing is being used at IPO, an oncological hospital, to make the vast amounts of text in digital health records easily available to doctors and nurses;
- With Centro Hospitalar do Porto we are exploiting genealogical data for the prediction of the age-of-onset for the familial amyloidotic polyneuropathy (*doença dos pezinhos*);
- We concluded a project with RandTech on the generation of software tests from user activity using data mining techniques;
- The Yake! keyword extractor has been adopted by a large community of users. In particular it has been reimplemented by SparkNLP and distributed with their package;
- We have applied predictive analytics to project management with the StrongStep company;
- A project on AI for Public Administration continued to develop a solution for predictive maintenance to be applied at Metro do Porto.

6.11.4 Activity Overview

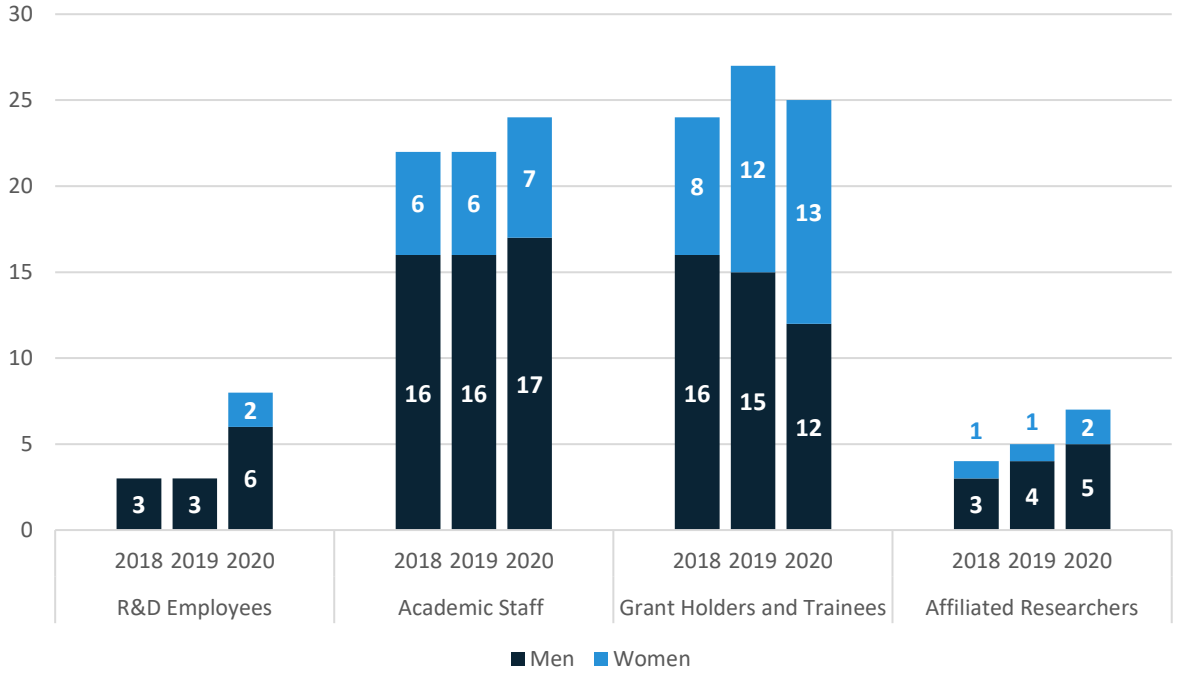


Figure 6.11.1 - LIAAD - Research team evolution

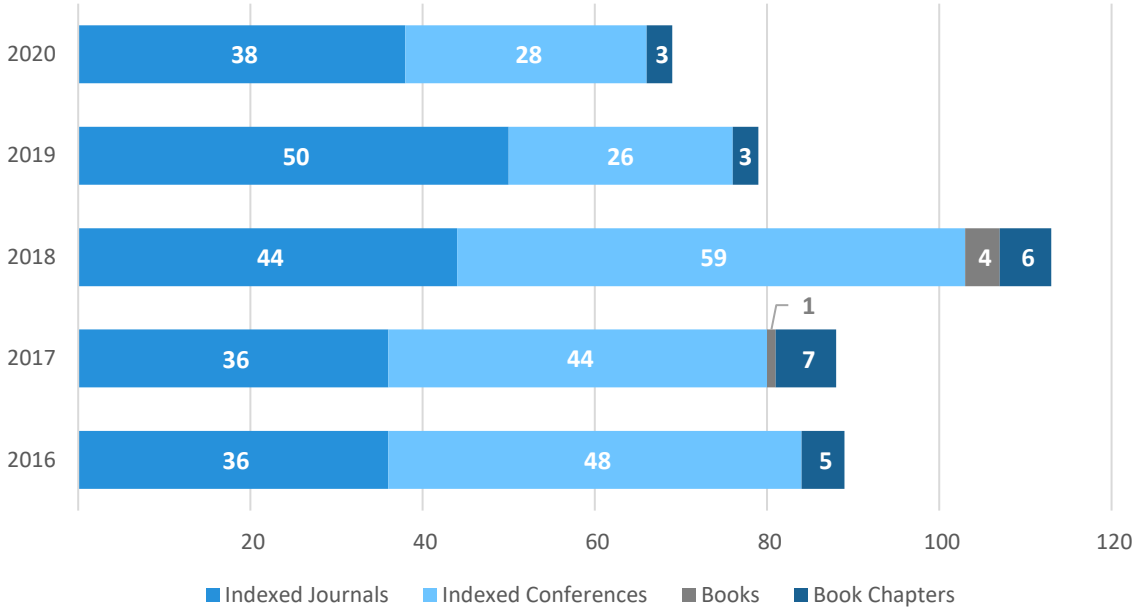


Figure 6.11.2 - LIAAD - Evolution of publications by members of the Centre

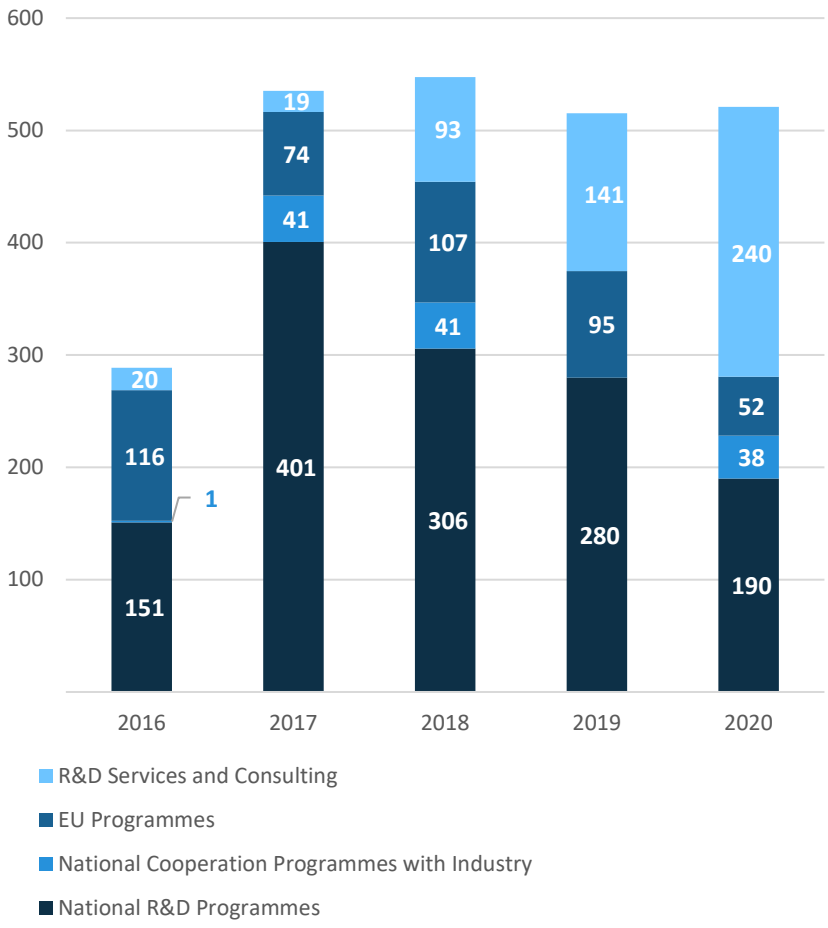


Figure 6.11.3 - LIAAD - Project funding evolution (k€)

6.12 CRACS – CENTRE FOR RESEARCH IN ADVANCED COMPUTING SYSTEMS

Coordinators: Luís Antunes and Ricardo Rocha

6.12.1 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. The core research team is composed mainly of faculty members at the CS department at FCUP. The research environment is enriched with talented junior researchers that together with senior researchers build the necessary critical mass and scientific competences to fulfil our mission. After a significant reduction in the number of researchers occurred last year, this year the number stabilised, from 52 in 2018 to 37 in 2019 and 34 core researchers in 2020, and, in particular, two new PhD members joined the Centre for a total of 19 PhD core members.

6.12.2 Research outcomes in 2020

A key goal for 2020 was to maintain/improve CRACS's international visibility, notoriety and publication output. In fact, there was a significant increase in the number of international events organised by CRACS members, from 2 in 2019 to 7 in 2020, in the number of participations in program committees of international events, from 32 in 2019 to 43 in 2020, and in the total number of publications in indexed journals and indexed conferences, from 45 in 2019 to 48 in 2020. CRACS members were also involved in the organisation of the first Summer School on Machine Learning and Big Data with Quantum Computing that, due to COVID-19, had to be moved to a fully virtual event, which in turn allowed to motivate a worldwide registration for the event with around 2.000 participants following the online sessions. We also aimed to be successful in new projects, preferentially European, in order to increase our funding level, which had decreased significantly in the last two years, but this has not been achieved.

In what follows, we summarise the main research achievements in 2020:

- Lock-freedom: novel lock-free compression design for a lock-free trie-based hash map that reduces the depth of the internal hash levels. The new design minimises cache misses and increases the overall throughput of the default search, insert and remove operations;
- Computational complexity: (i) established the NP-hardness of the task of finding the smallest possible circuit for a given multi-output Boolean function; (ii) showed lower-bounds against semi-adaptive data structures for several variants of Patrascu's problem;
- Event processing: new polymorphic record calculus with flexible records that extends Ohori's original record calculus based on kind restriction, with additional powerful operations on records such as field addition and removal;
- Graph mining: (i) a novel and efficient online algorithm for subgraph counting in streaming networks; (ii) contributions towards a general combinatorial speedup of subgraph counting; (iii) a novel ranking methodology for ranking scientific authors incorporating the effect of reciprocated citations;
- Fake news detection: (i) novel process to identify bots; (ii) creation of a model to balance the need for information regarding volume and time;
- Digital forensic analysis: development of ML models for tampered videos and photos, external modules for the widely used and open-source Autopsy tool, application to fake news detection, spread of hate speech, and detection of digital kidnap and ransomware activities;
- Trust, privacy and security: (i) novel solution that extends current anti-cheat solutions through Intel SGX by moving the core cheat detection engine to a secure enclave provided by SGX while making use of a kernel module for the necessary primitives for system-wide protection; (ii) middleware layer solution for IoT devices that allows control of the data generated by the device to the owner, which can behave as its own data intermediary for potential consumers by monitoring, controlling, and negotiating the usage of their data;

- Property-based testing of Ethereum contracts: development of a property-based testing (PBT) framework for assessing the correctness of smart contracts in the Ethereum blockchain that instantiate the ERC-20 and ERC-721 token standards used for the representation of fungible and non-fungible tokens;
- SafeCities: (i) continued development of a system for indoor positioning that uses the capabilities of mobile devices, namely WiFi and Bluetooth receivers/transmitters coupled to an infrastructure of Bluetooth beacons, to pinpoint the position of users using triangulation and observed signal intensity. Work focused on the implementation of the system back office and on the capability to support third-party multimedia/game components created with platforms such Metaverse. An application scenario would be to run museum related school projects on mobile devices during visits. Another research direction is exploring the capabilities of computer vision techniques to allow the mobile device's camera to grab short videos during a visit that are then feed to TFLite model to infer the device's current location. We are currently working towards fusing these two approaches to create a, hopefully more flexible and robust, hybrid indoor location system; (ii) continued development of crowd-sourcing applications that take advantage of convolutional neural networks to allow users to photograph animals, plants and fungi and get immediate feedback on their genus or species. Besides the Portuguese flora and Portuguese diurnal butterflies, we are expanding our data sets with other sensitive taxa, namely, dragonflies and damselflies (Odonata) and moths (Lepidoptera/Heterocera); (iii) continued development of a modular and extensible platform for mobile devices, cloudlets, and clouds that can manage computational tasks spawned by devices and make informed decisions about offloading to neighbouring devices, cloudlets, or traditional clouds. In particular, we introduced the possibility of using soft real-time tasks and off-loading algorithms that take the deadlines into account, as well as execution time and local and total energy consumption;
- Logtalk: improved compilation of legacy Prolog code, improved meta-calls and lambdas performance, improved QuickCheck implementation, improved make tool, new suite of benchmark programs, added support for Ciao Prolog, LVM, Tau Prolog, and Trealla Prolog besides portability updates and fixes for most of the supported backend Prolog compilers. Logtalk has around 500 downloads per month.

6.12.3 Innovation outcomes in 2020

For the third consecutive year, CRACS shows increasing IP protection, exploitation and technology transfer outputs, namely 3 patent applications in 2020 (compared to 1 in 2019 and 2018 and none in 2017 and 2016).

Other important innovation outcomes were:

- SafeCities (with BOSCH): several proof-of-concept prototypes for: environmental monitoring tools for biodiversity in cities; software frameworks supporting crowd-sourcing applications with offloading options to cloudlets and cloud-infrastructure; Lepilens (iOS + Web / open-source); Floralens; Jay (open-source).
- Câmara Municipal de Gaia (Parque Biológico de Gaia): continued development and support for a citizen science platform, named STOP Cortaderia (web/mobile apps and database), for monitoring the spread and control of the invasive species Cortaderia selloana.
- Museu de História Natural e da Ciência da Universidade do Porto (Galeria da Biodiversidade): an indoor positioning system and a museum app that allows for an improved visiting experience (contents dynamically adjusted to age, learned and expressed interests, augmented reality and gamification). Indoor location with Bluetooth beacons (Android app, Web, back office) and through computer vision (Android app, TFLite models), and integrated support for third-party components (Multiverse and others).
- Automated assessment (Erasmus+ project): an interoperability specification and authoring system for gamified exercises. The target group is programming instructors and students learning programming. The main results have been: gamification scheme for programming exercises; data exchange format for gamified programming exercises; tools supporting editing and conversion of programming exercises; programming courses featuring gamified exercises; programming learning environment featuring

gamified exercises. The source code of all the specifications and tools made within the scope of the project is available at https://github.com/FGPE-Erasmus;

- INOSS platform (Efacec): design of a cloud solution for the INOSS integrated platform, design and evaluation of support mechanisms for data analysis of the data generated by the platform, and security evaluation of the proposal.

6.12.4 Activity Overview

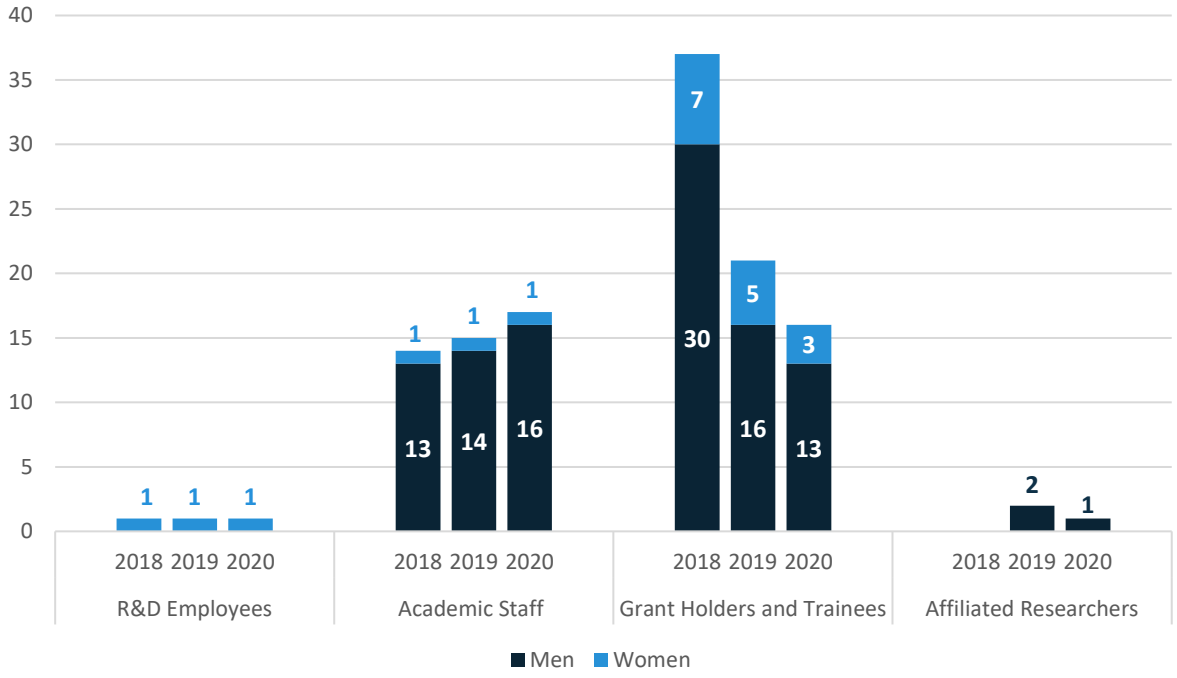


Figure 6.12.1 - CRACS - Research team evolution

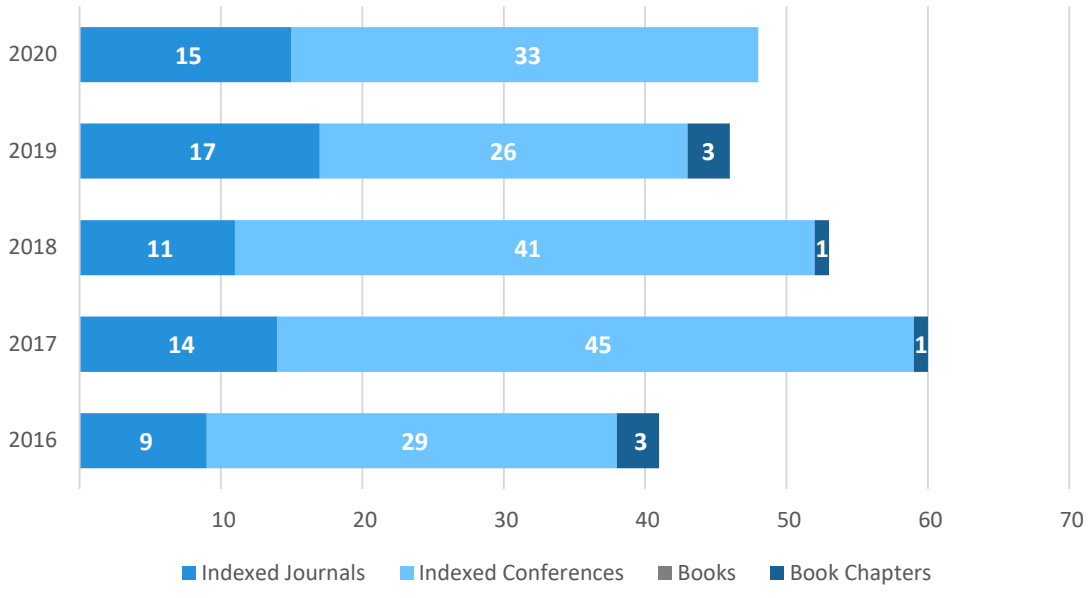


Figure 6.12.2 – CRACS - Evolution of publications by members of the Centre

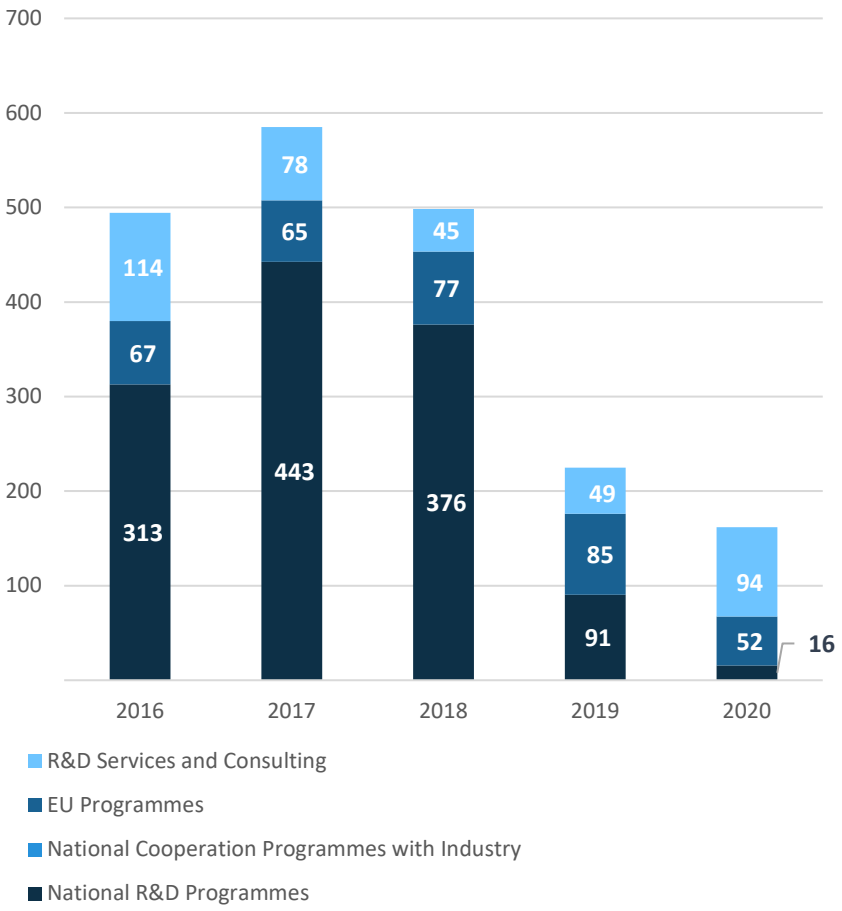


Figure 6.12.3 - CRACS - Project funding evolution (k€)

6.13 HASLAB – HIGH-ASSURANCE SOFTWARE LABORATORY

Coordinators: Alcino Cunha and António Luís Sousa

6.13.1 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.

6.13.2 Research Outcomes in 2020

Two of the main research goals for 2020 were to increase the publication outcome, namely in high profile venues and to increase the research funding dedicated to lower level TRLs.

Concerning the former, the Centre indeed increased the number of articles and papers published in top-rated journals and conferences, namely published 2 papers at a CORE A* conference, and 5 papers at Q1 journals.

Among these, we highlight a paper published in the scientific journal ACM Computing Surveys, one of the journals with the greatest impact factor in the field of Computer Science, entitled “A Survey and Classification of Software-Defined Storage Systems”, co-written by researchers Ricardo Macedo, João Paulo and José Pereira. This article presents different approaches to the Software-Defined Storage paradigm, whose goal is to improve end-to-end control and functionality of large-scale infrastructures, such as the cloud and supercomputers, as well as ensuring different levels of performance for users.

Another highlight was the paper “GenoDedup: Similarity-Based Deduplication and Delta-Encoding for Genome Sequencing Data”, co-authored by João Paulo, presenting a new data deduplication solution that enables the storage and access to human genome information more quickly, and with lower associated storage costs. This article was published in the scientific journal IEEE Transactions on Computers, one of the most relevant journals in the field of Computer Science.

Finally we also highlight the paper “The Last Mile: High-Assurance and High-Speed Cryptographic Implementations”, co-authored by José Almeida, Manuel Barbosa, and Tiago Oliveira, and presented at IEEE Symposium on Security and Privacy 2020, that describes another outcome of the internationally recognised research being conducted by the Centre on the topic of Cryptography and Information Security.

Regarding the second goal, the Centre has started two new research projects: BigHPC and AIDA, within the scope of the initiative “Go Portugal – Global Science and Technology Partnerships Portugal”.

The BigHPC project - *The Management Framework for Consolidated Big Data and High-Performance Computing*, started in April 2020 and aims to create an integrated platform that favors the efficient and low-cost management of advanced computing centres, particularly concerning parallel and Big Data applications. This project is coordinated by Wavecom, in partnership with INESC TEC, the Laboratory of Instrumentation and Experimental Particle Physics (LIP), the MACC, the University of Texas at Austin (UT Austin) and the TACC.

The AIDA project - *Adaptive, Intelligent and Distributed Assurance Platform*, that started in May 2020, aims to improve the RAID platform, a system marketed by the telecommunications analyst Mobileum for the comprehensive risk management in companies, thus making it compatible with 5G networks and edge computing. The project’s promoter is Mobileum, with INESC TEC, the University of Coimbra and the Carnegie Mellon University as partners.

Three distinctions are also worth mentioning. Luís Soares Barbosa was nominated Chair of the IFIP Technical Committee 1 - Foundations of Computer Science. The International Federation for Information Processing (IFIP) Technical Committee 1 is an international committee that aims at the development of the theory and computer

science and of its bridges with other domains of knowledge and socially relevant applications. José Creissac Campos was elected chair of the EICS Steering Committee. The ACM SIGCHI Engineering Interactive Computing Systems (EICS) conference is one of the most relevant international conferences devoted to all aspects of engineering usable and effective interactive computing systems. Rui Oliveira was appointed chair of the IEEE Symposium on Reliable Distributed Systems, one of the most relevant and long-standing conferences devoted to distributed systems.

6.13.3 Innovation outcomes in 2020

In terms of innovation 2020 was marked by several initiatives to help fight against the COVID-19 pandemic, in which several members of HASLab have participated.

The “Measuring the Iceberg” study aims to develop an open social media survey in order to estimate the number of confirmed cases with COVID-19 symptoms and monitor their evolution in eleven countries. In addition to providing the total number of symptomatic infected people per day, the study helps researchers observe the evolution of the disease. Everyone can access the survey, available online, in 60 different languages. This international study began in early March, and it has been implemented in several countries, namely Spain, Portugal, Argentina, Chile, Cyprus, France, Germany, Greece, Italy, Japan, the United Kingdom, and the United States. This study was one of the five finalists of the international competition COVID-19 Symptom Data Challenge and received an honourable mention and $3,000 in AWS credit in the XPRIZE Pandemic Response Challenge.

The STAYAWAY COVID app is other initiative where HASLab team had an active participation. STAYAWAY COVID is a system that, thanks to the voluntary participation of the population, will support the country in the screening of COVID-19. The respective app can be installed on mobile phones and used to detect the physical proximity between smartphones, in order to inform users who have been in the same space as someone infected with the new coronavirus over the previous 14 days. Thanks to this information, users can promptly request a diagnosis for the infection, even before the occurrence of any symptoms. The mobile application is available for iOS and Android.

The Psicovida app aims to provide free psychological support during the pandemic. The main goal is to support the community by ensuring equitable and free access to psychological crisis intervention in the current pandemic context. It is a mobile application that allows users to speak directly with qualified psychologists, through video calls, while providing several self-help strategies. The app is free and can be downloaded for Android and iOS.

These two mobile applications received an honourable mention in the category "Application of the year", of the “Os Melhores do Portugal Tecnológico” awards, granted by Exame Informática magazine.

Concerning the goal of moving from prototype-level high-assurance software development tools to production-level open-source tools with a significant user-base, 2020 saw a big step up in promoting the techniques and tools being developed in the Centre. In particular, the board managing the Alloy language, a highly popular language and tool for formal software design, decided to integrate Electrum (http://haslab.github.io/Electrum/), an Alloy extension being developed in the Centre, as the next official release of the language, Alloy 6.

6.13.4 Activity Overview

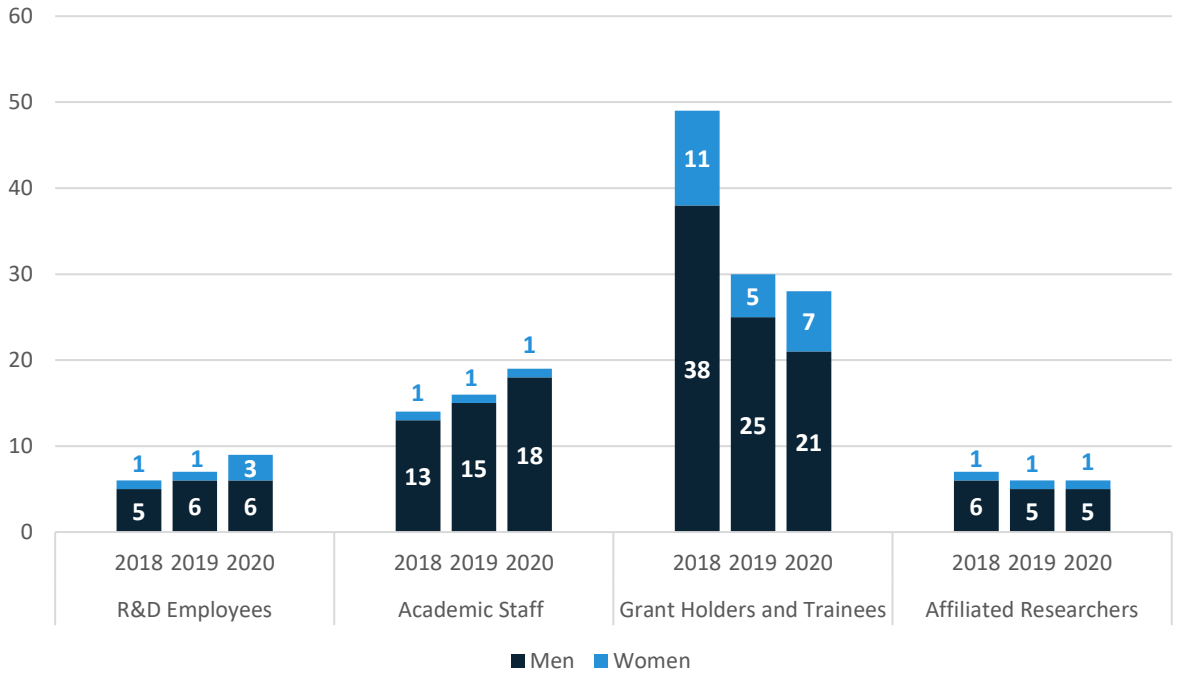


Figure 6.13.1 - HASLab - Research team evolution

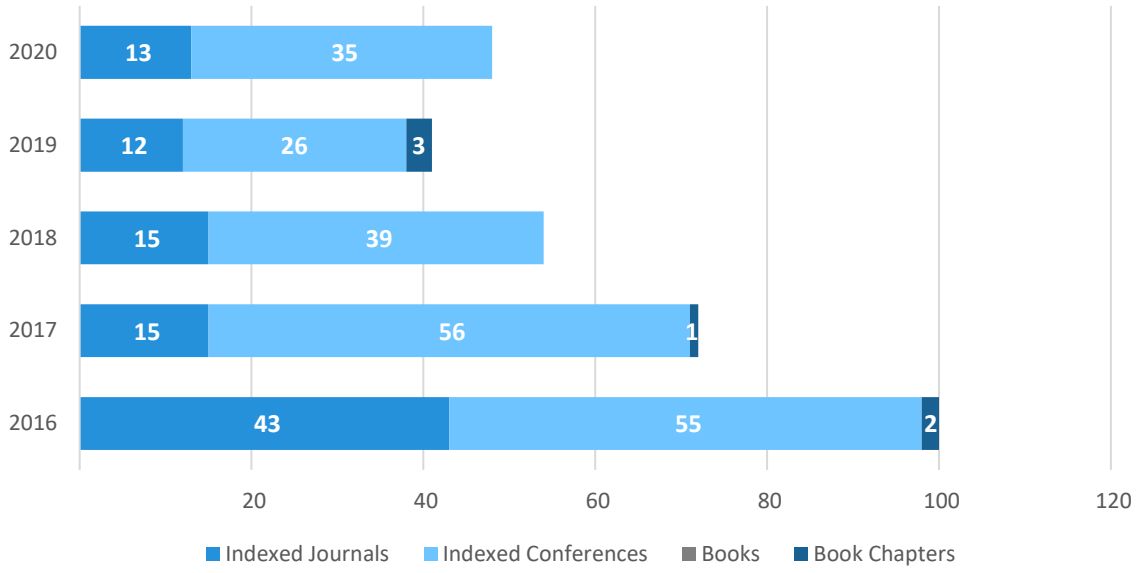


Figure 6.13.2 - HASLab - Evolution of publications by members of the Centre

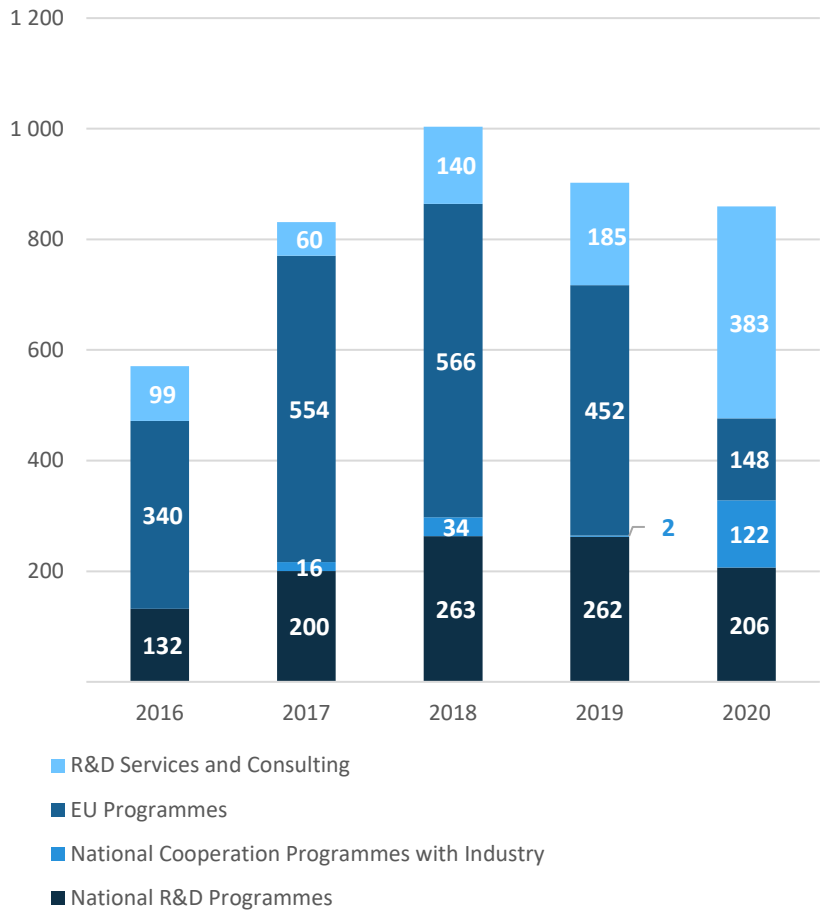


Figure 6.13.3 - HASLab - Project funding evolution (k€)

7 RESEARCH INFRASTRUCTURES

7.1 TEChnologies for the Sea (TEC4Sea)

7.1.1 Mission and positioning

The TEChnology for Sea infrastructure (TEC4Sea; www.tec4sea.com), currently under implementation, is a platform designed to support multidisciplinary research, development, and test of marine robotics, telecommunications, and sensing technologies for operation in oceanic environments. It is open to both the R&D community and the industrial sector, thus providing the equipment, expertise, and logistics needed to support those communities in developing, evaluating, and validating technological solutions designed for maritime environments, thus fostering and advancing the blue economy.

TEC4Sea has three main objectives: supporting the R&D community, supporting the industrial sector, and pushing the technological envelope in developing technology for maritime environments, by making available facilities, resources, and know-how to economic agents and researchers.

TEC4Sea is a vertically integrated infrastructure; its expertise and resources range from pure conceptual research to field deployment missions, with strong industrial and logistic competences in prototype production and an eclectic set of laboratories, testbeds, equipment, and support facilities for experiments in controlled and real environments. It can thus support researchers in all phases of technology development, from conception and theoretical analysis to prototype development, field deployment, and technology validation.

Its geographic location (allowing fast access to deep sea), multidisciplinary nature, and vertically integrated structure are vital assets in supporting the development, evaluation, and validation of technological solutions designed for the ocean environment, allowing researchers to evolve from simulation/lab experiment to deployment and field trials. Its focus on ocean technology development–not on the ocean itself–and structural characteristics define it as a unique research infrastructure in Europe.

TEC4Sea has poles in Porto and Faro, two major coastal cities in Portugal. Its implementation phase is coordinated by Paulo Mónica as Principal Investigator. The implementation management team also includes Eduardo Silva, António Silva, Aníbal Matos, José Almeida, Olivier Pellegrin, Carlos Pinho, Diana Viegas, Luís Pessoa, Bruno Ferreira, Maria Graça Barbosa, and Marta Barbas.

7.1.2 Main achievements in 2020

During 2020, the implementation works have proceeded as planned in general terms, albeit with the need for some timing readjustments, and the need to implement some risk mitigation measures. With many of the smaller investments already finished by the end of 2019, the major activity during 2020 was the follow-up of the large vessel construction.

During 2020, the negotiation process with the Administração dos Portos do Douro, Leixões e Viana do Castelo leading to the creation of support facilities in the Leixões harbor resulted in the identification of a location to install facilities. A tender for the acquisition of relocatable facilities (laboratory and workshop) was launched. The update of back-office labs (Sensors, Telecommunications, and Ocean Engineering) is now almost complete. The capability of performing operations and collecting data in the underwater environment also witnessed large developments with the acquisition of sensors, underwater acoustic communications equipment as well as the preparation of the tender for the acquisition of the underwater relocatable landers.

It should also be mentioned that while still in its implementation phase, the existence of the TEC4Sea infrastructure is already constituting an important factor in attracting new international projects, financing sources, and research partners. Additionally, during this year, we have seen a growth in the number of entities potentially interested in adhering to the infrastructure, which indicates that a healthy and diverse ecosystem will certainly appear around this infrastructure, from which many synergies and technological advances should be expected.

7.2 European Multidisciplinary Seafloor Observatory – Portugal (EMSO-PT)

7.2.1 Mission and positioning

EMSO-PT is a research infrastructure led 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.

INESC TEC core research team associated with this infrastructure includes Eduardo Silva, Aníbal Matos, José Almeida, Alfredo Martins, Hugo Ferreira, and Nuno Abreu.

7.2.2 Main achievements in 2020

The main achievements of EMSO-PT during 2020 were:

- Assembly of an EGIM (EMSO Generic Instrumentation Module) according to the specification developed within the scope of the H2020 EMSODEV project. This module is composed by a set of different sensors for oceanographic data collection. The ultimate goal is its integration in a Turtle lander to make part of the North Portugal EMSO-PT node;
- Finalisation of the upgrade of a Slocum glider. The glider is now equipped with CTD, dissolved oxygen, and optical backscatter sensors, and also with rechargeable batteries and ready to perform mission up to 1000 m deep;
- Preparation of the public tender for the acquisition of two more gliders.

7.3 Robotics and Autonomous Systems Laboratory

7.3.1 Mission and positioning

The Robotics and Autonomous Systems Laboratory has two physical locations within the ISEP and FEUP campuses. These dedicated facilities support R&D activities, technical training of human resources as well as advanced education programs. In fact, as a research lab in an academic environment it fosters undergraduate research, supports multiple engineering course and academic activities.

The mission of the laboratory is the research of excellence in Autonomous Systems enabling the observation and operations in complex, unstructured and harsh environments. The multiple-purpose robotic operations include data gathering, inspection, mapping, surveillance, and/or intervention. The impact in the economic and social fabric development is also part of the objectives - by contributing to the performance, competitiveness and internationalisation of Portuguese companies and institutions.

The total area of the laboratory exceeds 1000m2. The facilities include two test tanks, the larger one with dimensions 10mx6m and is 5m deep, and a workshop for prototyping. The laboratory infrastructure also includes a large set of robotics platforms (underwater, surface, aerial, and terrestrial), most of them able to operate in real environments, as well as a large number of sensors and auxiliary equipment. Such assets contribute to a great operationallity and have been fundamental for the establishment of partnerships.

7.3.2 Main achievements in 2020

The main achievement of the Robotics and Autonomous Systems Laboratory for 2020 were the following:

- Upgrade of the workshop facilities (added a large size industrial 3D printer, capable of 600mmx600mm600mm printing volumes and high temperature industrial materials; a new electric tapping machine; a spot welding machine; workbenches with wheels and upgrade of the tools sets);
- Upgrade of robotic platforms taking advantage of the ongoing projects:
    - Grifo-X UAV, a multi-rotor UAV with +20kg payload and accurate navigation;
    - IRIS underwater Robot, a robotic underwater system for lost fishing gear recover;
    - MARA and UX1Neo AUV prototypes, robotic underwater systems for confined spaces exploration;
    - SHAD AUV, a man portable AUV for operation in open waters;
    - Small size ASVs for under and above water perception.
- Upgrade of the scientific instruments available with new sensors such as Hyper spectral cameras, LiDARS, Multibeam sonars, thermal cameras, and several underwater sensors;
- Training of technicians to operate facilities and provide support to field operations.

7.4 Laboratory of Microfabrication

7.4.1 Mission and positioning

The Microfabrication Laboratory explores the femtosecond laser direct writing capabilities to support the activities on integrated optics and optofluidics and also to provide support to other areas of research within CAP and INESCTEC. For example, microfluidics and optofluidics chips are produced to implement biosensors, while first order Bragg gratings and long period gratings are made by laser point-by-point direct writing to implement new sensing heads that will lead to the development of better and more reliable sensing heads.

This lab is complemented with a class 100/1000 cleanroom which was implemented as part of University of Porto (Center of Materials of Porto University – CEMUP) but with strong support of INESC TEC (cleanroom designing, equipments, etc).

The Research activity supported by this lab includes:

- Three-dimensional direct inscription of waveguides and complex integrated optical devices;
- Fabrication of Bragg and long period gratings (first and higher order structures);
- Fabrication of microfluidic devices using FLICE techniques (exposure followed by etching);
- Fabrication of optofluidic devices for sensing applications;
- Micromachining;
- High resolution 3D photopolymerization.

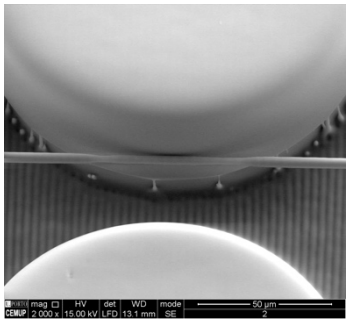
7.4.2 Main achievements in 2020

During 2020, tridimensional structures made by selective photopolymerization was demonstrated and the process calibrated (energy, velocity, polarization, scanning trajectories, etc). Suspended structures as small as 270nm were achieved. Multiple polymeric 3D objects were fabricated such as woodpiles, cubes, spherical lens and prisms.

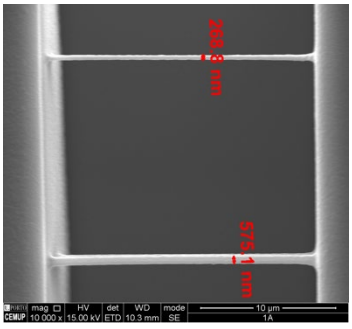
The fabrication of near-surface waveguides is always a challenge due to surface ablation. During 2020 these waveguides were employed in the demonstration of a refractive index sensor based in a Mach-Zehnder configuration, to excite surface plasmons and to excite whispery gallery modes in a bubble resonator.

Also, the fabrication of monolithic devices in silica was demonstrated; while the subject is not new, the structures fabrication elevate the state-of-the-art due the small dimensions, roughness and relative positioning between structures.

Main fabrication set-up for femtosecond laser writing at three wavelengths (342, 515 and 1030nm). The system uses translation and galvanometric scanning, together or independently.



The photograph shows the circular resonator and the suspended waveguide to excite the whispery gallery optical modes within a microfluidic channel. This was completely fabricated in fused silica.



The picture shows a suspended line between two supporting structures, all fabricated by femtosecond multiphoton polymerization in SZ2080.

7.5 Biomedical Imaging Lab

7.5.1 Mission and positioning

The mission of the Biomedical Imaging Lab is to promote scientific knowledge excellence through fundamental and applied research, advanced training and innovation in signal processing, medical image analysis and machine leaning methodologies. These methodologies will be applied to medical and biological signals and images, with the aim of creating computer-aided diagnosis tools to support medical decision making.

The Lab has 5 university professors, 2 post-docs, 11 PhD students and 9 MSc students.

7.5.2 Main achievements in 2020

In 2020, the main achievements of the Biomedical Image Lab were the following:

- The project SCREEN-DR ended in December 2020. In this project, the following achievements deserve a mention:
    - A deep learning model for retinal image quality detection;
    - A deep learning model for detection and referral of Diabetic Retinopathy in retinal images, tested at image level, and at eye level, when characterised by macula and optic disc centred images;
    - A deep learning model for Diabetic Retinopathy grading in retinal images.
- The project CRX-AI4COVID was approved and developed during 2020. In this project we have the following achievements:
    - A dataset containing the manual labels given by two radiologists, including intra- and inter-observer variability, in 1.845 chest X-ray images;
    - A deep learning model for Covid-19 detection in X-ray images.
- A new FCT project was approved for Covid-19 detection using Computer Vision and Point-of-Care Ultrasound imaging;
- The project CAGE was approved in 2020, for Computer Assisted Gastric Cancer Diagnosis;
- The project TAMI started in 2020. The C-BER team gives contribution on the lung pathology classification based on X-ray chest images;
- 13 papers were published in high impact international journals (12 in the first quartile Q1 and 1 in Q2);
- The lab had an important contribution in the first edition of INESC TEC Science and Society Journal, where the Lab researchers made contribution as editor and paper authorship in 3 articles;
- 2 PhD grants were approved in 2020 and 9 other PhD students have been developing their theses in the Lab. 2 of them were preparing the submission, that took place in January 2021;
- A patent was filed (Portuguese and European versions) for the detection of retinal quality, pathology and referability from eye fundus images.

7.6 Smart Grids and Electric Vehicles Laboratory (SGEVL)

7.6.1 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.

Research areas

- Directly associated: DMS/EMS and Network Automation, Industrial Electronics, Static and Dynamic Analysis of Power Systems, X-Energy Management Systems, RES & DER Integration;
- Other areas: Multi-Energy Systems, Energy Analytics and Forecasting.

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 management structure is also responsible for the implementation of specific procedures to grant access by national and international researchers that are external to the infrastructure.

7.6.2 Main achievements in 2020

The main achievements of the RI for 2020 were:

- Pre-certification for functionality and electrical safety (international standards) of the most recent Smart Hybrid Inverters (SHI) and Smart Electric Vehicle Supply Equipment (SEVSE), developed within the InteGrid project;
- European patent application with No. EP20161436 and title “Power Converter” invented by João Cunha Ramos, PhD student and researcher at SGEVL, in the area of power electronics;
- Four new invention declarations submitted by João Cunha Ramos, under designations SGEVL Back-Office Kernel and UniGUI, Modbus Gateway over TCP/UDP/WebSocket, Grid-forming control algorithms and Single-stage power converter (for AC-AC, DC-DC or AC-DC) with resource to an integrated high-frequency transformer;
- Implementation of test setup and customised acquisition infrastructure for EV charging load disaggregation, as part of contract with *Eneida* (Grid2C project). Execution of the two first measurement campaigns;
- Conclusion of the acquisition of the 100 kVA power-hardware-in-the-loop (PHIL) amplifier. Implementation of the hardware and software modification to OPAL-RT to interface with new amplifier;
- Implementation of an hardware and software solution to make the EVSE compatible with ISO 15118 standard for vehicle-to-grid communication interface for bi-directional charging/discharging of electric vehicles (ongoing);
- Design and implementation of the electrical interfaces and liquid cooling system to accommodate the installation of the amplifier;
- Release of the brand new SGEVL website: https://sgevlab.inesctec.pt/;
- Installation of the HEMS, SHI and SEVSE solutions from the InteGrid project in the demonstrator (*Valverde* and *Alcochete*). Monitoring, analysis and continuous improvement of the solutions.

7.7 iiLAB - Computer Graphics and Virtual Environments Lab

7.7.1 Mission and positioning

To disclose the state-of-the-art in advanced production technologies through the demonstration of research, experimentation and advanced training results. iiLab supports technology-based innovation in public and private organisations, thus contributing to the development of their skills in the development, adoption and implementation of advanced production technologies, leading to a sustainable competitiveness in the circular economy context.

- Demonstration of concepts and advanced technologies in the areas of robotics, automation, industrial cyber-physical systems (Internet of things) in the form of a show-room.
- Dissemination of INESC TEC's expertise for the industry and the community in general.
- Experimentation and prototyping space for technological companies.
- Tailor-made training for senior managers and senior executives of industrial companies.

7.7.2 Main achievements in 2020

- Approval of the project "Ampliação da Infraestrutura Tecnológica do INESC TEC para a Transformação Digital da Indústria (iiLab)", reference NORTE-01-0246-FEDER-000059, submitted to the call NORTE-46-2019-18, designation "INFRAESTRUTURAS TECNOLÓGICAS (IT) DA REGIÃO NORTE: CENTROS INTERFACE", program "Programa Operacional Regional do Norte, Investigação, desenvolvimento tecnológico e inovação", objective "Reforçar a investigação, o desenvolvimento tecnológico e a inovação";
- Agreement with the P. Porto to rent new installations for the laboratory at the PORTIC- Porto Research, Technology & Innovation Centre;
- Training courses and sessions:
    - Immersive Reality in the Context of Industry 4.0: Impact on People and Organisation (January);
    - Advanced Program in Industry 4.0;
    - Webinar | Smart Manufacturing driven by digital technologies;
    - Webinar |Digital Transformation of Learning;
    - Advanced Program in Industry 4.0;
    - Webinar | Digital Transformation of Learning;
    - Projeto FEUP (reception of students from FEUP to demonstrate new innovative technologies and perform INESC TEC iilab and project dissemination to the academic area);
    - Mobile Robotics LabMeeting (in order to share the results, progress and the challenges of the Centre in this research area).
- Project demonstration actions:
    - FASTEN final project demonstration to industrial partners (webinar with live cameras to iiLAB);
    - SCALABLE4.0: Final Project EU Review Meeting and demonstration to industrial partners (webinar with live cameras to iiLAB).
- Visits to iiLab
    - During the training sessions with professionals from the following companies: Sonae Capital, Sonae Arauco, Azevedos Industria, Amorim, VW Autoeuropa, AC Relvas and ADIRA. Additionally, a group of master students from Master in Management from University Portucalense also visit the iilab to be aware of the technologies developed by INESC TEC in the context of the industry;

- Also Toyota Caetano Portugal, Fluidotronica, Colep Portugal, CENFIM, Adira, Efeacec, OLI, Grupo Casais, Simoldes, PRODUTECH. Furthermore, individual visits were also promoted with the objective to present new technologies with particular interest for the companies/institutions. Some examples are: Rui Azevedo, Gislotica, FFonseca, Deltamatic, FLUPOL, DCSI, Controlar, ISQ, Center for Computer Graphics (CCG), School of Education (ESE), School of Health (ESS), TU Delft, LSM/University of Patras, among others. Academic visits with students from FEUP, Portucalense and Coventry University were also organised to present and disseminate our innovative technologies.

- Project Demonstrators
  - Preparation of pilots in the Scalable and FASTEN projects;
  - The pilot "Internal Logistics 4.0" was installed in the scope of the Produtech national project, but no demonstration was made;
  - FCT RADAR: Autonomous Robot for Surface Disinfection at Health Care Facilities - The pilot "RADAR" was installed in the scope of the FCT - Foundation of Science and Technology project and the final demonstration took place in Hospital São Martinho, at Valongo. Afterward, a partnership between CRIIS and DCSI culminated in the system commercialisation by the latter;
  - H2020 FASTEN: Mobile Manipulator for Pick & Place;
  - Digital Twin Demonstration, for intralogistics activities in the industry;
  - PRODUTECH SIF - Programming By Demonstration of Industrial;
  - Manipulators using a 6D Marker and an IMU. Demonstration performed in the context of an industrial spray coating application;
  - H2020 ScalABLE 4.0 - Agile Mobile Manipulator demonstration applied for the assembly of a car engine block based on force control;
  - H2020 ScalABLE 4.0 - Collaborative Robotic Systems and Digital Twin for Flexible Production Systems | Multi-Product Production Line Scenarios;
  - MANUFACTUR 4.0 - Mobile Manipulator for Machine Tending Operations;
  - MANUFACTUR 4.0 - Laser-Based Projection Mapping system for supporting operators on marking and cutting metal structures in the naval and metalworking Industry;
  - MirrorLabs - AR/VR-based human-robot co-production system.
- Applications that were boosted by the existence of the laboratory and which were approved:
  - FCT Radar: Development of an Autonomous Robot for Surface Disinfection, based on UV light, at Health Care Facilities;
  - P2020 PRODUTECH4S&C: Soluções inovadoras, sustentáveis e circulares com impacto na fileira das tecnologias de produção;
  - P2020 PAC: Portugal Auto Cluster for the Future is a mobilizing project closely aligned with the action plan of the Mobinov Cluster | Automobile Cluster Portugal and aims at the development, testing and demonstration of a new generation of technologies - products and processes - identified as critical for a new positioning of the national automobile cluster in the global value chains of the vehicle of the future;
  - H2020 Experiment SafeCoating: The aim of this proposal is the incorporation of safety features in an existing industrial robotic cell, dedicated to advanced coating application, leading to an enhancement in the cooperation between highly skilled operators and industrial robots, in an especially meticulous operation, conducted on highly customized products of large dimensions and complex geometry;
  - H2020 AIRegio;
  - H2020 BetterFactory;

- H2020 Mari4Yard: Development a new User-centric solutions for a flexible and modular manufacturing in small and medium-sized shipyards;
- MirrorLabs2 – creating similar learning environment for students all over Europe for human-robot coproduction (EIT-Manufacturing 2021);
- Several Direct Contract Projects in the area of industrial robotics (>3).

7.8 Laboratory of Robotics and IoT for Smart Precision Agriculture and Forestry

7.8.1 Mission and positioning

The Laboratory of Robotics and Internet-of-Things (IoT) for Smart Precision Agriculture and Forestry was established in 2013, with the mission of developing robotics, automation, and IoT based solutions, to improve the levels of smart precision ("right time, right amount, right place") agriculture and forestry, profitability, and automation in three main environments: Permanent Crops (such as steep slope vineyards, olive groves, tree fruits), Forest biomass harvesting, Protected Cultivation (conventional and urban).

This laboratory is developing its RTD activities based on a ten-year roadmap, primarily aligned to European reality (societal challenges), European agendas (euRobotics, FCT Research and Innovation Thematic Agenda for Agrofood, Forestry and Biodiversity, strategic approach to EU agricultural research & innovation), FAO's agricultural agenda (Food and Agriculture Driving action across the 2030 Agenda for Sustainable Development), and to the TEC4AGRO-FOOD Innovation Area agenda (TEC4AGRO-FOOD is INESC TEC's Innovation Area for Agro-Food and Forestry).

Research Team: Filipe Neves Santos (PhD), António Paulo Moreira (Prof. PhD), Mário Cunha (Prof. PhD), José Boaventura (Prof. PhD), António Valente (Prof. PhD), Manuel Silva (Prof. PhD), Héber Sobreira (PhD), Tatiana Pinho (PhD), André Bianchi Figueiredo (PhD), Luís Santos (PhD candidate), Pedro Moura (MSc), Sandro Magalhães (PhD candidate), André Aguiar (PhD candidate), Daniel Silva (PhD candidate), Luís Castro (MSc), Vítor Tinoco (MSc), Jorge Pinto (MSc).

Reference Centres: CRIIS (Leader), CAP, CESE, CSIG, HASLAB, LIAAD, CITE.

7.8.2 Main achievements in 2020

In 2020, several international projects were submitted and approved, namely NOVATERRA, SCORPION, PRYSM and AGROBIT. The SCORPION project is a 2.5M€ project with 11 European partners and it is coordinated by INESC TEC. Besides these European projects, other 4 National projects (direct contract and P2020) were approved. These projects are aligned to the Laboratory of Robotics and IoT for Smart Precision Agriculture and Forestry strategy and they represent an income higher than 1.5M€ for the next 3 years period.

16 scientific publications were published in international and indexed peer review journals, 2 patents were submitted, 5 master theses were realized in this laboratory, and hosted 5 PhD works. More than 40 references were made in mass media and in technical magazines.

7.9 Computer Graphics and Virtual Environments Lab

7.9.1 Mission and positioning

The mission of the Computer Graphics and Virtual Environments Lab is to advance multidisciplinary scientific research in the field of Computer Graphics, with particular emphasis on Immersive Environments.

From the fundamental investigation of technologies and algorithms to support digital mediation in virtual environments, to user-centric authoring tools, the laboratory has developed several innovative computational tools. But the focus is also on the study of human perception and augmentation, with a view to improving the processes associated with the application areas of Industry 4.0, Health, Tourism, Culture and Education.

The positioning of the lab is in the following research lines:

- Studies in human augmentation for enhanced performance in professional and personal activities;
- Multisensory virtual environments do provide enhanced presence and immersion;
- Immersive learning environments and authoring tools to enhance training and education;
- Serious Games and Gamification to promote increased motivation and efficacy in cultural heritage, training and behaviour change;
- Immersive 360º video tools to improve communication;
- Extended reality frameworks to deploy the most cost-effective solutions.

Reference Laboratory
Be a reference in the field of multisensory virtual reality, perceptual equivalence, human performance, and technology that creates innovative solutions in a wide set of areas of application.

7.9.2 Main achievements in 2020

- Design and development of a virtual reality training tool for an international company;
- Development of an energy saving gamified application within the Feedback project;
- Framework for the assisted creation and edition of virtual environments to be used collaboratively in Virtual Reality (VR) and Augmented Reality (AR) in project Painter;
- New cost action project “LITHME – Language in the Human-Machine Era”;
- Conclusion of “Project Real time Tracking and displaying multiple objects in extreme lighting conditions”;
- Concluded PhD theses:
    - Hernâni Barros Zão Corga Oliveira, Literacia em saúde: uma proposta de intervenção em rede para o desafio de saúde pública em Portugal, Programa Doutoral em Media Digitais, UP, 2020.
    - Vanessa Quintal Cesário, Enhancing museum experiences for teenagers through gamification and storytelling frameworks, Programa Doutoral em Media Digitais, UP, 2020.
    - Anabela Gonçalves Rodrigues Marto, Multisensory Immersive Contents for Cultural Heritage, Doutoramento em Informática, UTAD, 2020.
- Publications:
    - 12 Journal Papers
    - 7 Conference Papers
    - 2 Book Chapters

7.10 CLOUDinha Laboratory

7.10.1 Mission and positioning

The laboratory acts as a computational support to research and development activities of INESC TEC and UMinho, providing bare metal, virtualisation capabilities, containers and security features such as SGX.

The cluster is composed of several different generations of hardware namely, Sandy Bridge, Ivy Bridge, Haswell and Kaby Lake. It is currently composed of 100 machines based on commodity hardware with Intel Core i3 CPUs, 16GB of memory and 256GB HDD, SDD, NVMe capacity and 10GbE, and it serves the research community with bare metal, virtualisation capabilities, containers, GPUs and SGX security features.

7.10.2 Main achievements in 2020

- Target new application areas in the domains of privacy preserving computation and distributed deep learning;
- Research and development on software defined storage targeting IO fairness on multi-tenant systems;
- Keep supporting the research community in areas where computational resources are required.

8 SPECIAL PROJECTS

8.1 UT AUSTIN PORTUGAL PROGRAM

Coordinators: José Manuel Mendonça and Rui Oliveira

The UT Austin Portugal Program is a partnership between the Portuguese Science and Technology Foundation (FCT) and The University of Texas at Austin (UT Austin).

For over a decade, these two long-standing transatlantic partners have thrived on creating a genuinely collaborative R&D ecosystem that brought together universities, research performing institutions and laboratories, technology transfer offices and companies in Portugal with UT Austin's counterparts. In the third phase of the Partnership, collaborations go beyond Austin to encompass another world-class institution that is part of the University of Texas System: the MD Anderson Cancer Center, based in Houston.

8.1.1 Main Achievements in 2020

Implementing the established Plan amid a world pandemic has proved quite a challenge, but one that has attested for the Program's resilience, adaptiveness, and sense of commitment to its ever more far-reaching community. The COVID-19 crisis has disrupted the way activities and projects were undertaken. The UT Austin Portugal Program has not been immune to this unprecedented situation. Due to its international nature, it has certainly been more exposed to the pandemic's harsh effects than S&T partnerships acting at a local level. Activities contingent on international mobility were the most severely affected. Research exchanges and delegation visits either to Austin or Portugal had to be put off. On-site training, networking and other stakeholders' engagement events called for readjustments, throwing the team into a fast-paced learning process to ensure a seamless transition to hybrid or full-digital settings.

However, the pandemic did not hold the Program back from announcing the 2019 Call for Strategic Research Projects results nor bringing together in a virtual environment a panel of experts to evaluate the 54 exploratory projects deemed eligible, of which eight were awarded public funding. It prevented the Program from launching the 2020 Exploratory Research Call in the final quarter of the year as planned, though.

The Research Component and main supporting actions:

2019 Strategic and Exploratory Research Projects

At the height of Portugal's lockdown, in April 2020, the Partnership announced its support to an elite of three-year-long industry-led consortia focused on delivering innovative science-based solutions to a range of application markets, from health to climate change to automotive and aerospatial or high-performance computing infrastructures. Instead of five projects, eleven high-scored transatlantic consortia were selected for funding thanks to an increase in the public budget on the Portuguese side. In the face of unexpected challenges, the Program demonstrated agility and flexibility, though.

An example was UT Austin's pragmatic decision to use part of the Program's 2020 education budget (particularly associated with travel and subsistence of its staff and mentorship of Portuguese researchers at the American partner) to finance its eleven winning research teams following the doubling of funds in Portugal.

Amid the COVID-19 pandemic, the Program also worked with FCT to set up the 2019 Call for Exploratory Research Projects' evaluation process. The final meeting of a world-class panel of academics and researchers happened in June 2020 in a digital format, leading to eight high-risk/high-impact projects being granted funding to navigate unchartered territory in the scientific fields at the basis of the Program's knowledge portfolio.

Consequently, 2020 saw the initiation of nineteen new R&D projects from across the Program's key scientific areas, reflecting an integrated approach to the knowledge-to-value chain. The Program is now in a better position to build up a portfolio of projects - where it is possible to see clusters of knowledge emerging around certain application markets/domains - and to set up closer links with national strategic interest initiatives. Newcomers to the Program, these consortia were offered support and guidance from the first moment, with the Program acting as a liaison office between them and their sponsors and society. Two webinars on science communication were designed and delivered to raise awareness among project teams of the importance of (the right) approach to tackle communication and increase project visibility to generate further interest and commitment of target

stakeholders. The training was complemented by releasing a practical guide offering several tips, recommendations and valuable sources on research communication strategy.

In 2020, one of the Program's main priority was to connect with all strategic research consortia and earn their trust by expressing its full support throughout project implementation in different ways: acting as a fast-tracking partner to FCT and ANI for queries, doubts and concerns brought up by consortia; passing on information from the sponsors; offering tailored advice on communication matters to raise project profile; spotting synergetic opportunities with other projects and high-level initiatives, either championed or not by the Program; developing monitoring tools to see how the transatlantic collaboration for each project is working (including project management; sharing and commercialisation of IP) and progressing to help the Program achieve its long-term goals. In June and later on, in November 2020, the Program's Leadership in Portugal held individual meetings with grantees to specifically identify potential constraints projects could or would be facing, technically and financially, due to the pandemic. Conversations revealed that flexibility with funding and management rules was extremely important for consortia to weather the COVID-19 crisis-prompted storm.

The Digital Shift in Networking and Educational Activities – Annual Conference and Masterclasses

The pandemic also prompted the Program to embark on the new digital adventure to keep the ball rolling as much as possible. On-site training and networking activities were forced to transition to a digital model. This shift threw the Program's team into a learning sprint about the do's and don'ts of digital events to not fail the 2020 Annual Conference edition.

The Conference, whose underlying theme was *Innovation at the Intersection of Academia and Industry*, turned out to be a far-reaching event, with people from locations well beyond the geographic boundaries of FCT's joint venture signing up to watch it live. The two Keynote Sessions and the four e-Masterclasses that filled up the Annual Conference's programming afforded an opportunity to bring closer together participants with some of our community's sharpest scientific minds and other top-tier speakers affiliated to prestigious research and technology organisations outside of the Partnership. The Conference even staged an e-Poster Exhibition and e-Networking Corner for participants with registered cooperation matching profiles.

Monitoring and Internal Stakeholders' Engagement Activities and Communication Activities

In the 2019 Annual Report, the Program made a forward-looking statement that it would be increasing the proportion of reporting related to impact in the forthcoming years. Such a commitment entails putting in place a monitoring and evaluation system that attests to the Program's learning and improvement culture and intention to disseminate and communicate the outputs and outcomes of its main activities. This system is also made of independent, highly experienced and reliable people who help the Program take the right pathways based on its progress weighed against predefined goals. In 2020, the Program organised its first Governing Board and External Review Committee Meetings since Phase 3. In February, the Program's Leadership met with the Area Directors in Portugal to present them the 2020 Activity Plan and receive their inputs and suggestions. First-line Ambassadors of the Program, the Area Directors play a fundamental role in growing the brand and the International Partnership's scientific prestige in and outside of Portugal. Two members of INESC TEC's Board of Directors take on this role: Rui Oliveira – Area Director in Portugal for Advanced Computing and João Claro – Area Director in Portugal for Technology Innovation and Entrepreneurship.

The Program also went on sharing a steady stream of news/stories, digital content and data to build up its brand and convey its value/impact. Creative teasers and promotional videos were launched, being the most important the video showcasing the 11 Strategic Research Projects. This full in-house production, premiered at the 2020 Annual Conference, gave a glimpse of how the Program tackled global challenges through research-based innovation spearheaded by transatlantic company-driven consortia.

9 SUPPORT SERVICES

9.1 LEGAL SUPPORT SERVICE

Manager: Maria da Graça Barbosa

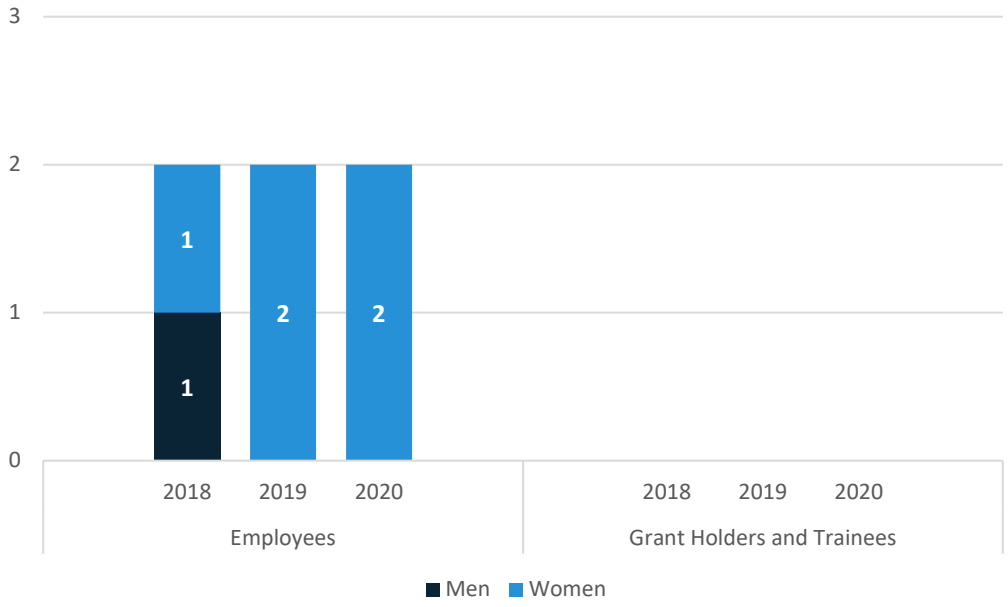


Figure 9.1.1 - AJ - Team composition and evolution

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, public procurement of goods, services and works, intellectual property and personal data protection. 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 minimise its costs.

9.1.2 Highlights in 2020

2020 was dramatically impacted by the response to the Covid-19 Pandemic, which implied the Legal Support Service in a particularly relevant and demanding way. Due to this particular and exceptional context, the achievements in 2020 are mainly related with the response to the pandemic challenges and requests, to the detriment of the pursuit of the objectives set for the year.

Activities related to the Covid-19 Pandemic response:

- Permanent updating of the daily legislative production, approving exceptional and temporary measures to prevent or fight against the pandemic or its consequences, processing and providing just in time information to the Board of Directors and the services, and accompanying the implementation of the exceptional measures to INESC TEC activities and people, namely the Contingency Plans and reorganisation of the work, with most of the INESC TEC team working from home;
- Study and application of the legal framework of teleworking, both in mandatory and optional regimes, and other legal aspects related to human resources in the pandemic context;

- Attendance of several online training sessions and information webinars by all AJ team members, in order to keep up with the various context and legal changes;
- Intense collaboration with ISPUP, especially with regard to data protection in several research projects, mostly related to COVID 19, and other initiatives related to the Pandemic;
- Fundamental participation of AJ team in the legal support to the development of several projects submitted to FCT Open Calls, such as "RESEARCH 4 COVID-19", regarding the contributions of R&D institutions in the fight against the pandemic; special highlight to the legal support to the StayAway COVID System, including in the drafting of the due Data Protection Impact Assessment and the validation of the applicable legal framework;

Other highlights:

- Study of the legal implications and monitoring of the application of the legal framework for the Horizon Europe Programme. Legal support to the drafting and negotiation of Consortium Agreements and other contractual instruments in the framework of European Projects already approved;
- Definition and permanent update of the internal procedures for application of the Public Procurement Code and complementary or special legislation for R&D activities, as well as launching of open tenders for acquisition of several services and goods. Reporting of all the public procurement procedures observed in several acquisitions, to ensure accountability to the financing entities;
- Legal support to the ongoing process of transformation of Human Resources management policies and procedures;
- Legal support to the formalisation of operations related to INESC TEC's participation in associations and companies, namely collaborative laboratories - with special highlight to ForestWise - and spin-off companies, as well as the design and implementation of the licensing models associated to such operations in close collaboration with SAL, such as Unexmin Georobotics, Insignals Neurotech and iLoF;
- Continued participation in the multidisciplinary Data Protection Team, appointed to support and monitor compliance with the GDPR and complementary national legislation, namely through: meetings with staff and researchers, awareness initiatives, seminars, and early identification and monitoring of research projects with potential data protection implications; preparation of templates, negotiation and drafting of data sharing and data processing agreements, general legal counselling and permanent legal support to the activity of the appointed Data Protection Officer (DPO);
- Preparation of templates, available in the intranet, for the most frequent types of contracts and other frequently requested documents;
- Participation in the implementation of the Intellectual Property Regulation, namely by ensuring its translation into appropriate provisions in contracts, either with personnel or with other entities, also in compliance with the Industrial Property Code, and through internal awareness raising about its content and interpretation;
- Participation in follow-up negotiations with INESC TEC Associates, further to the approval of the IP Regulation;
- Legal support to the negotiation and drafting of licensing deals in close collaboration with SAL;
- Joint effort with SAL in the preparation of dedicated tech transfer task force aimed at improving knowledge sharing between both services and the continued monitoring and follow up of R&D projects and other relevant activities;
- Participation in international fora of discussion of relevant legal topics for RTOs, namely through EARTO association;
- Participation in the workgroup on gender equality;
- Follow-up of the approval process of the INESC TEC Ethics Code, prepared by the workgroup on Ethics.

9.2 ACCOUNTING AND FINANCE SERVICE

Manager: Paula Faria

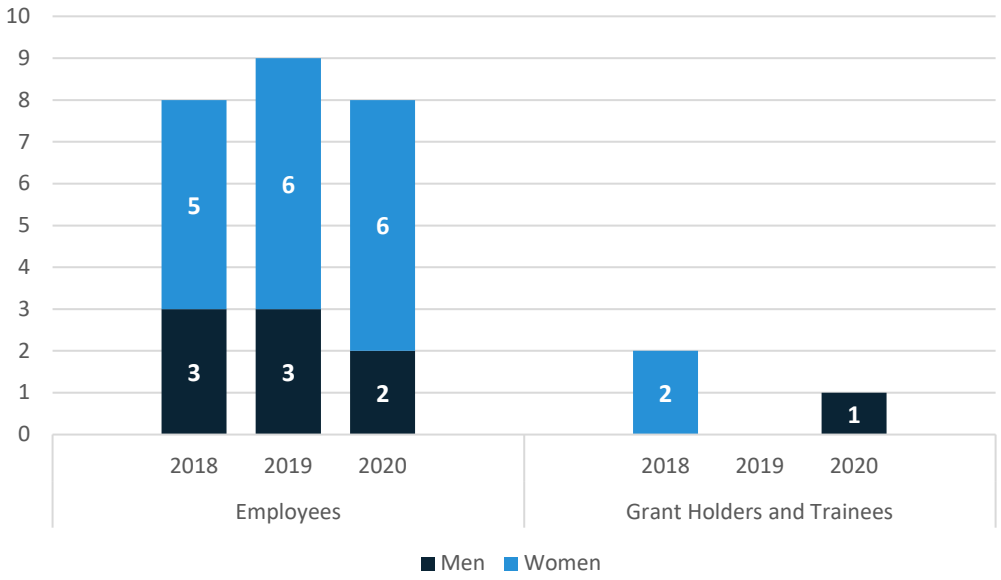


Figure 9.2.1 - CF - Team composition and evolution

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 2020

The COVID-19 pandemic has created a new set of challenges for the Finance and Accounting Service, such as leading a team towards remote working and ensure that the Service became digital-ready within the shortest possible amount of time.

The Plan for 2020 already comprised the endorsement of technological solutions towards a paper-free office. This proved to be a timely concern given the pressing needs that have since arisen.

The main highlights of 2020 are:

- The process of Electronic billing evolved to a higher level of completion;
- Definition of a Filing Plan for Financial Data under the Digital Archive;
- Elaboration of a Digital Archive Handbook;
- Follow-up of canceled trips and vouchers issued;
- Implementation of a new reporting to *Tribunal de Contas*;
- Monitoring of Tax Inspections;
- Upgrade of accounting processes and procedures handbooks, namely Suppliers and Fixed Assets.

9.3 MANAGEMENT CONTROL SERVICE

Manager: Vanda Ferreira
Assistant Manager: Bárbara Maia

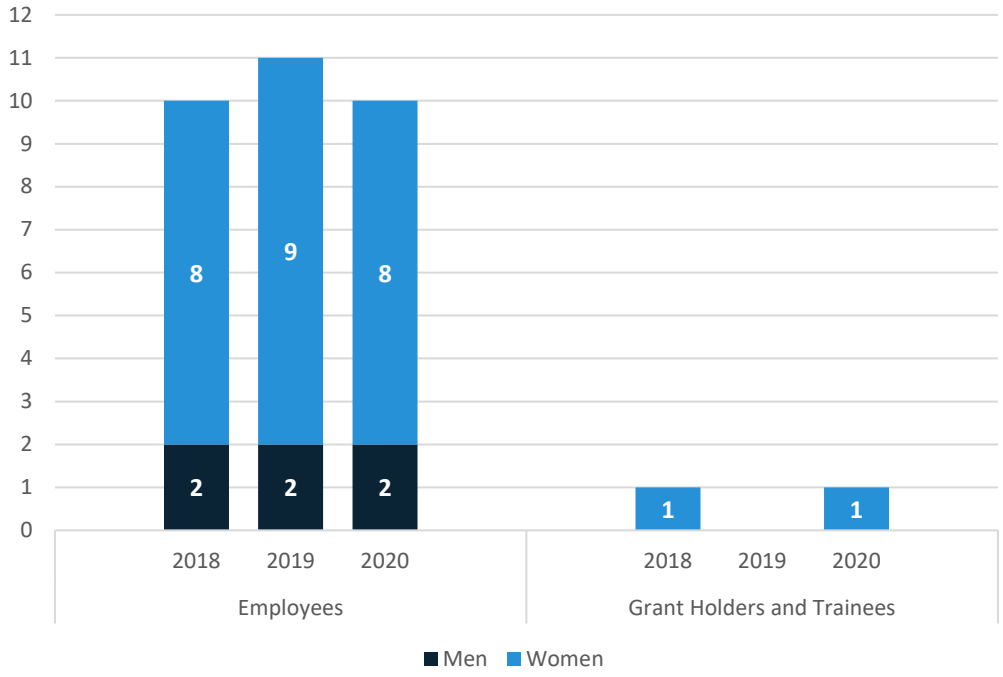


Figure 9.3.1 - CG - Team composition and evolution

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 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 2020

In 2020 the service reported 218 projects to the respective funding entities, representing more than 12 million euros of expenses.

Among these, 69 projects were funded by H2020 European Union framework program, 10 of which were coordinated by INESC TEC, all with multiple partners, and one of them with almost 50 partners. The service also reported 18 projects funded by other European programs, such as INTERREG and others. The expenses reported throughout the year amounted to 3 million euros.

With regard to national projects, the service managed 68 projects funded by Fundação para a Ciência e a Tecnologia (FCT), reporting more than 6 million euros of expenses and 33 projects in cooperation with companies, funded by Agência Nacional de Inovação (ANI), reporting 1.4 million euros of expenses.

There were also a set of strategic projects, large-scale funding, such as FCT's Multiannual funding, or regional (CCDRN) funding for highly qualified human resources that required a large effort from the service.

As to internal control matters we would like to highlight the continuous improvement with information services on all the management support tools.

9.4 HUMAN RESOURCES SERVICE

Manager: Luís Seca

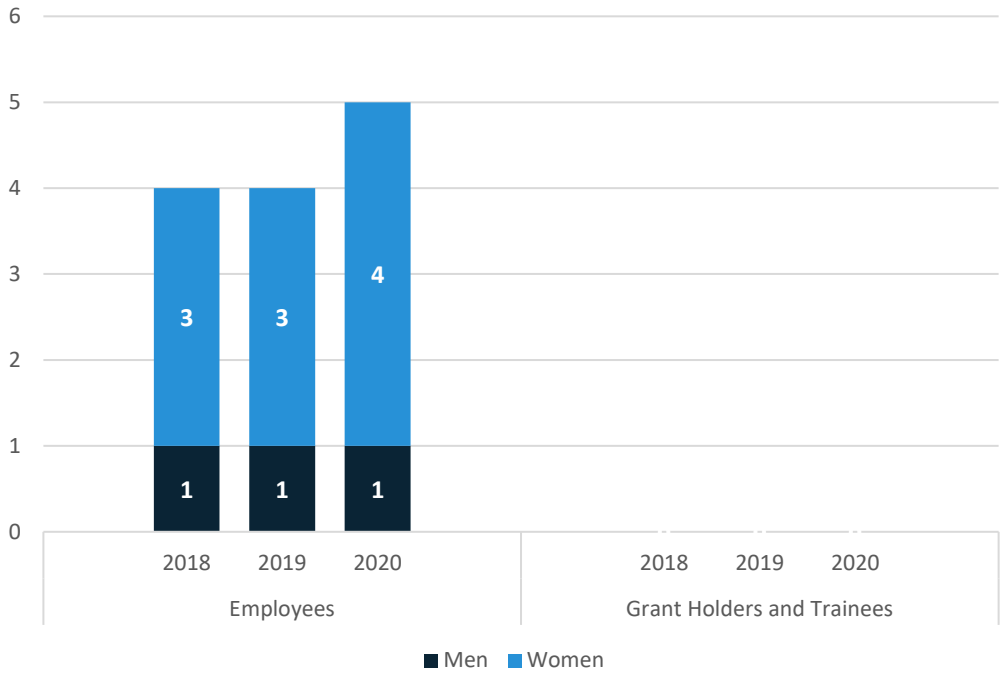


Figure 9.4.1 - RH - Team composition and evolution

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.

9.4.2 Highlights in 2020

2020 was a challenging year for HR due to COVID-19 pandemic that increased the pressure on the team in a year of profound changes, with the integration of two new dimensions in the service, the collaborator life cycle and Strategy and Development. The pandemic had a significant impact in the speed of implementation of the new model, as the team had to respond to a completely new situation that involved a tremendous effort. Still, steady steps were given in the incorporation of these dimensions as described below in the different highlights that are separated in Operational and Strategic for clarification purposes.

Operational

- Creation of an Implementation Committee, responsible for setting up the new HR Management Model, creating synergies between operational and strategic domains in order to prepare the future service coordination;
- Elaboration of the new INESC TEC Research Grant Holder Regulation, in the sequence of the new Research Grant Holder Statute (EBI), that established new conditions for grant holders, including the decision to support tuition fees;
- Implementation of the mechanism to pay the tuition fees to all grant holders who comply with the new Research Grant Holder Regulation of INESC TEC. This was a very complex task, involving several surveys and a significant interaction with grant holders;

- Definition of functional specifications for the automation of several internal processes in order to optimise the interaction with other services.

In response to the COVID-19 Pandemic:

- Establishment of a contingency plan, in articulation with SGI, to define the rules set by the the various stages of the pandemic's evolution and the restriction measures approved by the Government in the context of the states of emergency declared by the President of the Republic and, subsequently, the situations of calamity, alert and contingency declared by the Government;
- Definition of new communication strategy, namely for new researchers, including the revision of contents of welcome material;
- Definition of Remote Work Agreement for all contracted staff to support the implementation of a fully remote work regime;
- Establishment of an operational activity plan, to regulate the activity of the institution between May 2020 and December 2020, addressing different aspects related with presential and remote work conditions;
- Creation of two dedicated support lines to respond to COVID-19, with full time dedication to respond to all the challenges of remote work, including technical and well being support;
- Definition of a rationale for the creation of an Energy Subsidy, to support the increase of expenses for contracted staff in remote work, including the calculation of the energy requirements of a typical office in the Porto region.

Strategic

- Recruitment of 3 trainees from Universidade Católica Portuguesa to work on themes related with HR policies, namely:
    - roles and competencies;
    - performance appraisal;
    - recruitment and selection;
    - compensation;
    - training and development or careers.
- Creation of a framework for surveying existing functions and competencies to support the development of the new functions and competencies policy;
- Definition of work methodologies, composition and roles of team members, timberline and goals to achieve;
- Development of an app for institutional welcoming and onboarding at the Centre and respective Service;
- Implementation of a pilot on advanced training in project management, fully designed and organised by the human resources department;
- Definition and design of Working Groups (GTE) structure, including the choice of sponsors and leaders for each one of the groups;
- Revisiting and preliminary design of progression criteria and indicators for PhD Researchers to support the application to the call for the attribution of the Associate Laboratory Statute.

9.5 MANAGEMENT SUPPORT SERVICE

Manager: Isabel Macedo

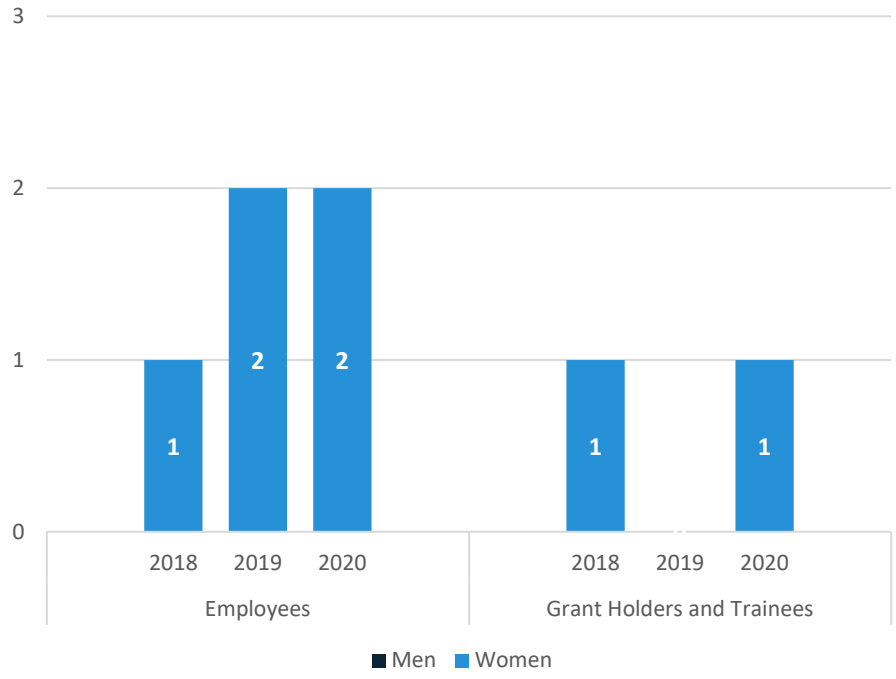


Figure 9.5.1 - AG - Team composition and evolution

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.

9.5.2 Highlights in 2020

Decision-making process

- Fully dematerialised decision-making process ensured as the Institution's activity shifted for remote/virtual mode in March 2020 due to the COVID-19 outbreak.

Direct support to Management

- Direct assistance to the Internal Seed Projects' initiative (follow-up of the 1st and 2nd calls) and to the Associate Laboratory application;
- Support and mediation to INESC TEC's accession to the associations EERA, FEEDINOV, IDSA, and SFCOLAB.

Information Management:

- Definition of an Open Access policy, to be deployed in 2021 as part of an overall policy on scientific publications;

- Content management and continuous update of INESC TEC's Intranet, IRIS, and Documental Repository. Co-creative development of the new INESC TEC's Moodle and Science & Society Magazine;
- Renewed liaison with the Data Management team to improve and ensure redundancy in the processes associated with INESC TEC's RDM (Research Data Repository);
- Continued work in data quality review and presentation of the institutional strategic performance indicators. Support to the external daily report of STAYAWAY App's activity indicators;
- Promotion of the new Curricula management platform CIÊNCIAVITAE and support in the migration process of INESC TEC researchers' CVs;
- Mapping of INESC TEC's institutional archive and information structure, completed with the definition of document/records retention periods and archival best practices, based on a transversal work with INESC TEC Support Services and external benchmarking.

Continuous improvement:

- Participation and contributions to the Data Protection Work Group.
- Incentive to dematerialisation through the institution, supporting the dramatic abandonment of paper-based filing systems triggered by COVID-19 Pandemic.

9.6 SECRETARIAL COORDINATION

Managers: Ana Isabel Oliveira and Grasiela Almeida

9.6.1 Presentation of the Service

Assistants are responsible for effectively executing the tasks required to support the development INESC TEC processes. Ana Isabel Oliveira manages the team of Executive Assistants of the Board of Directors and Grasiela Almeida manages the team of Assistants that support the Research Centres/Services.

9.6.2 Highlights in 2020

1. **Team Management**, through:
    a. **Internal training and coaching sessions** about internal rules and procedures such as the training session "Projects Budget Control", promoted with CG and also through the whole process of adaptation of the team and the institution to the new and disruptive *FCT Statute of the Research Fellow* and it's *Regulation for Studentships and Fellowships*;
    b. **Coordination of the team on the scope of the COVID'19 Pandemic**, including the production of weekly team schedules, coordination meetings with team and Coronavirus Support Group, allowing a continuous service without any rupture or quality decrease. This was only possible because of the support we all had from several of INESC TEC's Services and the swift adaptation of the whole institution to the remote work scenario and paper free processes;
    c. **The development of the team profile through the organisation of a full day workshop: the Assistant Day - 1st edition.** This initiative allowed to work on personal and professional excellence in a perspective of change (at INESC TEC) and also to develop creativity, communication, thinking and problem solving skills (at MINDSHAKE) while developing teamwork and increasing internal recognition for the role and also increasing the team's motivation;
    d. **Performance evaluation on the team regarding 2019**, overseeing the process closely with direct managers and the main services that assistants interact with;
    e. Full implementation of the digital archive regarding the team of Executive Assistants of the Boards of Directors.
2. **Focus on Continuous Improvement**, including:
    a. **Supervision of a Degree internship entitled *"Support for the digital transformation process and de-materialization of processes"*** focused on the team's archives, resulting in the production of a "Recommendations and Standards Plan" and also a "Structure for a Digital Archive" to support Paper-free processes. The implementation still needs further development with the Management Support Service;
    b. **Support to the new Intranet platform**, following its release in January 2020, by identifying bugs and improvement suggestions in its early stage;
    c. **Submission of a Proposal for Requirements of the new Resource Booking Platform**.
3. **Supplier Relationship Management** regarding services related to the assistant's activity, including contract management with INESC TEC suppliers in 2020 (travel agency, rental car company, private transport company and hotels).
4. **Information Management tools** designed to share information, templates and documents with the team, namely the constant update of a shared Directory and the **Implementation of the new Boards of Directors' Executive Assistants Network**, a new shared area to be used specifically by these colleagues.

The team of Assistants is composed by 17 members, as presented below.

Assistant	Supports PA (Personal Assistant) or Structure (Organisational Structure)
Ana Isabel Oliveira	**PA:** José Manuel Mendonça, Gabriel David, João Claro, Luís Carneiro, José Carlos Príncipe, José Fortes. **Structure:** General Council, Fiscal Council, Infrastructures Maintenance Service, Scientific Advisory Board, Business Advisory Board, Workers Committee**. Intervention Areas/Projects:** Secretarial Coordination, Board of Directors Budget, Communications, Continuous Improvement, ForestWISE CoLAB.
Lídia Vilas Boas	**PA:** João Peças Lopes, Luís Seca, Manuel Ricardo, Mário Jorge Leitão. **Structures:** Infrastructures Maintenance Service, Human Resources, Clusters. **Intervention Areas/Projects:** Activity Plan, Activity Report, IES, Conference organisation, Infrastructure Expenses Management, Operational Activity Plan – COVID-19, Technical Comission for Social Responsibility.
Sandra Nunes	**PA:** Bernardo Almada Lobo, José Carlos Caldeira, Rui Oliveira, Vladimiro Miranda, Pedro Guedes de Oliveira, José C. Marques Santos. **Structures:** Conflict of Interest Management Commission, TEC4. **Intervention Areas/Projects**: Manufacturing Vanguard Initiative, STAYAWAY App, Quarternaire.
Ana Paula Silva	**Structure:** Centre for Information Systems and Computer Graphics.
Catarina Fernandes	**Structure:** High-Assurance Software Laboratory.
Cláudia Almeida	**Structure:** Robotics Autonomous Systems @ISEP LSA **Intervention Areas/Projects:** TEC4SEA.
Flávia Ferreira	**Structure:** Robotics Industry Intelligent Systems Centre.
Grasiela Almeida	**Structures:** Enterprise Systems Engineering Centre; Innovation, Technology and Entrepreneurship Centre; Networks Communications Service. **Intervention Areas/Projects:** Secretarial Coordination, TEC4INDUSTRY.
Helena Silva	**Structures:** Industrial Engineering Management Centre, Communication Service, Organisation Management Services, Funding Opportunities Office.
Joana Dumas	**Structures:** Artificial Intelligence Decision Support Lab, Advanced Computing Systems Centre.
Luísa Mendonça	**Structure:** Applied Photonics Centre.
Marta Oliveira	**Structures:** Enterprise Systems Engineering Centre; Innovation, Technology and Entrepreneurship Centre; Systems Administration and Management Information Systems Services. **Intervention Areas/Projects:** TEC4INDUSTRY.
Paula Castro	**Structure:** Power and Energy Systems Centre.
Renata Rodrigues	**Structure:** Telecommunications and Multimedia Centre.
Rute Ferreira	**Structure:** Biomedical Engineering Research Centre, Technology Licensing Office Service **Intervention Areas/Projects:** TEC4HEALTH e TEC4AGROFOOD.
Sílvia Pina	**Structure:** Robotics and Autonomous Systems Centre (CRAS)@FEUP **Intervention Areas/Projects:** TEC4SEA.
Vera Pinto	**Structure:** International Partnership Office.

9.7 FUNDING OPPORTUNITIES OFFICE

Manager: Marta Barbas

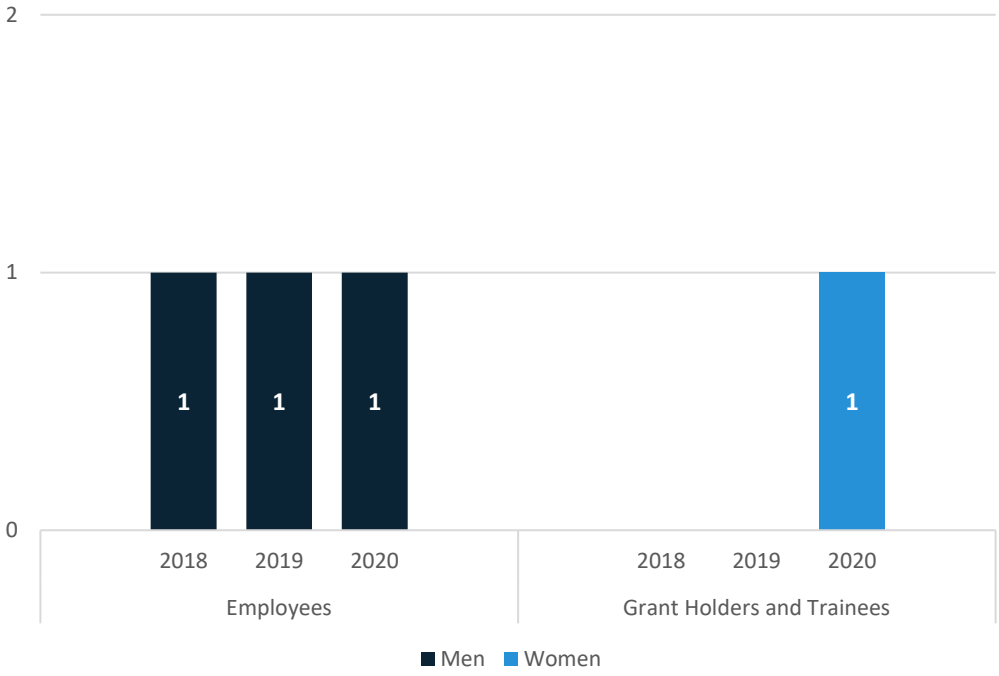


Figure 9.7.1 - SAAF - Team composition and evolution

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 2020

In the first quarter of the year the capacity of the Service was reinforced as planned in 2019. For this purpose, a position for an extra team member was open and a person was effectively recruited in February, focused on supporting H2020 applications and improve INESC TEC response to the future HEurope calls.

Despite the COVID 19 pandemic constraints felt throughout the year, it was possible to pursue with the support to researchers as planned and sometimes even surpass the regular activities.

From all the activities developed we shall highlight, for its relevance, that the sService accompanied the preparation of the Associate Laboratory application, which is crucial to fund INESC TEC most basic research activities, and also the funding application to HPC, a project to develop a technological platform that aims at the identification, specification, development and testing of innovative solutions to allow maximising the sustainability of the operation of facilities for advanced computing and data centers, taking advantage of the Deucalion supercomputer to be installed at Ave Park which will be a highly strategic funding.

Some facts and figures related to the proposals submitted accompanied by the service:

- 3rd edition of the call for health research projects Fundação ‘la Caixa’: 2 proposals;
- 1st edition of R&D Projects for Inland territories Fundação ‘la Caixa’: 1 proposal;
- EEA Grants Research – 3 proposals;

- FCT Call for Research projects between Portugal and India (2019-2021): 4 proposals;
- FCT Call for SR&TD Project Grants 2020: 161 proposals;
- FCT Forest Fire Prevention research projects 2019 Call: 4 proposals;
- FCT AI 4 COVID-19 Call: Data Science and Artificial Intelligence in the Public Administration to strengthen the fight against COVID-19 and future pandemics – 2020: 4 proposals;
- FCT call for exploratory international cooperation projects UT Austin Portugal – 2019: 2 proposals;
- FCT Call for Advanced Computing Projects - 1st edition: 3 proposals;
- FCT Call CHIST-ERA: pathfinder programme for European coordinated research on future and emerging Information and Communication Technologies: 4 proposals;
- FCT Special support for rapid implementation projects for innovative response solutions to COVID-19 pandemic: 17 proposals;
- ANI P2020 Call for R&D Co-promotion Projects: 27 proposals;
- ANI P2020 Call for R&D Co-promotion Projects COVID-19: 2 proposals;
- ANI P2020 Call for R&D Co-promotion Projects for Inland territories: 3 proposals;
- NORTE 2020 Call for R&D Integrated Projects: 1 proposal;
- HORIZON 2020: 100 proposals were submitted in 68 different calls but we shall highlight 1 successful proposal coordinated by INESC TEC, which submission were strongly supported by the service: SCORPION submitted to the call SU-SPACE-EGNSS-3-2019-2020 in March;
- ESA Express Procurement Plus – EXPRO+, Port of the Future: 1 proposal;
- EIT Manufacturing - Call 2021: 13 proposals.

9.8 TECHNOLOGY LICENSING OFFICE

Manager: Daniel Marques de Vasconcelos

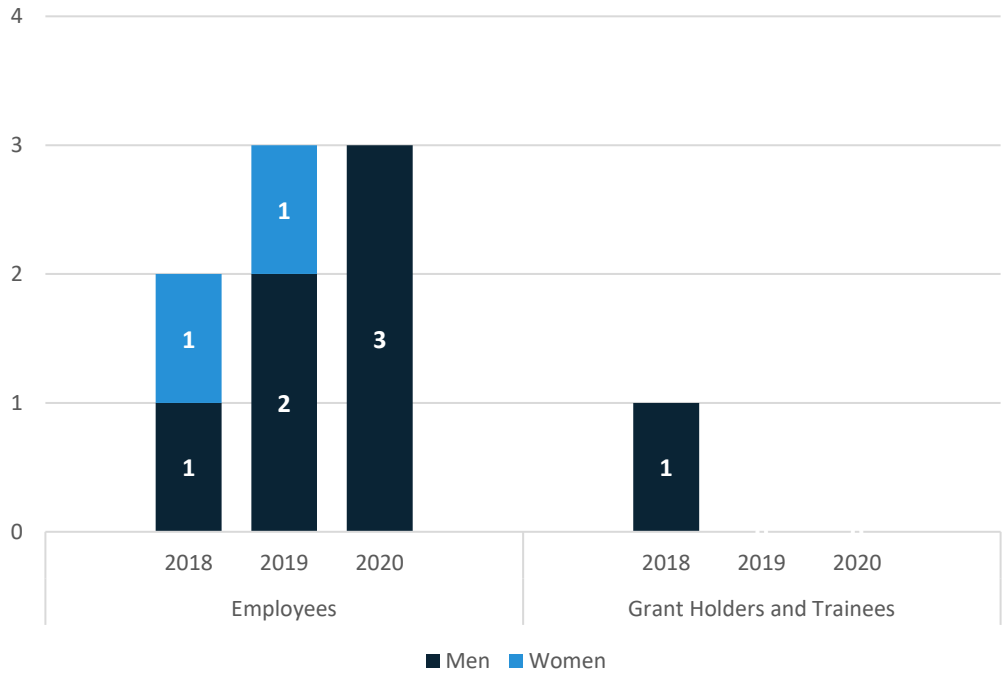


Figure 9.8.1 - SAL - Team composition and evolution

9.8.1 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 TEC4s. 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.

9.8.2 Highlights in 2020

Following its mission and goals, SAL presented a high improvement in scouting, protection and licensing during 2020:

- 26 invention disclosures (vs 9 in 2019);
- 6 software copyright registrations (vs 2 in 2019);
- 7 first priority patent filings (vs 2 in 2019);
- 30 patent applications PCT and National Phases (vs 26 in 2019);
- 7 granted patents (vs 4 in 2019);
- 5 licence agreements (vs 1 in 2019).

In the second semester of 2020, the office adopted a new organisation and strategy, moving most of its efforts towards licensing. SAL's KPIs in 2020 are totally in line with the median presented by other technology transfer offices in Europe according to the annual survey carried out by the prestigious ASTP. INESC TEC was again in the

top 5 Portuguese applicants at EPO in 2020, being the only Portuguese entity to be for the fourth year in a row in this top 5 ranking.

There was also a strong focus on supporting INESC TEC's spin-offs, not only in licensing but in managing intellectual property rights and negotiations.

SAL was also deeply involved in PNEUMA project, the national emergency ventilator, helping the engineering team with IP, regulatory, clinical validation, industrialisation, and engagement with critical stakeholders, such as INFARMED, ARS Norte, and SELT. In the context of COVID-19 initiatives, the office helped at choosing the open source license for StayAway COVID app, as well as at registering its trademark.

The office supported researchers and other INESC TEC's Services at analysing dozens of proposals and contracts, especially for the IP sections and pricing (State-aid mitigation).

In the Interconnect H2020 project, SAL was in charge for the activities in the exploitation plan work package, in close collaboration with TNO.

In 2020, the office organised and/or participated as an invited speaker about IP in domestic events organised by ANI and F-Iniciativas. The office is deeply committed to increasing the international reputation of INESC TEC in Intellectual Property forums. Daniel Vasconcelos was appointed as the new European IP Helpdesk Ambassador for Portugal (European Enterprise Network). Moreover, three SAL employees became ASTP members in 2020, being now an active presence on advanced webinars and courses on technology transfer and networking events. In the context of Interconnect H2020 project, SAL delivered two workshops for the whole consortium on IP basics and on Software IP. Moreover, Daniel Vasconcelos represents INESC TEC at the high-ranked TTO Circle.

9.9 INTERNATIONAL RELATIONS OFFICE

Manager: Andreia Passos

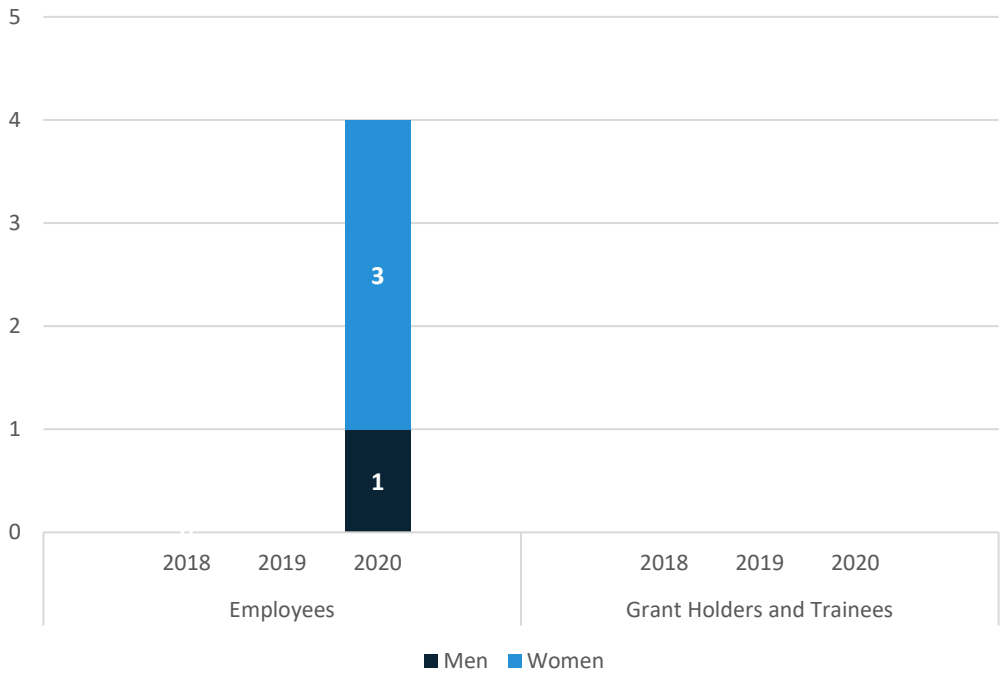


Figure 9.9.1 - SRI - Team composition and evolution

9.9.1 Presentation of the Service

The International Relations Service (SRI) was created in 2020 to assist the INESC TEC's Board of Directors (BoD) in designing, implementing, and monitoring the organisation's overall internationalisation strategy. Additionally, the Service accommodates three market-based offices: The Brazil and India Offices and INESC Brussels Hub.

9.9.2 Highlights in 2020

To some extent, the activity plan outlined for the year 2020 was affected by the Covid-19 outbreak, which refrained international mobility and sent most of INESC TEC's staff home in March for an undefined period. For a new-born service whose scope of action is very much contingent on the international setting, such an unprecedented event was - not surprisingly – impactful. A good example is the CENTRA 5 meeting, whose 2020 edition had been handed over to the SRI. This international encounter ended up being postponed to 2021. Still, until such a decision was made, the SRI team kept its nose to the grindstone to implement the initially approved event plan.

With almost everyone working from home, the Service went backstage but embraced the situation as an opportunity to channel its efforts into developing proposals for supporting documentation and procedures in the three areas of the service. Some of these documents have already been released as versions 1.0; others are yet in the making or awaiting the right moment to be disseminated. Additionally, the SRI invested in establishing relationships with other services of the organisational chart deemed as potentially critical in SRI's efforts to deliver its value proposition to INESC TEC's community: Legal Support, Human Resources, Secretariat Coordination, Funding Opportunities Office and Management Support. The forging of collaborations extended beyond the organisation. In 2020, the Service bridged with the University of Minho's International Relations Office; the National Institute of Advanced Industrial Science and Technology's Department of Information Technology and Human Factors Research Promotion Division (International Relations) in Japan, and the Fraunhofer's International HR & Labor Law Department, in Germany, with the view of identifying good practices regarding supporting activities in the fields of international cooperation and global talent mobility.

As the organisation managed to adapt to the pandemic's many challenges, the Service was first put to the test in the area of international mobility. It was gradually involved in mobility processes with foreign newcomers and requested to assist foreign staff - who found themselves in Portugal at a time when immigration and border controls legislation was frequently changing as part of the Portuguese Government's fight against Covid-19 - with queries. Indeed, many of these INESC TEC members needed specific support, and the Service stepped in to inform and guide them in close collaboration with AJ and HR. This was a very important fast-learning process we embarked on, pushing us to delve into several topics that came to help us realise the importance of:

- Moving forward with the drafting of the Welcome Appointment Guidelines and the Mobility Quick Guide for Foreign Newcomers;
- Gaining further understanding of issues that are becoming increasingly relevant to stay on top of global remote work and home-office-related challenges and continue attracting foreign talent to the institution. This expertise we have been acquiring since 2020 has led the SRI to become involved more recently in the first recruitment processes of personnel working from their home-based countries.

As far as outward mobility is concerned, drawing on the UT Austin Portugal Program's experience, we created a post-visit report form that we successfully tested with some staff who returned from exchanges abroad. We also became accountable for coordinating the internal call for the International Internships Program of Japan's National Institute of Informatics, which received very positive remarks from our liaison contact at the Japanese partner. Such an experience prompted us to initiate in the very end of 2020 the drafting of an exchange program coordinated and hosted by INESC TEC that we expect to plant the seeds of a ground-breaking initiative in the medium term.

As far as international cooperation is concerned, we started supporting the negotiation, drafting, signing, and follow-up of international Memoranda of Understanding (e.g., MoU with Thailand's Thammasat University and the MoU with Taiwan's NARLabs), being consulted for other (potentially) non-binding agreement proposals upon request of the Legal Service. To this work, the internal *Memo on International Agreements: Analysis of current organisational practices regarding the signing, monitoring and evaluation of MoUs and similar international agreements* was particularly relevant. It provided the Executive Board with conclusions and recommendations that we used, for instance, to put forward a proposal for a set of guidelines on international MoUs. Nevertheless, the document has not been released because the Executive Board wanted - understandably - to extend SRI's preliminary mapping of practices to national MoUs and other types of agreements. Additionally, we proposed a revised wording of INESC TEC's MoU template to reflect good international practices in the writing of nonbinding international agreements. The template was reviewed and approved by the Legal Service in the meantime.

The SRI was also called on to assist the PNEUMA's team in the initial stage of interactions with potential foreign partners and intermediates outside of Europe who had expressed interest in the project's outcomes. It also helped the Brazil Office organise the PNEUMA 2020 – Partnership for New Emergency Universal Machine-Assisted Ventilation webinar, which brought together INESC TEC (Portugal), INESC P&D Brazil (Brazil) and IRESEN/GEP (Morocco). The Service wrote up a report at the end of the event.

Another landmark in the Service's last year performance was the internal report *Towards an Internationalisation Strategy – Clusters' International Profiling and Internationalisation Strategy Design Tool.* This report highlighted several conclusions and recommendations regarding INESC TEC's 4 Clusters' international standing and the need for more robust internationalisation indicators in the institution. Additionally, it proposed a visual tool supplemented by several guiding questions to assist the organisation in designing and communicating an internationalisation strategy, which was presented, for the first time, in December 2020, to one of INESC TEC's four Clusters in order to get their feedback and buy-in. One of this tool's goals is to help Clusters embed internationalisation in their R&D agendas consistently and have them leveraging individual-based international networking opportunities.

Acting as a watchdog on internationalisation, the Service wrote its first briefings: three on the India-Portugal Summit, circulated amongst previously identified key internal stakeholders and another on the EU and UK Trade and Cooperation Agreement, which has evolved, more recently, into an encompassing document (memo) reflecting contributions from other services as well. Finally, the Service kept on INESC Brussels HUB.

9.9.3 Highlights of 2020 – INESC Brussels Hub

The year started with the final efforts to establish the physical space and basic services in Brussels. The office was inaugurated on the 3rd of February 2020 with the hosting of a project meeting attended by researchers affiliated to INESC P&D Brasil and INESC TEC.

In February, the office held 5 international project meetings (2 from INESC TEC) and 17 meetings with European stakeholders to introduce INESC's representation in Brussels. In this period, the HUB developed a set of robust indicators to measure INESC's activity and structured information about all institutes to be used in presentation templates in EU *fora*.

Such outputs contributed to increasing the HUB's visibility and supporting representation and lobbying activities throughout the year (particularly in meetings with the European Commission (4), the European Parliament, European networks, and platforms, including the 7 EARTO thematic workgroups). The HUB also supported the development of 5 tenders (1 approved with the participation of INESC TEC) and 1 COST Action (also involving INESC TEC).

INESC TEC participated actively in the thematic and transversal HUB Work Groups, producing many high-quality outputs and promoting collaboration between researchers across INESC's universe who had never worked together until then. These efforts resulted in the joint submission of projects - 3 tenders, 1 H2020 project and 1 FCT project. Involved researchers have acknowledged that these opportunities stemmed from the HUB's activity.

54 INESC TEC researchers participated in the Horizon Europe training workshop and 18 bilateral meetings with specific INESC TEC's services were held to support diverse needs related with EU positioning and successful participation. 2 INESC TEC senior researchers participated in 2 Science Business thematic closed meetings, where networking and interaction with industry and other research entities were made possible. The HUB supported the application of 1 INESC TEC Board Member to a high-level representative position in an EU institution. It also contributed to INESC TEC Associate Laboratory's application by providing inputs to its EU positioning and future vision.

The HUB promoted INESC TEC's direct engagement in lobbying efforts on synergies between EU funding instruments and programmes. It produced and published a position paper with a wide impact on EU institutions and national and regional entities. The HUB also supported the lobbying towards creating funding lines for technology infrastructures in Horizon Europe in close articulation with INESC TEC's Board of Directors.

9.10 COMMUNICATION SERVICE

Manager: Sandra Pinto

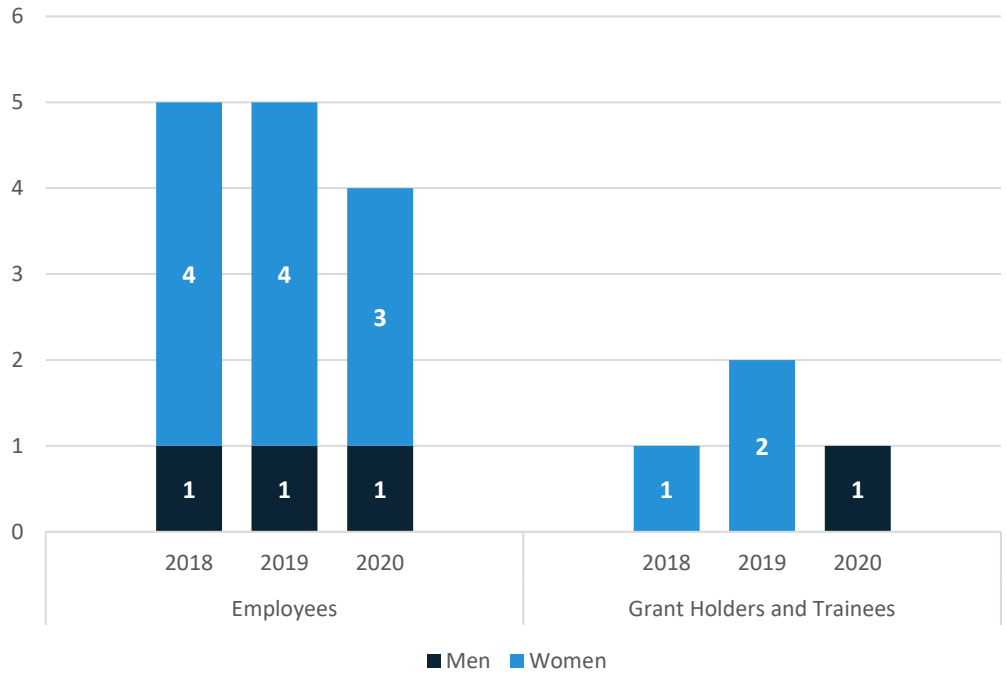


Figure 9.10.1 – SCOM - Team composition and evolution

9.10.1 Presentation of the Service

The Communication Service collaborates with the Board in the definition of the institution's communication strategies and image. The main activities are planning, implementing, organising and coordinating both internal and external communication, according to the regulations and procedures established, thus promoting the status and notability of the institution.

9.10.2 Highlights in 2020

9.10.2.1 New Communication Achievements

- **STAYAWAY COVID was the "star" project for INESC TEC in 2020, and the communication team was strongly involved in several initiatives with relevant public impact**. Some examples are: the graphic identity developed for the application and the **image application** to the various screens of the app; **the leadership of the press office**; the **crisis communication plan**; the **website development**; the creation and regular updating of **social networks**; the capture of **exclusive photos** for the app; the production of a **promo video and video tutorial**; the creation of the app's **promotional kit**; the organisation of the app's **public launch event**; the **promotion of the app** at universities, student associations and shopping centres; the **liaison with the communication offices of the Ministries involved, as well as of** partner entities; the **collection of testimonies and influencers**; the proofreading/translation of content;
- Among other INESC TEC's technological initiatives in the context of the COVID-19 pandemic, it is worth mentioning the **emergency ventilator PNEUMA**; the communication team created a **website in three languages**, a **crisis communication plan** and a **media advisory support**. These two initiatives and others were included in a **new section created on the INESC TEC's website and on BIP INESC TEC Magazine**;

- With a minimalist celebration already planned, the pandemic further reduced the activities planned for **INESC TEC's 35th birthday**. However, it was possible to associate the 35 years of INESC TEC brand to the **commemorative event of 40 years of INESC**. Other initiatives include **two videos of Gen Talks** and a **video alluding to one of INESC TEC's "parents"** on Father's Day, produced for dissemination on social networks;
- One of the most important communication resources created in 2020 was the **new INESC TEC Science & Society magazine**, the first issue of which was launched in November 2020. SCOM was responsible for the magazine's graphic image and dissemination;
- Another section on BIP INESC TEC Magazine was created: the **podcast Science Bits** (9 podcasts) - focusing on disseminating the latest trends in science and technology. The number of page views and countries that visited BIP increased in 2020;
- Considering the lockdown during the first months of the pandemic, it became necessary to think of **creative ways to boost social interaction among employees**, encouraging communication and sharing experiences. Thus, the **chat channel "INESCTEC @ Home**" was created, promoted by SCOM, in which employees were invited to participate in daily challenges. Also noteworthy is the "**Logbook at Home" initiative**, in which each Centre or Service was invited to report, as a daily record, how they interacted as a team. 17 logbooks were written and shared on the Intranet.
- A **diagnostic work** was carried out on **INESC TEC's communication materials**, whose aim was to understand **the extent to which they addressed the needs** presented by the different segments of the institution. In this sense, a survey was made of the existing materials, with a consultation with 38 coordinators/managers. Based on the report, very detailed and exhaustive, it was possible to **define a strategic action plan for external and internal communication** that was included in the 2021 Communication Plan.
- The **session "Journalists and researchers: how to communicate?", exclusive to Coordinators and the Board**, took place during the pre-pandemic period, promoted by the Science Editor of the Público newspaper, Teresa Firmino. Moreover, the **first edition of the SCOM webinar "Integrated Science Communication" took place in June**. In this webinar, featuring almost the entire SCOM team, the participants were able to get to know the Service's areas of action, the extent to which researchers can benefit from the Service in their communication tasks and get tips on how to interact with the media, share content on social networks and make presentations, among others.

9.10.2.2 External Communication

- **2020 was the year that recorded the highest number of news over the last 20 years**. In fact, in this atypical pandemic year, **INESC TEC has exponentially increased its media projection**, largely thanks to the STAYAWAY COVID app. Compared to 2019, the number of news almost tripled in relation to the same period (Δ +1838 news) and the **Automatic Advertising Value (AAV**) was almost 7 times higher (Δ + 54.9M€). In addition, five news were published on the Medium platform and two interviews in Water Power Magazine and in El País.
- In 2020 there was a **consistent increase in the number of followers on all social networks**, with **LinkedIn being the network with the highest increase**, compared to the same period last year. The engagement rate was higher than the average reference value in all networks. **As for reach, Instagram and LinkedIn grew** compared to 2019. LinkedIn remains as the social network "trend".
- Due to the pandemic, many events have been postponed and cancelled, while others have reinvented themselves as online or hybrid. Even so**, SCOM supported the organisation and/or dissemination of 21 events in 2020.**
- Concerning the **support to the R&D projects**, SCOM members supported the communication actions/materials for European projects InterConnect, TRUST-AI, Atlantis, M NEST I & M NEST RIS, Demeter, AIDA and FEEdBACk, as well as national project PORTXXI and EEN network. The team also designed the Communication Plan for four projects and one spin-off.

- Although there was a sharp decrease in video production between March and September, due to the restrictions caused by the pandemic, in the last quarter, with the resumption of events in an online format, there was a **higher number of requests for videos about projects**, **technologies and testimonials**, precisely for use in online events. 59 videos were produced by SCOM **and photos were captured for 28 albums.**
- Regarding to communication material, the focus was on the **new version of the Annual Report**, which represented another qualitative leap in the public presentation of INESC TEC.
- With regard to Science communication initiatives, and despite the pandemic, INESC TEC participated in the **Science 2020 Meeting and in the European Researchers' Night**.
- SCOM continued to be in charge of all the communication activities and strategy of the **UT Austin Portugal Program.**

9.10.2.3 Internal Communication

- Excluding events that required close interaction between employees, as was the case of the 35-year Internal Meeting, hiking and team building activities, SCOM sought to adapt the rest to a hybrid format or 100% online – for instance, **the Strategic Meeting and the Multicultural Party**. It became necessary to innovate in the format, focusing on videos and a greater dynamic concerning how the events were guided.
- All the **translation** and **proofreading** requests by the Centres and Services were carried out, according to SCOM's schedule.

9.11 NETWORKS AND COMMUNICATIONS SERVICE

Manager: Gil Coutinho

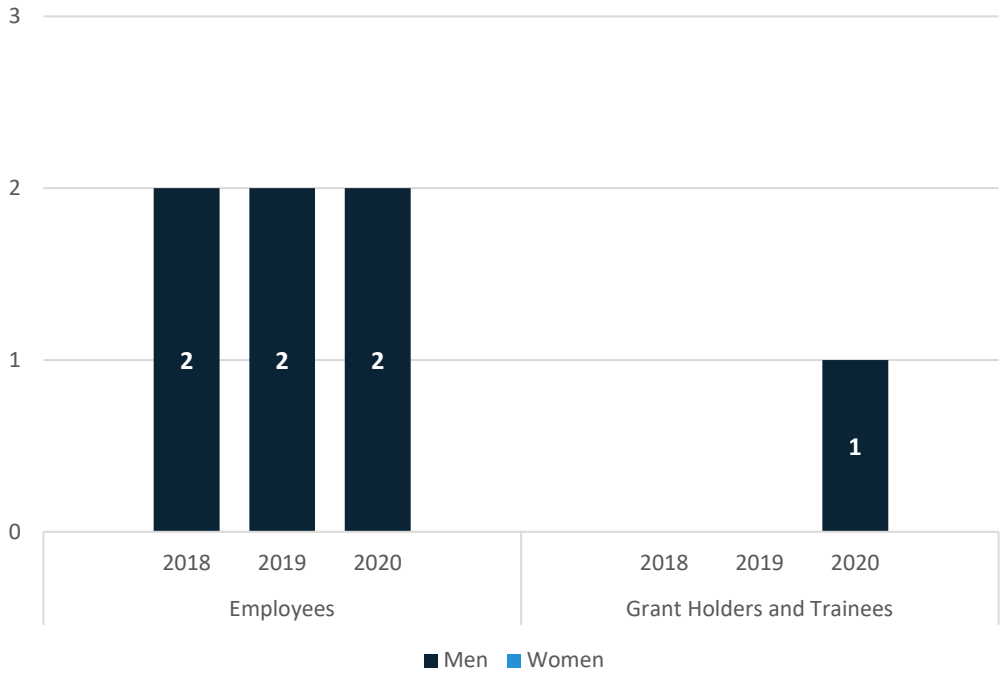


Figure 9.11.1 - SRC - Team composition and evolution

9.11.1 Presentation of the Service

The mission of the Networks and Communications Service (SRC) is to plan, manage and operate the communications infrastructures of INESC TEC. SRC runs INESC TEC's voice and data communication networks and is responsible for the implementation and maintenance of network-based services and for providing the respective support to end-users. The main areas of the team's activity are:

- Local Area Network (including cabled and wi-fi components);
- External connectivity (e.g. Internet);
- Voice communications (e.g. VoIP);
- Printing and scanning systems;
- Core mail system (e.g. Mail transfer agents, anti-virus, anti-spam);
- Remote access (e.g. VPN);
- Video-conference systems and solutions;
- Audio/Video streaming and broadcasting;
- Physical facility management (e.g. Datacenters);
- Support to events and remote facilities (including e.g. iiLab, INESC Brussels hub);
- User support.

9.11.2 Highlights in 2020

Unsurprisingly, SRC's main activity in 2020 was directly or indirectly related to the Covid-19 pandemic.

As soon as the first lockdown took place, a great effort was undertaken in order to help users successfully and efficiently work remotely. In particular, guidance and support was provided to users in order for them to install, configure and utilise services like VPN in their laptops or home computers, VoIP applications in their desktops or smart phones and also videoconferencing solutions like e.g. Zoom or MS Teams, for personal use or event organisation. Furthermore, in articulation with the Covid-19 Support Team, SRC gave direct support to users who had infrastructural debilities in their home networks. Finally, as for support is concerned, SRC team participated in the support team of the STAYAWAY COVID contact tracing app.

On the infrastructure side, Covid-related activities focused on the permanent monitorisation of the infrastructure, tuning or upgrading it whenever and as soon as it was necessary. Furthermore, local presence in INESC TEC's main building was guaranteed throughout the year, thus allowing for immediate action in the infrastructure or other devices (like e.g. phones or printers).

Other planned and unplanned highlights include:

- The conclusion of the refurbishment works of the main datacenter of INESC TEC building A, with significant improvements in redundancy, energy efficiency, noise isolation and other features such as automatic fire detection and suppression;
- The evolution of the core network, with a backbone that now operates at 40 gigabit/s and provides a greater number of 10 gigabit/s connections to servers and storage devices;
- The evolution of the VPN service, which by the end of the year started an upgrade process which greatly improved its security, resiliency and capacity;
- The deployment of the new printing and scanning equipment, which integrate a printing-as-a-service solution and will allow a follow-user document release principle;
- The start of the implementation of a new VoIP solution, which aims to decommission and replace the outdated infrastructure;
- The study and pilot implementation of an Intrusion Detection System based on potentially multiple network probes;
- The planning and elaboration of a new architecture of the centralised logging system, aiming namely to a more resilient, scalable and faster solution;
- The continuous effort to reduce the overall security risk exposures, by the implementation of firewall policies to deploy systems and services.

9.12 MANAGEMENT INFORMATION SYSTEMS SERVICE

Manager: José Carlos Sousa

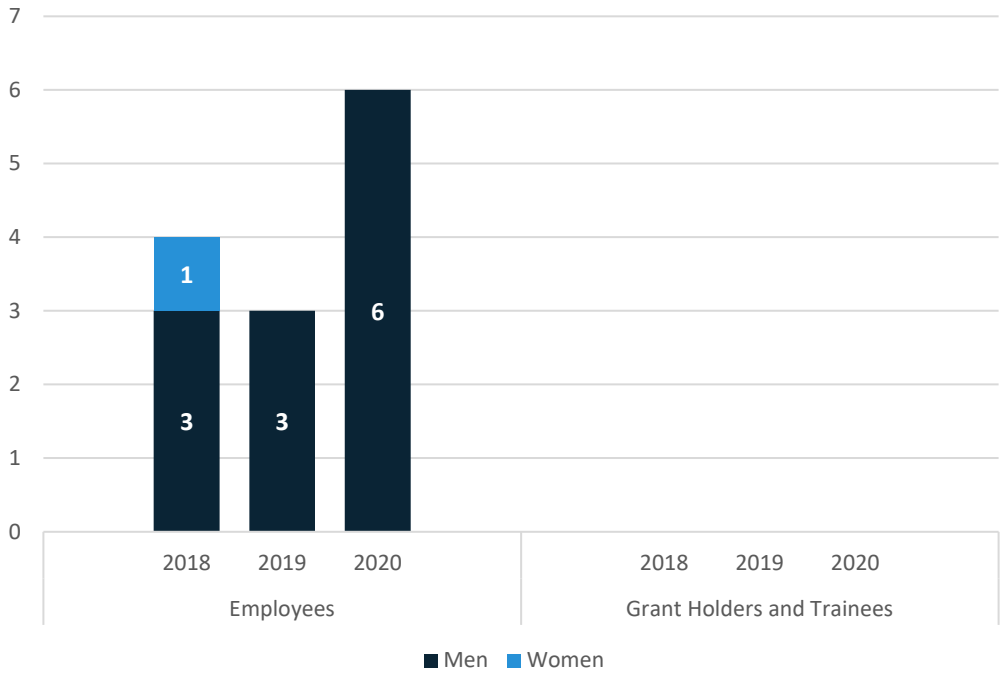


Figure 9.12.1 - SIG - Team composition and evolution

9.12.1 Presentation of the Service

The Management Information Systems Service is in charge of the development and maintenance of INESC TEC's management information system.

The main systems under SIG supervision are the Human Resources system, the Intranet supporting the automated workflow processes and internal institutional communication, the INESC TEC Research Information System (IRIS), the Institutional Repository and the Website. SIG also supports the several Services in their interaction with the financial SAP system.

Starting in 2020, SIG took charge of UOne Connect, a European Project Management system.

The team size in 2020 has been 4.8 FTE, corresponding to the addition of two new members, now totalising six technicians.

9.12.2 Highlights in 2020

The main new functionalities added to the Intranet system were:

- Updates to the Grant Workflow to support the new requirements derived from the Grant Regulation, including a new assessment system;
- Integration of Electronic Invoicing with the INESC TEC information system, which allowed it to be more effective when working on digital invoices;
- Dematerialisation of HR processes, including the support for teleworking contracts.

The IRIS kept growing through the addition of more modules:

- The Research Lines module allows the management of the research lines and their association with INESC TEC researchers;
- The Supervised Theses module consolidates data from Higher Education Institutions and input from INESC TEC researchers;
- To improve the project follow-up during the COVID pandemics, a project monitoring report has been implemented;
- Improvement of the information on scientific results both in each researcher's personal information and in the performance indicators reported to the Associates.

In the Website, the main developments were the following:

- New integrated system for the dissemination of news by the Communication Service.

SIG assumed in August 2020 the development of the uONEConnect platform. The InterConnect European project keeps the roles of main specifier of its requirements and of its initial user. The most significant improvements made in 2020 regard:

- Managing amendments versions that provide historical data for track changes purposes;
- The improvement of the financial report approval workflow by involving the work package managers in the approval process;
- New KPI's and visual indicators in the financial reports that have improved the monitoring of financial execution by providing more tools for coordination control;
- Improved partner communication within the platform.

The response to the COVID-19 pandemic included the creation of areas in the website and in the intranet to disseminate updates on the various initiatives to combat the pandemic among INESC TEC members. With the need to increase teleworking, measures were taken to digitise the work. Namely, new processes for teleworking agreement and remote attendance control, and the availability of documents in digital format. SIG also implemented the Pneuma and Stayaway Covid websites, which aim to disseminate information about some of INESC TEC's contributions to the response to the pandemic.

9.13 SYSTEM ADMINISTRATION SERVICE

Manager: Jaime Dias

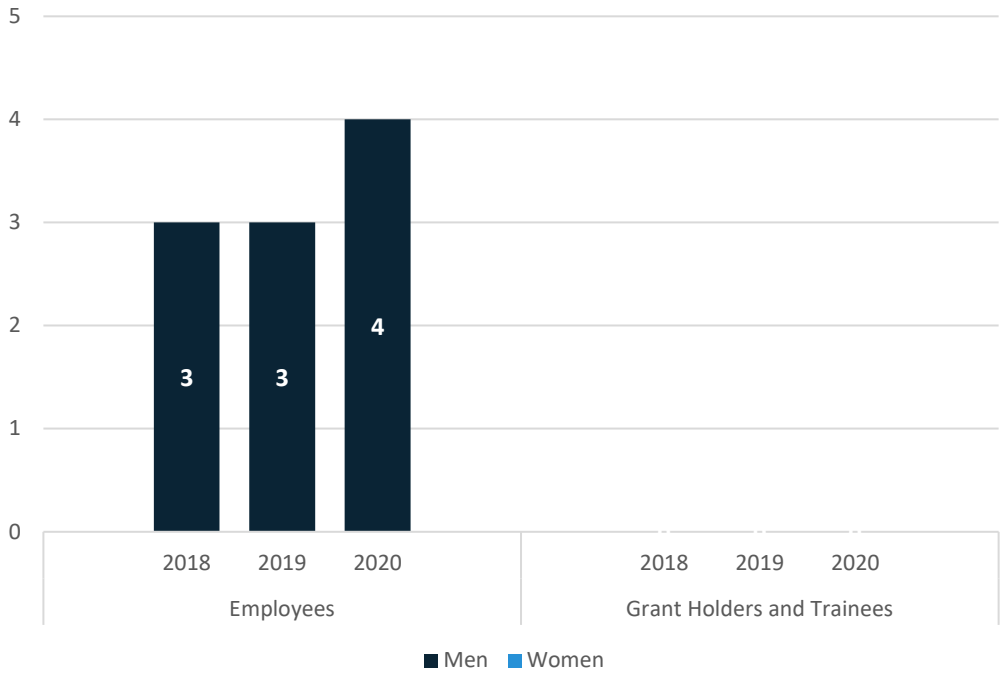


Figure 9.13.1 - SAS - Team composition and evolution

9.13.1 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. SAS is a member of the multidisciplinary Data Protection Team, appointed to support and monitor the implementation and compliance with the European General Data Protection Regulation. 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.

9.13.2 Highlights in 2020

During 2020, the INESC TEC teleworking due to the COVID-19 pandemic increased the usage of computational resources, collaborative services, and the helpdesk support as well.

The cluster hosted around 360 virtual machines, which includes the INESC TEC main services and Research & Development applications. The INESC TEC cluster in the Faculty of Sciences was moved to the new INESC TEC datacenter.

During 2020, a platform for Kubernetes management was deployed. The Gitlab service was upgraded so that it may be possible to integrate with different Kubernetes clusters per project.

The INESC TEC Identity Provider (IdP) was configured and then enabled on the beginning of 2020, allowing INESC TEC users to access FCCN and eduGAIN services, such as Colibri (Zoom), Videocast and Educast, with their INESC TEC Directory accounts.

SAS has the responsibility of administering and maintaining existing services/systems with minimal downtime and to continuously improve them. Next the main services available to end-users that are administered by SAS are highlighted:

- The mail server (mail.inesctec.pt), an on-premise Exchange mailbox server for the INESC TEC collaborators. During 2020, the mailbox server stored around 1400 mailboxes;
- The Drive (drive.inesctec.pt), an on-premises file access and sharing service for Services and Centres. During 2020, around 300 daily active users store 9 million files, summing a total of 10 TiB;
- The Gitlab (gitlab.inesctec.pt), an on-premise Git repository service. With more than 1000 users, the number of projects grew from around 1900 on 2019 to more than 2500 on 2020;
- The Chat (chat.inesctec.pt), an on-premises ChatOps service, grew from 60 teams with around 1000 users on 2019 to 75 teams with around 1600 users on 2020. A videconference server (Jitsi) was installed and integrated with the Chat service to enable users to easily make video calls;
- The RDM (rdm.inesctec.pt), the INESC TEC scientific dataset repository, has received 41 datasets from INESC TEC researchers until 2020;
- SAS hosted around 100 web sites during 2020, most of them are wordpress instances. SAS is responsible for the hosting and security monitoring of web framework instances;

Like in 2019, but increased with teleworking due to the COVID-19 pandemic, the tasks related with support to end-users and for Research and Development were those that took most of the time. Two members of the SAS team spent around 80% of their time on support requests. While the number or support requests handled and closed were more than 1400, a bit higher than in 2019, the nature of many of those support requests changed considerably, with impact on the time spent. These support tickets only account for less than 60% of the support requests, which means that more than 2400 support requests were solved during 2020, most of them from home.

The SAS Team manages around 210 PCs, more than 80 of services and 140 of centres. The management includes software and hardware maintenance.

In 2020, SAS renegociated the Kasperky, Adobe, Matworks, and Microsoft software license agreements, including Office 365 licenses for all the INESC TEC users with no additional costs.

Whenever required, SAS helps assistants and users assessing technical requirements of computer and software acquisitions and, when these are more complex, SAS also requests quotes.

SAS contributed actively on the Data Protection Team to several actions and tasks, mainly on: system security audit actions, and security policy definition; technology, infrastructures and data handling procedures analysis; awareness initiatives, seminars on data protection and research; and assistance on the identification of research projects with potential privacy and data protection implications.

9.14 INFRASTRUCTURE MANAGEMENT SERVICE

Manager: Jorge Couto

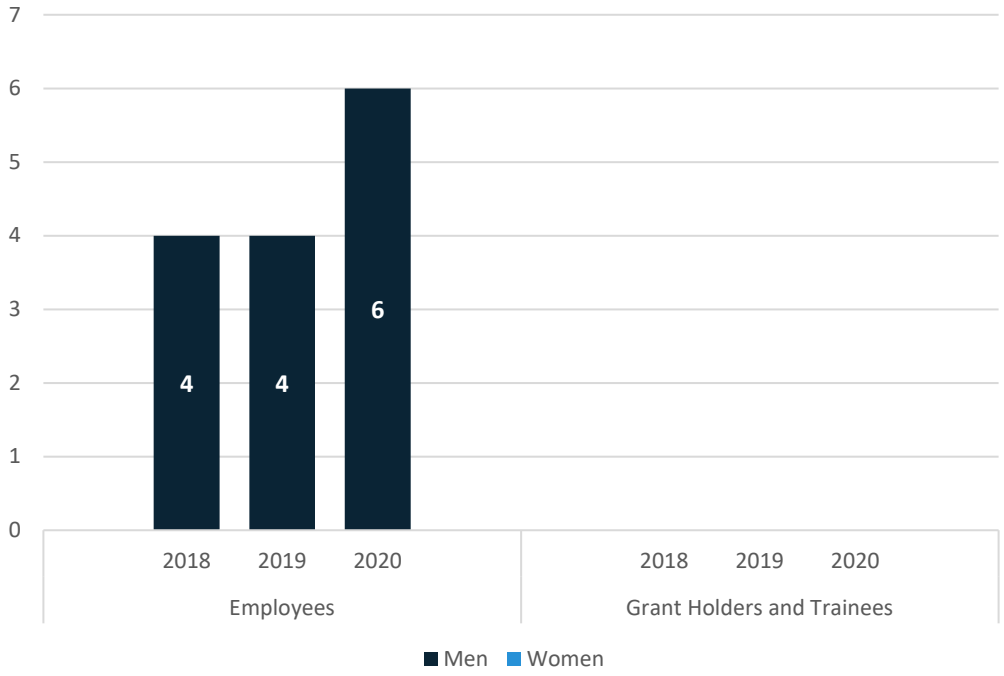


Figure 9.14.1 - SGI - Team composition and evolution

9.14.1 Presentation of the Service

The Infrastructure Management Service assures the support services necessary for the adequate management and maintenance of INESC TEC buildings infrastructures.

9.14.2 Highlights in 2020

The following achievements can be identified in the Service during 2020:

- Rationalisation and optimisation of the air conditioning system with the aim of improving comfort levels and reducing costs of operation;
- Actions to prevent and fight building fires were implemented, namely the improvement of overall equipment installed at INESC TEC buildings to detect and fight building fires. All the technical verifications were made, and a fire drill took place to test the adequacy of equipment and procedures;
- Improve internal processes allowing better maintenance and support services with the existing resources;
- Maintenance actions in the buildings' electrical infrastructure (transformer substation, main and partial LV switchboards and water pumps);
- Constant improvement of building conditions, including painting and rearrangement of several offices to improve working conditions;
- Constant follow-up of the Operational Activity Plan following COVID-19;
- Improvement of the conditions of lunchrooms and Bar Service, namely in the layout and all necessary changes related to COVID-19;

- Renewal of furniture, lighting and blinds in room 4.7, painting of ceilings and walls;
- Preventive maintenance of the electricity transformer stations in Buildings A and B, with cleaning and retightening of the transformer, and thermographic analysis of the transformers and Media voltage cells;
- New LV Switch Cabinet in the basement of A Building, to support 3 new wallbox for charging Electric Vehicles and to create new circuits for laboratory;
- Support to all Institutional, internal and external events;
- Secretarial support and services;
- Incorporate the measures outlined by the Social Responsibility Commission;
- Create electrical and access conditions for the new parking lot at Quinta de Santo António;
- Integration of a new element in the team to provide support to the new parking lot.

10 ANNEX I

10.1 CTM – ACTIVITY RESULTS IN 2020

10.1.1 Activity indicators

The following tables present CTM research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.1.1 - CTM - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	10	13	10	-3
		Academic Staff	14	15	14	-1
		Grant Holders and Trainees	53	46	52	6
		Total Core Researchers	**77**	**74**	**76**	**2**
		Total Core PhD	**25**	**27**	**26**	**-1**
	Affiliated Researchers		9	7	9	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		**87**	**82**	**86**	**4**
	Total Integrated PhD		**34**	**34**	**35**	**1**

Table 10.1.2 - CTM – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	257	474	470	-5
PN-PICT	National R&D Programmes - S&T Integrated Projects	290	95		-95
PN-COOP	National Cooperation Programmes with Industry	274	248	322	75
PUE-FP	EU Framework Programmes	189	245	240	-5
PUE-DIV	EU Cooperation Programmes - Other			-3	-3
SERV-NAC	R&D Services and Consulting - National	253	302	295	-7
SERV-INT	R&D Services and Consulting - International	116	89	123	34
OP	Other Funding Programmes	32	23	51	29
Total Funding		**1419**	**1 487**	**1 498**	**11**

Table 10.1.3 - CTM - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	26	35	39
Indexed Conferences	43	53	38
Books			
Book Chapters		7	2
Concluded PhD Theses - Members	6	4	3
Concluded PhD Theses - Supervised	9	7	3

Table 10.1.4 - CTM - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	1	3	1
Software copyright registrations	0	1	0
Patent first priority filings (New inventions)	1	0	0
Patent applications (Internationalisation)	8	12	4
Granted patents	5	3	2
Licence agreements	0	1	1
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.1.5 - CTM - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	5
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	4
International events in which INESC TEC members participate in the program committees	35
Participation in events such as fairs, exhibitions or similar	2
Conferences, workshops and scientific sessions organised by the Centre	3
Participants in the conferences, workshops and scientific sessions organised by the Centre	150
Advanced training courses organised by the Centre	2

Table 10.1.6 - CTM - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	EVOXANT	André Marçal	15/06/2016	15/06/2019
PN-FCT	TEC4SEA-1	Rui Lopes Campos	01/09/2017	30/08/2021
PN-FCT	Blueenergy	Manuel Cândido Santos	01/10/2018	31/03/2020
PN-FCT	CLARE	Jaime Cardoso	01/07/2018	31/10/2021
PN-FCT	LUCAS	Hélder Filipe Oliveira	26/07/2018	25/07/2021
PN-FCT	ENDURANCE	Luís Manuel Pessoa	01/07/2018	29/12/2020
PN-FCT	PEPCC	João Canas Ferreira	01/10/2018	31/12/2021
PN-FCT	GROW	Rui Lopes Campos	01/10/2018	31/07/2021
PN-FCT	AUTOMOTIVE	Ana Filipa Sequeira	01/10/2018	30/09/2021
PN-FCT	S-MODE	Hélder Filipe Oliveira	01/07/2018	30/06/2021
PN-FCT	HELP-MD	Matthew Davies	01/10/2018	30/09/2021
PN-FCT	NeurOxide	Vítor Grade Tavares	01/10/2018	30/09/2021
PN-FCT	XPERIMUS	Rui Penha	26/11/2018	25/11/2021
PN-COOP	BCCT.Plan	Hélder Filipe Oliveira	01/11/2016	30/04/2020
PN-COOP	5G	Manuel Ricardo	01/01/2018	31/03/2021
PN-COOP	CHIC	Paula Viana	01/10/2017	31/12/2020
PN-COOP	STRx	Luís Manuel Pessoa	01/05/2019	30/04/2022
PN-COOP	TAMI	Jaime Cardoso	01/04/2020	31/03/2023
PUE-FP	TERAPOD	Luís Manuel Pessoa	01/09/2017	31/05/2021
PUE-FP	FotoInMotion	Paula Viana	01/01/2018	31/12/2020
PUE-FP	RESPONDRONE	Rui Lopes Campos	01/05/2019	30/04/2022
PUE-FP	EuConNeCts4	Rui Lopes Campos	01/06/2019	01/12/2021
PUE-FP	InterConnect-1	Filipe André Ribeiro	01/10/2019	30/09/2023
SERV-NAC	Where.is	Luís Manuel Pessoa	01/12/2017	30/11/2019
SERV-NAC	FollicleCounter	Hélder Filipe Oliveira	01/12/2018	28/02/2021
SERV-NAC	Evo3DModel	Hélder Filipe Oliveira	01/02/2019	31/12/2020
SERV-NAC	EasyRide	Jaime Cardoso	01/01/2019	31/12/2021
SERV-NAC	v-CardID3	Ana Maria Rebelo	01/12/2018	30/09/2020
SERV-NAC	TenisApp2	Filipe André Ribeiro	01/10/2019	31/03/2021
SERV-NAC	CorkNetmon	Rui Lopes Campos	02/12/2019	30/04/2020
SERV-NAC	WiFi4DSO	Filipe André Ribeiro	20/12/2019	20/06/2020
SERV-NAC	STRx_Licenciamento	Filipe André Ribeiro	11/05/2020	11/05/2022
SERV-NAC	SLID	Luís Manuel Pessoa	01/11/2019	01/11/2021
SERV-INT	SIMBEDplus	Rui Lopes Campos	01/05/2019	30/04/2020
SERV-INT	NFCAD	Luís Manuel Pessoa	01/07/2019	30/09/2020
OP	Inphinit	Paula Viana	01/12/2019	01/12/2022
OP	IWBF2020	Ana Filipa Sequeira	25/10/2019	25/09/2020
OP	VISUM2020	Ana Maria Rebelo	01/10/2020	01/08/2021

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

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International Journals with Scientific Referees

1. Allahdadi, A, Morla, R, Cardoso, JS, "802.11 wireless simulation and anomaly detection using HMM and UBM", Simulation, pp.003754972095848, 2020
2. Bahubalindruni, PG, Tiwari, B, Pereira, M, Santa, A, Martins, J, Rovisco, A, Tavares, V, Martins, R, Fortunato, E, Barquinha, P, "Rail-to-Rail Timing Signals Generation Using InGaZnO TFTs For Flexible X-Ray Detector", IEEE Journal of the Electron Devices Society, vol.8, pp.157-162, 2020
3. Bessa, S, Gouveia, PF, Carvalho, PH, Rodrigues, C, Silva, NL, Cardoso, F, Cardoso, JS, Oliveira, HP, Cardoso, MJ, "3D Digital Breast Cancer Models with Multimodal Fusion Algorithms", The Breast, 2020
4. Cardoso, JS, Silva, W, Cardoso, MJ, "Evolution, current challenges, and future possibilities in the objective assessment of aesthetic outcome of breast cancer locoregional treatment", Breast, vol.49, pp.123-130, 2020
5. Clemente, MP, Moreira, A, Carvalho, N, Bernardes, G, Ferreira, AP, Amarante, JM, Mendes, J, "Orofacial Trauma on the Anterior Zone of a Trumpet's Player Maxilla: Concept of the Oral Rehabilitation-A Case Report", International Journal of Environmental Research and Public Health, vol.17, pp.1-19, DEC, 2020
6. Costa, DG, Vasques, F, Portugal, P, Aguiar, A, "A Distributed Multi-Tier Emergency Alerting System Exploiting Sensors-Based Event Detection to Support Smart City Applications", Sensors, vol.20, pp.170, 2020
7. Costa, DG, Vasques, F, Portugal, P, Aguiar, A, "On the Use of Cameras for the Detection of Critical Events in Sensors-Based Emergency Alerting Systems", Journal of Sensor and Actuator Networks, vol.9, pp.46, 2020
8. Derogarian Miyandoab, FD, Canas Ferreira, JC, Grade Tavares, VMG, Machado da Silva, JM, Velez, FJ, "A Multifunctional Integrated Circuit Router for Body Area Network Wearable Systems", IEEE/ACM Transactions on Networking, pp.1-14, 2020
9. Dias, LA, Ferreira, JC, Fernandes, MAC, "Parallel Implementation of K-Means Algorithm on FPGA", IEEE Access, vol.8, pp.41071-41084, 2020
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11. Ferreira, ML, Ferreira, JC, "A Dynamically Reconfigurable Dual-Waveform Baseband Modulator for Flexible Wireless Communications", Journal of Signal Processing Systems for Signal Image and Video Technology, vol.92, pp.409-424, APR, 2020
12. Gomes, R, Duarte, C, Pedro, JC, "Analysis and Design of a Polar Digitally Modulated CMOS PA Based on Switched Constant-Current", IEEE Transactions on Microwave Theory and Techniques, vol.68, pp.785-795, FEB, 2020
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14. Jesus, TC, Costa, DG, Portugal, P, Vasques, F, "FoV-Based Quality Assessment and Optimization for Area Coverage in Wireless Visual Sensor Networks", IEEE Access, vol.8, pp.109568-109580, 2020
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19. Martins, J, Cardoso, JS, Soares, F, "Offline computer -aided diagnosis for Glaucoma detection using fundus images targeted at mobile devices", Computer Methods and Programs in Biomedicine, vol.192, AUG, 2020

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28. Rio Torto, I, Fernandes, K, Teixeira, LF, "Understanding the decisions of CNNs: an in-model approach", Pattern Recognition Letters, 2020

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5. Araujo, JH, Kraemer, R, Santos, HM, Pereira, F, Salgado, HM, Pessoa, LM, "LASER diode-based transmitter module for optical wireless communications", 2020 12th International Symposium on Communication Systems, Networks and Digital Signal Processing, CSNDSP 2020, 2020

6. Araujo, JH, Kraemer, R, Tavares, JS, Pereira, F, Salgado, HM, Pessoa, LM, "5.36 Gbit/s OFDM optical wireless communication link over the underwater channel", 2020 12th International Symposium on Communication Systems, Networks and Digital Signal Processing, CSNDSP 2020, 2020

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8. Carvalho, G, Ferreira, JC, Tavares, VG, "Hardware architecture for integrate-and-fire signal reconstruction on FPGA", 2020 XXXV Conference on Design of Circuits and Integrated Systems (DCIS), 2020

9. Castro, E, Pereira, JC, Cardoso, JS, "Soft Rotation Equivariant Convolutional Neural Networks", 2020 International Joint Conference on Neural Networks (IJCNN), 2020

10. Coelho, A, Campos, R, Ricardo, M, "Proactive Queue Management for Flying Networks", 2020 IEEE 31st Annual International Symposium on Personal, Indoor and Mobile Radio Communications, 2020

11. Costa, DG, Vasques, F, Aguiar, A, Portugal, P, "Automatic Assignment of Emergency Vehicles in Response to Sensors-based Generated Alarms in Smart City Scenarios", IEEE International Smart Cities Conference, ISC2 2020, Piscataway, NJ, USA, September 28 - October 1, 2020, pp.1-7, 2020

12. Cruz, R, Fontes, H, Ruela, J, Ricardo, M, Campos, R, "On the Reproduction of Real Wireless Channel Occupancy in ns-3", 12th Workshop on ns-3, WNS3, vol.abs/2003.05256, 2020

13. da Silva, EP, Ramos, EM, da Silva, LT, Cardoso, JS, Giraldi, GA, "Video Summarization through Total Variation, Deep Semi-supervised Autoencoder and Clustering Algorithms", VISAPP: PROCEEDINGS OF THE 15TH International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, Vol 4: Visapp, pp.315-322, 2020

14. Ferreira, A, Silva, J, Brito, F, Sinha, D, "Impact of a shift-invariant harmonic phase model in fully parametric harmonic voice representation and time/frequency synthesis", ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings, vol.2020-May, pp.701-705, 2020

15. Ferreira, P, Teixeira, JG, Teixeira, LF, "Understanding the Impact of Artificial Intelligence on Services", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.202-213, 2020

16. Ferreira, PM, Pernes, D, Rebelo, A, Cardoso, JS, "Learning signer-invariant representations with adversarial training", Twelfth International Conference on Machine Vision (ICMV 2019), 2020

17. Fonseca, P, Gericota, M, Tavares, VG, Matos, JN, "Recent activities by IEEE education society portugal chapter", IEEE Global Engineering Education Conference, EDUCON, vol.2020-April, pp.1928-1931, 2020

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19. Goncalves, T, Silva, W, Cardoso, J, "Deep Aesthetic Assessment of Breast Cancer Surgery Outcomes", IFMBE Proceedings, vol.76, pp.1967-1983, 2020

20. Lourenco, C, Tjepkema Cloostermans, MC, Teixeira, LF, van Putten, MJAM, "Deep Learning for Interictal Epileptiform Discharge Detection from Scalp EEG Recordings", IFMBE Proceedings, vol.76, pp.1984-1997, 2020

21. Magalhaes, E, Jacob, J, Nilsson, N, Nordahl, R, Bernardes, G, "Physics-based Concatenative Sound Synthesis of Photogrammetric models for Aural and Haptic Feedback in Virtual Environments", Proceedings - 2020 IEEE Conference on Virtual Reality and 3D User Interfaces, VRW 2020, pp.376-379, 2020

22. Magalhães, P, d'Orey, PM, Andrade, MT, Castro, F, "Video-assisted overtaking system enabled by C-V2X mode 4 communications", International Conference on Wireless and Mobile Computing, Networking and Communications, vol.2020-October, 2020

23. Malafaya, D, Domingues, S, Oliveira, HP, "Domain Adaptation for Heart Rate Extraction in the Neonatal Intensive Care Unit", IEEE International Conference on Bioinformatics and Biomedicine, BIBM 2020, Virtual Event, South Korea, December 16-19, 2020, pp.1082-1086, 2020

24. Paulino, N, Ferreira, JC, Bispo, J, Cardoso, JMP, "Executing ARMv8 Loop Traces on Reconfigurable Accelerator via Binary Translation Framework", 30th International Conference on Field-Programmable Logic and Applications, FPL 2020, Gothenburg, Sweden, August 31 - September 4, 2020, pp.367, 2020

25. Pinto, JR, Cardoso, JS, "Explaining ECG Biometrics: Is It All in the QRS?", BIOSIG 2020 - Proceedings of the 19th International Conference of the Biometrics Special Interest Group, online, 16.-18. September 2020., vol. 306, pp.139-150, 2020

26. Pinto, JR, Cardoso, JS, "Self-Learning with Stochastic Triplet Loss", 2020 International Joint Conference on Neural Networks (IJCNN), 2020

27. Pinto, JR, Cardoso, JS, Correia, MV, "Secure Triplet Loss for End-to-End Deep Biometrics", 2020 8th International Workshop on Biometrics and Forensics (IWBF), 2020

28. Pinto, JR, Gonçalves, T, Pinto, C, Sanhudo, L, Fonseca, J, Gonçalves, F, Carvalho, P, Cardoso, JS, "Audiovisual Classification of Group Emotion Valence Using Activity Recognition Networks", 2020 IEEE 4th International Conference on Image Processing, Applications and Systems (IPAS), 2020

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30. Sequeira, AF, Silva, W, Pinto, JR, Goncalves, T, Cardoso, JS, "Interpretable Biometrics: Should We Rethink How Presentation Attack Detection is Evaluated?", 8th International Workshop on Biometrics and Forensics, IWBF 2020, Porto, Portugal, April 29-30, 2020, pp.1-6, 2020
31. Silva, JMD, Cerrone, I, Malagon, D, Marinho, J, Mundy, S, Gaspar, J, Mendes, JG, "An Active Implant to Restore Dental Proprioceptivity", 2020 23rd Euromicro Conference on Digital System Design (DSD), 2020
32. Silva, W, Poellinger, A, Cardoso, JS, Reyes, M, "Interpretability-guided content-based medical image retrieval", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12261 LNCS, pp.305-314, 2020
33. Teixeira, FB, Moreira, N, Abreu, N, Ferreira, BM, Ricardo, M, Campos, R, "UDMSim: A Simulation Platform for Underwater Data Muling Communications", 16th International Conference on Wireless and Mobile Computing, Networking and Communications, WiMob 2020, Thessaloniki, Greece, October 12-14, 2020, vol.2020-October, pp.1-6, 2020
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35. Teixeira, JF, Bessa, S, Gouveia, PF, Oliveira, HP, "A Framework for Fusion of T1-Weighted and Dynamic MRI Sequences", Lecture Notes in Computer Science - Image Analysis and Recognition, pp.157-169, 2020
36. Teixeira, JF, Carreiro, AM, Santos, RM, Oliveira, HP, "B-Mode Ultrasound Breast Anatomy Segmentation", Lecture Notes in Computer Science - Image Analysis and Recognition, pp.193-201, 2020
37. Viana, P, Carvalho, P, Andrade, MT, Jonker, PP, Papanikolaou, V, Teixeira, IN, Vilaça, L, Pinto, JP, Costa, T, "Semantic Storytelling Automation: A Context-Aware and Metadata-Driven Approach", Proceedings of the 28th ACM International Conference on Multimedia, 2020
38. Vieira Marques, P, Teixeira, JF, Valente, J, Pinho, B, Guedes, R, Almeida, R, Jacome, C, Pereira, A, Jacinto, T, Amaral, R, Goncalves, I, Sousa, AS, Couto, M, Pereira, M, Magalhaes, M, Bordalo, D, Silva, LN, Fonseca, JA, "Combined Image-Based Approach for Monitoring the Adherence to Inhaled Medications", XV Mediterranean Conference on Medical and Biological Engineering and Computing - Medicon 2019, vol.76, pp.1399-1404, 2020

Books

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Chapter/Paper in Books

1. Corintha, I, Outeiro, L, Dias, R, Bernardes, G, "AM-I-BLUES: An Interactive Digital Music Instrument for Guiding Novice Pianist in the Improvisation of Jazz Melodies", Springer Series in Design and Innovation - Advances in Design, Music and Arts, pp.689-698, 2020
2. Lopes Ferreira, M, Canas Ferreira, J, "Flexible Baseband Modulator Architecture for Multi-Waveform 5G Communications", Field Programmable Gate Arrays (FPGAs) II, 2020

Publications (Editor)

Blank

Dissertations (PhD)

1. Allahdadidastjerdi, A., “Performance Anomaly Detection in 802.11 Wireless Networks Applying Hidden Markov Models”.

2. Ferreira, P., “Sign Language Recognition: Integrating Prior Domain Knowledge into Deep Neural Networks”.
3. Santos, H., “Antenna Design for Integration into Active Devices Targeting 5G and Beyond”.

10.2 CAP – ACTIVITY RESULTS IN 2020

10.2.1 Activity indicators

The following tables present CAP research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.2.1 - CAP – Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	8	9	10	1
		Academic Staff	7	8	8	0
		Grant Holders and Trainees	17	13	18	5
		Total Core Researchers	**32**	**30**	**36**	**6**
		Total Core PhD	**15**	**15**	**15**	**0**
	Affiliated Researchers		5	5	5	0
	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	**39**	**37**	**42**	**5**
		Total Integrated PhD	**20**	**20**	**20**	**0**

Table 10.2.2 - CAP - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	214	370	289	-81
PN-PICT	National R&D Programmes - S&T Integrated Projects	220	81	22	-58
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes		22	211	190
PUE-DIV	EU Cooperation Programmes - Other	35	70	38	-32
SERV-NAC	R&D Services and Consulting - National	34	46	46	0
SERV-INT	R&D Services and Consulting - International	15		4	4
OP	Other Funding Programmes				
	Total Funding	**540**	**608**	**610**	**3**

Table 10.2.3 - CAP - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	22	25	22
Indexed Conferences	12	29	2
Books			
Book Chapters			
Concluded PhD Theses - Members	4		
Concluded PhD Theses - Supervised	4	1	

Table 10.2.4 - CAP - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	3	1	2
Software copyright registrations	0	0	0
Patent first priority filings (New inventions)	3	0	2
Patent applications (Internationalisation)	4	4	9
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs established	0	0	0
Spin-offs in development	0	1	1

Table 10.2.5 - CAP - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	16
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	5
Participation in events such as fairs, exhibitions or similar	1
Conferences, workshops and scientific sessions organised by the Centre	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	300
Advanced training courses organised by the Centre	0

Table 10.2.6 - CAP - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	TEC4SEA-2	Pedro Jorge	01/09/2017	30/08/2021
PN-FCT	FLAPSYS	Pedro Jorge	01/03/2018	30/09/2021
PN-FCT	SolSensors	Luís Carlos Coelho	01/05/2018	30/04/2021
PN-FCT	ENDOR	Orlando Frazão	01/06/2018	31/05/2021
PN-FCT	MetBots	Rui Costa Martins	26/07/2018	24/07/2021
PN-FCT	GreenNanoSensing	Ariel Guerreiro	01/07/2018	30/06/2021
PUE-DIV	CostActions	José Luís Santos	01/01/2008	
PUE-DIV	AGRINUPES-1	Pedro Jorge	01/04/2017	31/12/2020
PUE-DIV	SAFEWATER	Pedro Jorge	03/04/2018	02/04/2021
PUE-FP	INSite-1	Pedro Jorge	01/01/2020	31/12/2022
PUE-FP	WiPTherm	Orlando Frazão	01/11/2019	31/10/2022
SERV-NAC	LED	Paulo Vicente Marques	19/12/2018	18/06/2020
SERV-NAC	SmartEcotec	Ireneu Dias	01/12/2019	31/10/2020
SERV-NAC	OpTweezers	Ireneu Dias	01/11/2019	01/11/2020
SERV-NAC	GREENPEG	Pedro Jorge	01/12/2020	01/01/2021
SERV-NAC	CONSAIL	Orlando Frazão	01/01/2021	01/01/2022
SERV-INT	ESAPlastics-1	Ireneu Dias	01/10/2019	28/02/2021

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

10.2.2 List of Publications

International Journals with Scientific Referees

1. Alves, RA, Guerreiro, A, Navarro Cia, M, "Bridging the hydrodynamic Drude model and local transformation optics theory", Physical Review B, vol.101, 2020
2. Amorim, VA, Maia, JM, Viveiros, D, Marques, PVS, "Inscription of surface waveguides in glass by femtosecond laser writing for enhanced evanescent wave overlap", Journal of Optics, vol.22, AUG, 2020
3. Dantas, D, Soares, L, Novais, S, Vilarinho, R, Moreira, JA, Silva, S, Frazao, O, Oliveira, T, Leal, N, Faisca, P, Reis, J, "Discrimination of benign and malignant lesions in canine mammary tissue samples using Raman spectroscopy: A pilot study", Animals, vol.10, pp.1-16, 2020
4. Ferreira, TD, Silva, NA, Bertolami, O, Gomes, C, Guerreiro, A, "Using numerical methods from nonlocal optics to simulate the dynamics of N -body systems in alternative theories of gravity", Physical Review E, vol.101, 2020
5. Gomes, AD, Ferreira, MS, Bierlich, J, Kobelke, J, Rothhardt, M, Bartelt, H, Frazao, O, "Hollow microsphere combined with optical harmonic Vernier effect for strain and temperature discrimination", Optics and Laser Technology, vol.127, pp.106198, JUL, 2020

6. Gomes, AD, Kobelke, J, Bierlich, J, Dellith, J, Rothhardt, M, Bartelt, H, Frazao, O, "Giant refractometric sensitivity by combining extreme optical Vernier effect and modal interference", SCIENTIFIC REPORTS, vol.10, 2020

7. Linhares, CC, Santo, JE, Teixeira, RR, Coutinho, CP, Tavares, SMO, Pinto, M, Costa, JS, Mendes, H, Monteiro, CS, Rodrigues, AV, Frazão, O, "Magnetostriction assessment with strain gauges and fiber bragg gratings", EAI Endorsed Transactions on Energy Web, vol.7, pp.161420, 2020

8. Magalhaes, R, Silva, S, Frazao, O, "Curvature Sensor Based on a Long-Period Grating in a Fiber Ring Resonator Interrogated by an OTDR", Photonic Sensors, vol.10, pp.1-6, 2020

9. Maia, JM, Amorim, VA, Viveiros, D, Marques, PVS, "Magnetic field sensors in fused silica fabricated by femtosecond laser micromachining", Journal of Physics: Photonics, vol.2, pp.015003, 2020

10. Mendes, JP, Coelho, L, Pereira, CM, Jorge, PAS, "Colorimetry-based system for gaseous carbon dioxide detection: Membrane optimization", U.Porto Journal of Engineering, vol.6, pp.59-69, 2020

11. Monteiro, CS, Raposo, M, Ribeiro, PA, Silva, SO, Frazao, O, "Tuning of Fiber Optic Surface Reflectivity through Graphene Oxide-Based Layer-by-Layer Film Coatings", Photonics, vol.7, pp.11, 2020

12. Moura Alves, M, Gouveia, AR, de Almeida, JMMM, Monteiro Silva, F, Silva, JA, Saraiva, C, "Behavior of Listeria monocytogenes in beef Sous vide cooking with Salvia officinalis L. essential oil, during storage at different temperatures", LWT, vol.132, pp.109896, 2020

13. Novais, S, Silva, SO, Frazao, O, "Curvature detection in a medical needle using a Fabry-Perot cavity as an intensity sensor", Measurement: Journal of the International Measurement Confederation, pp.107160, 2020

14. Paiva, JS, Jorge, PAS, Ribeiro, RSR, Balmana, M, Campos, D, Mereiter, S, Jin, CS, Karlsson, NG, Sampaio, P, Reis, CA, Cunha, JPS, "iLoF: An intelligent Lab on Fiber Approach for Human Cancer Single-Cell Type Identification", Scientific reports, vol.10, pp.3171, 2020

15. Ribeiro Robalinho, PMR, Gomes, AD, Frazao, O, "High Enhancement Strain Sensor based on Vernier Effect using 2-Fiber Loop Mirrors", IEEE Photonics Technology Letters, pp.1-1, 2020

16. Rocha, J, Abreu, T, Felgueiras, C, "Evaluation of potential tidal impoundment energy systems in Ria de Aveiro, Portugal", Energy Reports, vol.6, pp.226-230, DEC, 2020

17. Roriz, P, Silva, S, Frazao, O, Novais, S, "Optical Fiber Temperature Sensors and Their Biomedical Applications", Sensors, vol.20, pp.2113, 2020

18. Santos, LO, Xu, M, Virtuoso, F, "Probabilistic structural analysis of Sao Joao Bridge based on the on-site study of the time-dependent behavior of concrete", Structural Concrete, vol.21, pp.1298-1308, AUG, 2020

19. Silva, NA, Almeida, AL, Ferreira, TD, Guerreiro, A, "Dissipative solitons in an atomic medium assisted by an incoherent pumping field", Journal of Physics B: Atomic, Molecular and Optical Physics, 2020

20. Soares, L, Novais, S, Ferreira, A, Frazao, O, Silva, S, "Detection of the Crystallization Process of Paracetamol with a Multi-Mode Optical Fiber in a Reflective Configuration", SENSORS, vol.20, pp.87, Jan, 2020

21. Viveiros, D, Amorim, VA, Maia, JM, Silva, S, Frazao, O, Jorge, PAS, Fernandes, LA, Marques, PVS, "Femtosecond laser direct written off-axis fiber Bragg gratings for sensing applications", Optics and Laser Technology, vol.128, pp.106227, 2020

22. Viveiros, D, de Almeida, JMMM, Coelho, L, Vasconcelos, H, Maia, JM, Amorim, VA, Jorge, PAS, Marques, PVS, "Temperature Stability and Spectral Tuning of Long Period Fiber Gratings Fabricated by Femtosecond Laser Direct Writing", Sensors, vol.20, pp.3898, 2020

International Conference Proceedings with Scientific Referees

1. Vasconcelos, H, Almeida, JMMM, Saraiva, C, Viveiros, D, Jorge, PAS, Coelho, L, "Preliminary assessment on the detection of putrescine using long period fiber gratings coated with titanium dioxide and poly (ethylene-co-vinyl acetate)", Proceedings of SPIE - The International Society for Optical Engineering, vol.11354, 2020
2. Viveiros, D, De Almeida, JMMM, Coelho, L, Vasconcelos, H, Amorim, VA, Maia, JM, Jorge, PAS, Marques, PVS, "Femtosecond laser-written long period fibre gratings coated with titanium dioxide for improved sensitivity", Optical Sensing and Detection VI, 2020

Books

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Chapter/paper in Books

Blank

Publications (Editor)

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Dissertations (PhD)

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10.3 CRAS – ACTIVITY RESULTS IN 2020

10.3.1 Activity indicators

The following tables present CRAS research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.3.1 - CRAS - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	11	12	18	6
		Academic Staff	11	11	12	1
		Grant Holders and Trainees	22	25	32	7
		Total Core Researchers	**44**	**48**	**62**	**14**
		Total Core PhD	**14**	**14**	**16**	**2**
	Affiliated Researchers		0	0	0	0
	Administrative and Technical	Employees	4	3	3	0
		Grant Holders and Trainees	1	0	0	0
		Total Admin and Tech	**5**	**3**	**3**	**0**
		Total Integrated HR	**49**	**51**	**65**	**14**
		Total Integrated PhD	**14**	**14**	**16**	**2**

Table 10.3.2 - CRAS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	337	482	507	25
PN-PICT	National R&D Programmes - S&T Integrated Projects	101	13		-13
PN-COOP	National Cooperation Programmes with Industry	200	147	210	63
PUE-FP	EU Framework Programmes	530	276	767	491
PUE-DIV	EU Cooperation Programmes - Other	102	201	124	-78
SERV-NAC	R&D Services and Consulting - National	33	61	73	13
SERV-INT	R&D Services and Consulting - International	115	132	222	90
OP	Other Funding Programmes	94	7	28	21
	Total Funding	**1 511**	**1 380**	**1 932**	**552**

Table 10.3.3 - CRAS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	8	16	10
Indexed Conferences	27	29	10
Books			
Book Chapters	1		1
Concluded PhD Theses - Members	1		1
Concluded PhD Theses - Supervised	1		1

Table 10.3.4 - CRAS - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	1	1	0
Software copyright registrations	0	1	0
Patent first priority filings (New inventions)	2	0	0
Patent applications (Internationalisation)	2	2	4
Granted patents	0	0	0
Licence agreements	0	1	0
Spin-offs established	0	0	0
Spin-offs in development	0	1	1

Table 10.3.5 - CRAS - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	8
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	19
Participation in events such as fairs, exhibitions or similar	22
Conferences, workshops and scientific sessions organised by the Centre	2
Participants in the conferences, workshops and scientific sessions organised by the Centre	320
Advanced training courses organised by the Centre	2

Table 10.3.6 - CRAS - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	TEC4SEA	Eduardo Silva	01/09/2017	30/08/2021
PN-FCT	EMSO-PT	Aníbal Matos	01/07/2017	29/06/2021
PN-FCT	BIOREM	André Dias	01/06/2018	31/05/2021
PN-FCT	DIIUS	Andry Maykol Pinto	26/07/2018	25/07/2021
PN-FCT	ENDURANCE-1	Nuno Cruz	01/07/2018	29/12/2020
PN-FCT	GROW-1	Bruno Filipe Ferreira	01/10/2018	31/07/2021
PN-FCT	QuALTOS	Nuno Cruz	01/01/2020	31/12/2021
PN-COOP	FEEDFIRST	Eduardo Silva	01/01/2018	30/06/2021
PN-COOP	HiperSea	Eduardo Silva	01/07/2018	30/06/2021
PN-COOP	NESSIE	Aníbal Matos	01/01/2019	31/12/2021
PN-COOP	K2D	Aníbal Matos	01/07/2020	01/07/2023
PUE-DIV	PROTOATLANTIC	Eduardo Silva	01/11/2017	30/04/2021
PUE-DIV	INTENDU	Aníbal Matos	01/03/2018	28/02/2021
PUE-DIV	Prince	Hugo Miguel Silva	01/01/2019	31/12/2021
PUE-DIV	Nettag	Alfredo Martins	01/01/2019	30/06/2021
PUE-DIV	SHIELD	Hugo Miguel Silva	01/09/2020	31/08/2022
PUE-FP	VAMOS	Eduardo Silva	01/02/2015	31/01/2019
PUE-FP	Mine_Heritage	Eduardo Silva	01/01/2019	31/12/2021
PUE-FP	SPRING	Aníbal Matos	01/08/2019	31/07/2023
PUE-FP	DEEPFIELD	Eduardo Silva	01/10/2019	30/09/2022
PUE-FP	INSite	Diana Viegas	01/01/2020	31/12/2022
PUE-FP	ATLANTIS	Andry Maykol Pinto	01/01/2020	31/12/2022
PUE-FP	UNEXUP	José Miguel Almeida	01/01/2020	31/12/2022
SERV-NAC	Modulmar	Eduardo Silva	01/01/2019	28/02/2021
SERV-INT	ESAPlastics	Eduardo Silva	01/10/2019	28/02/2021
SERV-INT	SantoAntonio	Aníbal Matos	01/03/2019	31/07/2020
SERV-INT	KRISO 2020	José Miguel Almeida	15/08/2020	15/12/2020
SERV-INT	NoduleMiner6k	José Miguel Almeida	06/11/2020	06/03/2021
OP	Sail2020	Eduardo Silva	01/01/2020	31/12/2022
OP	INTHEBLACK2019	Eduardo Silva	03/04/2019	27/06/2019

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

10.3.2 List of Publications

International Journals with Scientific Referees

1. Almeida, J, Matias, B, Ferreira, A, Almeida, C, Martins, A, Silva, E, "Underwater Localization System Combining iUSBL with Dynamic SBL in ¡VAMOS! Trials", Sensors, vol.20, pp.4710, 2020
2. Diamant, R, Shachar, I, Makovsky, Y, Ferreira, BM, Cruz, NA, "Cross-Sensor Quality Assurance for Marine Observatories", Remote Sensing, vol.12, pp.1-16, NOV, 2020
3. dos Santos, PL, Freigoun, MT, Martin, CA, Rivera, DE, Hekler, EB, Romano, RA, Azevedo Perdicoulis, TPA, "System Identification of Just Walk: Using Matchable-Observable Linear Parametrizations", IEEE Transactions on Control Systems Technology, pp.1-12, 2020
4. Duarte, AJ, Malheiro, B, Arno, E, Perat, I, Silva, MF, Fuentes Dura, P, Guedes, P, Ferreira, P, "Engineering Education for Sustainable Development: The European Project Semester Approach", IEEE Transactions on Education, pp.1-10, 2020
5. Ferreira, A, Matias, B, Almeida, J, Silva, E, "Real-time GNSS precise positioning: RTKLIB for ROS", International Journal of Advanced Robotic Systems, vol.17, pp.172988142090452, 2020
6. Figueiredo, AB, Matos, AC, "MViDO: A high performance monocular vision-based system for docking a hovering AUV", Applied Sciences (Switzerland), vol.10, pp.2991, 2020
7. Leal, F, Veloso, B, Malheiro, B, Gonzalez Velez, H, Carlo Burguillo, JC, "A 2020 perspective on “Scalable modelling and recommendation using wiki-based crowdsourced repositories:” Fairness, scalability, and real-time recommendation", Electronic Commerce Research and Applications, pp.100951, 2020
8. Pinto, AM, Matos, AC, "MARESye: A hybrid imaging system for underwater robotic applications", Information Fusion, vol.55, pp.16-29, MAR, 2020
9. Teixeira, B, Silva, H, Matos, A, Silva, E, "Deep Learning for Underwater Visual Odometry Estimation", IEEE Access, vol.8, pp.44687-44701, 2020
10. Veloso, BM, Leal, F, Malheiro, B, Carlos Burguillo, JC, "A 2020 perspective on “Online guest profiling and hotel recommendation”", Electronic Commerce Research and Applications, pp.100957, 2020

International Conference Proceedings with Scientific Referees

1. Barbosa, J, Dias, A, Almeida, J, Silva, E, "Evaluation of Lightweight Convolutional Neural Networks for Real-Time Electrical Assets Detection", Advances in Intelligent Systems and Computing, vol.1092 AISC, pp.99-112, 2020
2. Campos, DF, Matos, A, Pinto, AM, "Multi-domain mapping for offshore asset inspection using an autonomous surface vehicle", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2020, pp.221-226, 2020
3. Fernandes, D, Pinheiro, F, Dias, A, Martins, A, Almeida, J, Silva, E, "Teaching robotics with a simulator environment developed for the autonomous driving competition", Advances in Intelligent Systems and Computing, vol.1023, pp.387-399, 2020
4. Leal, F, Veloso, B, Malheiro, B, Vélez, HG, "Trust and Reputation Smart Contracts for Explainable Recommendations", Trends and Innovations in Information Systems and Technologies - Advances in Intelligent Systems and Computing, pp.124-133, 2020
5. Leite, PN, Silva, RJ, Campos, DF, Pinto, AM, "Dense disparity maps from rgb and sparse depth information using deep regression models", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12131 LNCS, pp.379-392, 2020
6. Silva, P, Dias, A, Pires, A, Santos, T, Amaral, A, Rodrigues, P, Almeida, J, Silva, E, "3d reconstruction of historical sites using an uav", Robots in Human Life- Proceedings of the 23rd International Conference

on Climbing and Walking Robots and the Support Technologies for Mobile Machines, CLAWAR 2020, pp.121-128, 2020

7. Silva, RJ, Leite, PN, Pinto, AM, "Multi-agent optimization for offshore wind farm inspection using an improved population-based metaheuristic", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2020, pp.53-60, 2020
8. Teixeira, FB, Moreira, N, Abreu, N, Ferreira, BM, Ricardo, M, Campos, R, "UDMSim: A Simulation Platform for Underwater Data Muling Communications", 16th International Conference on Wireless and Mobile Computing, Networking and Communications, WiMob 2020, Thessaloniki, Greece, October 12-14, 2020, vol.2020-October, pp.1-6, 2020
9. Veloso, B, Malheiro, B, Burguillo, JC, Gama, J, "Impact of Trust and Reputation Based Brokerage on the CloudAnchor Platform", Advances in Practical Applications of Agents, Multi-Agent Systems, and Trustworthiness. The PAAMS Collection - Lecture Notes in Computer Science, pp.303-314, 2020
10. Zhu, A, Beer, C, Juhandi, K, Orlov, M, Bacau, NL, Kádár, L, Duarte, AJ, Malheiro, B, Justo, J, Silva, MF, Ribeiro, MC, Ferreira, PD, Guedes, P, "Sail Car—An EPS©ISEP 2019 Project", 2020 IEEE Global Engineering Education Conference (EDUCON), 2020

Books

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Chapter/Paper in Books

1. Azevedo Perdicoúlis, T, Jank, G, Lopes dos Santos, P, "Existence of Open Loop Equilibria for Disturbed Stackelberg Games", Systems of Systems - Engineering, Modeling, Simulation and Analysis [Working Title], 2020

Publications (Editor)

Blank

Dissertations (PhD)

1. Figueiredo, A., “Monocular vision-based system for docking a hovering AUV”.

10.4 C-BER – ACTIVITY RESULTS IN 2020

10.4.1 Activity indicators

The following tables present C-BER research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.4.1 - CBER - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	2	2	5	3
		Academic Staff	6	7	6	-1
		Grant Holders and Trainees	19	11	11	0
		Total Core Researchers	**27**	**20**	**22**	**2**
		Total Core PhD	**11**	**10**	**9**	**-1**
	Affiliated Researchers		0	1	1	0
	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	**28**	**22**	**24**	**2**
		Total Integrated PhD	**11**	**11**	**9**	**-2**

Table 10.4.2 – CBER - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	182	215	153	-61
PN-PICT	National R&D Programmes - S&T Integrated Projects	354	52		-52
PN-COOP	National Cooperation Programmes with Industry	1		28	28
PUE-FP	EU Framework Programmes				
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	7	3	35	32
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes				
	Total Funding	**544**	**272**	**216**	**-55**

Table 10.4.3 – CBER - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	19	22	23
Indexed Conferences	32	32	16
Books	1		
Book Chapters	1	4	
Concluded PhD Theses - Members			
Concluded PhD Theses - Supervised	1	1	

Table 10.4.4 – CBER - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	2	2	3
Software copyright registrations	2	0	1
Patent first priority filings (New inventions)	1	0	2
Patent applications (Internationalisation)	6	8	6
Granted patents	5	2	4
Licence agreements	0	0	0
Spin-offs established	0	1	0
Spin-offs in development	1	2	2

Table 10.4.5 – CBER - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	4
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	4
International events in which INESC TEC members participate in the program committees	11
Participation in events such as fairs, exhibitions or similar	2
Conferences, workshops and scientific sessions organised by the Centre	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	130
Advanced training courses organised by the Centre	0

Table 10.4.6 – CBER - List of projects

Type of Project	Short Nme	Leader	Starting date	Ending date (planned)
PN-FCT	SCREEN-DR	Aurélio Campilho	01/04/2016	31/12/2020
PN-FCT	PERFECT-1	João Paulo Cunha	01/07/2018	30/06/2021
PN-FCT	LUCAS-1	João Paulo Cunha	26/07/2018	25/07/2021
PN-FCT	WalkingPAD-1	Miguel Velhote Correia	11/11/2019	09/11/2021
PN-FCT	CAIRUS	João Claro	04/05/2020	04/08/2020
PN-FCT	CXR_AI4COVID19	Aurélio Campilho	01/05/2020	30/09/2020
PN-COOP	TexBoost	Miguel Velhote Correia	01/07/2017	31/12/2020
PN-COOP	TAMI-1	Aurélio Campilho	01/04/2020	31/03/2023
SERV-NAC	BioNanoTech	João Paulo Cunha	01/01/2020	01/01/2021

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

10.4.2 List of Publications

International Journals with Scientific Referees

1. Araujo, T, Aresta, G, Mendonca, L, Penas, S, Maia, C, Carneiro, A, Maria Mendonca, AM, Campilho, A, "DR|GRADUATE: uncertainty-aware deep learning-based diabetic retinopathy grading in eye fundus images", Medical Image Analysis, pp.101715, 2020
2. Araujo, T, Aresta, G, Mendonca, L, Penas, S, Maia, C, Carneiro, A, Mendonca, AM, Campilho, A, "Data Augmentation for Improving Proliferative Diabetic Retinopathy Detection in Eye Fundus Images", IEEE Access, vol.8, pp.182462-182474, 2020
3. Aresta, G, Ferreira, C, Pedrosa, J, Araujo, T, Rebelo, J, Negrao, E, Morgado, M, Alves, F, Cunha, A, Ramos, I, Campilho, A, "Automatic lung nodule detection combined with gaze information improves radiologists' screening performance", IEEE Journal of Biomedical and Health Informatics, pp.1-1, 2020
4. Cvijic, M, Bézy, S, Petrescu, A, Santos, P, Orlowska, M, Chakraborty, B, Duchenne, J, Pedrosa, J, Vanassche, T, D'Hooge, J, Voigt, JU, "Interplay of cardiac remodelling and myocardial stiffness in hypertensive heart disease: a shear wave imaging study using high-frame rate echocardiography", European Heart Journal - Cardiovascular Imaging, 2020
5. Martins, M, Gomes, P, Oliveira, C, Coimbra, M, da Silva, HP, "Design and Evaluation of a Diaphragm for Electrocardiography in Electronic Stethoscopes", IEEE Transactions on Biomedical Engineering, vol.67, pp.391-398, FEB, 2020
6. Melo, T, Mendonca, AM, Campilho, A, "Microaneurysm detection in color eye fundus images for diabetic retinopathy screening", Computers in Biology and Medicine, pp.103995, 2020
7. Mesquita, IA, Pereira da Fonseca, PFP, Borgonovo Santos, M, Ribeiro, E, Vieira Pinheiro, ARV, Correia, MV, Silva, C, "Comparison of upper limb kinematics in two activities of daily living with different handling requirements", Human Movement Science, vol.72, AUG, 2020

8. Murias Lopes, E, Vilas Boas, MD, Dias, D, Rosas, MJ, Vaz, R, Silva Cunha, JP, "IHandU: A novel quantitative wrist rigidity evaluation device for deep brain stimulation surgery", Sensors (Switzerland), vol.20, pp.331, 2020

9. Narciso, D, Melo, M, Raposo, JV, Cunha, J, Bessa, M, "Virtual reality in training: an experimental study with firefighters", Multimedia Tools and Applications, 2020

10. Oliveira, A, Dias, D, Lopes, EM, Vilas Boas, MD, Silva Cunha, JPS, "SnapKi—An Inertial Easy-to-Adapt Wearable Textile Device for Movement Quantification of Neurological Patients", Sensors, vol.20, pp.3875, 2020

11. Orlowska, M, Ramalli, A, Petrescu, A, Cvijic, M, Bezy, S, Santos, P, Pedrosa, J, Voigt, JU, D'Hooge, J, "A novel 2D speckle tracking method for high frame rate echocardiography", IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, pp.1-1, 2020

12. Paiva, JS, Jorge, PAS, Ribeiro, RSR, Balmana, M, Campos, D, Mereiter, S, Jin, CS, Karlsson, NG, Sampaio, P, Reis, CA, Cunha, JPS, "iLoF: An intelligent Lab on Fiber Approach for Human Cancer Single-Cell Type Identification", Scientific reports, vol.10, pp.3171, 2020

13. Petrescu, A, Bézy, S, Cvijic, M, Santos, P, Orlowska, M, Duchenne, J, Pedrosa, J, Van Keer, JM, Verbeken, E, von Bardeleben, S, Droogne, W, Bogaert, J, Van Cleemput, J, D'hooge, J, Voigt, JU, "Shear Wave Elastography Using High-Frame-Rate Imaging in the Follow-Up of Heart Transplantation Recipients", JACC: Cardiovascular Imaging, vol.13, pp.2304-2313, 2020

14. Pinheiro, G, Pereira, T, Dias, C, Freitas, C, Hespanhol, V, Costa, JL, Cunha, A, Oliveira, HP, "Identifying relationships between imaging phenotypes and lung cancer-related mutation status: EGFR and KRAS", Scientific Reports, vol.10, 2020

15. Pires, IM, Marques, G, Garcia, NM, Florez Revuelta, F, Canavarro Teixeira, M, Zdravevski, E, Spinsante, S, Coimbra, M, "Pattern Recognition Techniques for the Identification of Activities of Daily Living Using a Mobile Device Accelerometer", ELECTRONICS, vol.9, pp.509, MAR, 2020

16. Porwal, P, Pachade, S, Kokare, M, Deshmukh, G, Son, J, Bae, W, Liu, LH, Wang, J, Liu, XH, Gao, LX, Wu, TB, Xiao, J, Wang, FY, Yin, BC, Wang, YZ, Danala, G, He, LS, Choi, YH, Lee, YC, Jung, SH, Li, ZY, Sui, XD, Wu, JY, Li, XL, Zhou, T, Toth, J, Bara, A, Kori, A, Chennamsetty, SS, Safwan, M, Alex, V, Lyu, XZ, Cheng, L, Chu, QH, Li, PC, Ji, X, Zhang, SY, Shen, YX, Dai, L, Saha, O, Sathish, R, Melo, T, Araujo, T, Harangi, B, Sheng, B, Fang, RG, Sheet, D, Hajdu, A, Zheng, YJ, Mendonca, AM, Zhang, ST, Campilho, A, Zheng, B, Shen, D, Giancardo, L, Quellec, G, Meriaudeau, F, "IDRiD: Diabetic Retinopathy – Segmentation and Grading Challenge", Medical Image Analysis, pp.101561, 2020

17. Riaz, F, Rehman, S, Ajmal, M, Hafiz, R, Hassan, A, Aljohani, NR, Nawaz, R, Young, R, Coimbra, M, "Gaussian Mixture Model Based Probabilistic Modeling of Images for Medical Image Segmentation", IEEE Access, vol.8, pp.16846-16856, 2020

18. Rocha, J, Cunha, A, Mendonca, AM, "Conventional Filtering Versus U-Net Based Models for Pulmonary Nodule Segmentation in CT Images", Journal of Medical Systems, vol.44, 2020

19. Rocha, JN, Barnes, CM, Rees, P, Clark, CT, Stratton, G, Summers, HD, "Activity Mapping of Children in Play Using Multivariate Analysis of Movement Events", Medicine and Science in Sports and Exercise, vol.52, pp.259-266, JAN, 2020

20. Silva, F, Pereira, T, Frade, J, Mendes, J, Freitas, C, Hespanhol, V, Luis Costa, JL, Cunha, A, Oliveira, HP, "Pre-Training Autoencoder for Lung Nodule Malignancy Assessment Using CT Images", Applied Sciences, vol.10, pp.7837, 2020

21. Smailagic, A, Costa, P, Gaudio, A, Khandelwal, K, Mirshekari, M, Fagert, J, Walawalkar, D, Xu, SS, Galdran, A, Zhang, P, Campilho, A, Noh, HY, "O-MedAL: Online active deep learning for medical image analysis", Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, 2020

22. Vazquez Corral, J, Galdran, A, Cyriac, P, Bertalmio, M, "A fast image dehazing method that does not introduce color artifacts", Journal of Real-Time Image Processing, 2020

23. Vilas Boas, MD, Rocha, AP, Cardoso, MN, Fernandes, JM, Coelho, T, Cunha, JPS, "Clinical 3-D Gait Assessment of Patients With Polyneuropathy Associated With Hereditary Transthyretin Amyloidosis", Frontiers in Neurology, vol.11, 2020

International Conference Proceedings with Scientific Referees

1. Carvalho, CB, Pedrosa, J, Maia, C, Penas, S, Carneiro, A, Mendonça, L, Mendonça, AM, Campilho, A, "A Multi-dataset Approach for DME Risk Detection in Eye Fundus Images", Image Analysis and Recognition - 17th International Conference, ICIAR 2020, Póvoa de Varzim, Portugal, June 24-26, 2020, Proceedings, Part II, vol.12132, pp.285-298, 2020
2. Ferreira, CA, Aresta, G, Pedrosa, J, Rebelo, J, Negrao, E, Cunha, A, Ramos, I, Campilho, A, "Classification of Lung Nodules in CT Volumes Using the Lung-RADS™ Guidelines with Uncertainty Parameterization", 17th IEEE International Symposium on Biomedical Imaging, ISBI 2020, Iowa City, IA, USA, April 3-7, 2020, vol.2020-April, pp.791-794, 2020
3. Gaudio, A, Smailagic, A, Campilho, A, "Enhancement of retinal fundus images via pixel color amplification", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12132 LNCS, pp.299-312, 2020
4. Karacsony, T, Loesch Biffar, AM, Vollmar, C, Noachtar, S, Cunha, JPS, "A Deep Learning Architecture for Epileptic Seizure Classification Based on Object and Action Recognition", ICASSP 2020 - 2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2020
5. Machado, M, Ferreira, CA, Pedrosa, J, Negrao, E, Rebelo, J, Leitao, P, Carvalho, AS, Rodrigues, MC, Ramos, I, Cunha, A, Campilho, A, "Automatic Lung Reference Model", IFMBE Proceedings - XV Mediterranean Conference on Medical and Biological Engineering and Computing – MEDICON 2019, pp.999-1008, 2020
6. Maia, P, Lopes, E, Hartl, E, Vollmar, C, Noachtar, S, Silva Cunha, JPS, "Multimodal Approach for Epileptic Seizure Detection in Epilepsy Monitoring Units", XV Mediterranean Conference on Medical and Biological Engineering and Computing - MEDICON 2019, vol.76, pp.1093-1104, 2020
7. Mendonça, AM, Melo, T, Araújo, T, Campilho, A, "Optic Disc and Fovea Detection in Color Eye Fundus Images", Lecture Notes in Computer Science - Image Analysis and Recognition, pp.332-343, 2020
8. Oliveira, A, Dias, D, Lopes, EM, Do Carmo Vilas Boas, M, Silva Cunha, JP, "A Textile Embedded Wearable Device for Movement Disorders Quantification", Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, vol.2020-July, pp.4559-4562, 2020
9. Pedrosa, J, Aresta, G, Rebelo, J, Negrao, E, Ramos, I, Cunha, A, Campilho, A, "LNDetector: A Flexible Gaze Characterisation Collaborative Platform for Pulmonary Nodule Screening", IFMBE Proceedings, vol.76, pp.333-343, 2020
10. Pereira, D, Ferreira, MJ, Cruz Correia, RJ, Coimbra, MT, "Teaching Cardiopulmonary Auscultation to Medical Students using a Virtual Patient Simulation Technology", 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2020, Montreal, QC, Canada, July 20-24, 2020, vol.2020-July, pp.6032-6035, 2020
11. Pinto, JR, Cardoso, JS, Correia, MV, "Secure Triplet Loss for End-to-End Deep Biometrics", 2020 8th International Workshop on Biometrics and Forensics (IWBF), 2020
12. Reisinho, J, Coimbra, MT, Renna, F, "Deep Convolutional Neural Network Ensembles For Multi-Classification of Skin Lesions From Dermoscopic and Clinical Images", 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2020, Montreal, QC, Canada, July 20-24, 2020, vol.2020-July, pp.1940-1943, 2020
13. Rocha, AP, Fernandes, JM, Choupina, HMP, Vilas Boas, MC, Cunha, JPS, "Subject Identification Based on Gait Using a RGB-D Camera", Advances in Intelligent Systems and Computing, vol.942, pp.76-85, 2020
14. Rocha, J, Cunha, A, Mendonca, AM, "Segmentation of Pulmonary Nodules in CT Images Using the Sliding Band Filter", IFMBE Proceedings, vol.76, pp.353-357, 2020

15. Teixeira, PA, Sousa, PA, Coimbra, MT, "Computer Vision Challenges for Chronic Wounds Assessment", 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2020, Montreal, QC, Canada, July 20-24, 2020, pp.1840-1843, 2020

16. Zengin, H, Camara, J, Simães Coelho, PJ, Rodrigues, JMF, Cunha, A, "Low-Resolution Retinal Image Vessel Segmentation", Universal Access in Human-Computer Interaction. Applications and Practice - 14th International Conference, UAHCI 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19-24, 2020, Proceedings, Part II, vol.12189, pp.611-627, 2020

Books

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Chapter/Paper in Books

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Publications (Editor)

1. Campilho, A, Karray, F, Wang, Z, "Image Analysis and Recognition - 17th International Conference, ICIAR 2020, Póvoa de Varzim, Portugal, June 24-26, 2020, Proceedings, Part II", ICIAR (2), vol.12132, 2020

Dissertations (PhD)

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10.5 CPES – ACTIVITY RESULTS IN 2020

10.5.1 Activity indicators

The following tables present CPES research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.5.1 - CPES – Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	18	21	28	7
		Academic Staff	10	10	9	-1
		Grant Holders and Trainees	53	48	42	-6
		Total Core Researchers	**81**	**79**	**79**	**0**
		Total Core PhD	**25**	**26**	**25**	**-1**
	Affiliated Researchers		6	7	7	0
	Administrative and Technical	Employees	1	1	3	2
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**1**	**1**	**3**	**2**
		Total Integrated HR	**88**	**87**	**89**	**2**
		Total Integrated PhD	**30**	**32**	**32**	**0**

Table 10.5.2 - CPES – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes – FCT	405	488	246	-242
PN-PICT	National R&D Programmes - S&T Integrated Projects	34	4		-4
PN-COOP	National Cooperation Programmes with Industry	56	21	25	4
PUE-FP	EU Framework Programmes	855	977	1 693	716
PUE-DIV	EU Cooperation Programmes – Other	192	88		-88
SERV-NAC	R&D Services and Consulting - National	870	796	802	6
SERV-INT	R&D Services and Consulting - International	98	12	131	119
OP	Other Funding Programmes	27	155	157	2
	Total Funding	**2 738**	**2 583**	**3 055**	**472**

Table 10.5.3 - CPES– Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	71	97	110
Indexed Conferences	73	91	49
Books			1
Book Chapters	8	5	6
Concluded PhD Theses - Members	3	1	3
Concluded PhD Theses - Supervised	5	2	4

Table 10.5.4 - CPES – Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	4	1	12
Software copyright registrations	0	0	0
Patent first priority filings (New inventions)	0	1	2
Patent applications (Internationalisation)	0	1	4
Granted patents	1	1	0
Licence agreements	0	0	0
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.5.5 - CPES – Summary of participation in dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	20
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	17
Participation in events such as fairs, exhibitions or similar	0
Conferences, workshops and scientific sessions organised by the Centre	6
Participants in the conferences, workshops and scientific sessions organised by the Centre	1 265
Advanced training courses organised by the Centre	3

Table 10.5.6 – CPES - List of projects

List of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	ESGRIDS	João Peças Lopes	01/01/2017	31/12/2020
PN-FCT	SGEVL	Luís Seca	01/07/2017	29/06/2021
PN-FCT	UNiTED	João Catalão	01/06/2018	31/05/2021
PN-COOP	NEXTSTEP	Clara Sofia Gouveia	01/12/2016	30/11/2020
PN-COOP	GPDER	Ricardo Jorge Bessa	01/08/2019	28/01/2022
PN-COOP	BATERIAS2030	Clara Sofia Gouveia	01/07/2020	30/06/2023
PN-COOP	CITYCATALIST	David Emanuel Rua	01/07/2020	01/07/2023
PUE-FP	InteGrid	Ricardo Jorge Bessa	01/01/2017	31/10/2020
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	30/04/2021
PUE-FP	AmBIENCe	Nilufar Neyestani	01/06/2019	30/11/2021
PUE-FP	EMB3Rs	Tiago André Soares	02/09/2019	01/09/2022
PUE-FP	Smart4RES	Ricardo Jorge Bessa	01/11/2019	30/04/2023
PUE-FP	XFLEX_HIDRO	Carlos Moreira	01/09/2019	31/08/2023
PUE-FP	InterConnect	David Emanuel Rua	01/10/2019	30/09/2023
PUE-FP	POCITYF	Luís Miguel Miranda	01/10/2019	30/09/2024
PUE-FP	ATTEST	André Guimarães Madureira	01/03/2020	28/02/2023
PUE-FP	EUniversal	Clara Sofia Gouveia	01/02/2020	31/07/2023
PUE-FP	OneNet	Ricardo Jorge Bessa	01/10/2020	30/09/2023
SERV-NAC	EFACEC-DMS	Jorge Correia Pereira	15/04/2001	31/12/2030
SERV-NAC	INFRA_PT	João Peças Lopes	20/07/2017	31/03/2021
SERV-NAC	EstinvestQoS	José Nuno Fidalgo	01/12/2017	31/07/2020
SERV-NAC	AO_Perdas	Luís Seca	01/01/2018	31/03/2021
SERV-NAC	GEST_STORAGE	Clara Sofia Gouveia	02/04/2018	31/03/2020
SERV-NAC	HEAD-1	João Peças Lopes	01/01/2018	31/03/2021
SERV-NAC	FLEXERGY	Clara Sofia Gouveia	01/09/2018	31/03/2021
SERV-NAC	LPVAnalytics	Ricardo Jorge Bessa	01/06/2018	30/06/2020
SERV-NAC	RedeDistDigital	Clara Sofia Gouveia	17/10/2018	12/03/2020
SERV-NAC	NazareSustentavel	Luís Seca	10/01/2019	31/03/2021
SERV-NAC	FlutuacoesPV	Helena Vasconcelos	21/03/2019	31/03/2020
SERV-NAC	perdasOFFSHORE	Filipe Joel Soares	15/05/2019	30/06/2020
SERV-NAC	LossPD	José Nuno Fidalgo	02/05/2019	31/05/2020
SERV-NAC	FlexAgg	Ricardo Jorge Bessa	01/05/2019	30/09/2020
SERV-NAC	Perfis_Perdas_2020	José Nuno Fidalgo	21/05/2019	24/01/2020
SERV-NAC	IeM_QST	José Nuno Fidalgo	16/08/2019	16/06/2020
SERV-NAC	ProtTerrasR	João Peças Lopes	01/07/2019	31/10/2020
SERV-NAC	AI4Substation	Ricardo Jorge Bessa	01/11/2019	28/02/2021
SERV-NAC	GridPlan	Filipe Joel Soares	01/10/2019	31/01/2021
SERV-NAC	FlexOPlan	Ricardo Jorge Bessa	01/05/2019	30/06/2021
SERV-NAC	Grid2C	André Guimarães Madureira	01/12/2019	01/01/2022
SERV-NAC	PV_Ourique_MODEL	Bernardo Silva	15/01/2020	07/09/2020
SERV-NAC	SmartClima	David Emanuel Rua	15/01/2020	31/03/2021
SERV-NAC	LeilaoFV2	João Peças Lopes	01/02/2020	01/03/2020
SERV-NAC	Wind_Urze_Alecrim	João Peças Lopes	01/06/2020	30/11/2020
SERV-NAC	PegoBiomassa	João Peças Lopes	15/05/2020	31/03/2021
SERV-NAC	WindConsult	João Peças Lopes	08/06/2020	18/06/2020
SERV-NAC	PV_Losses	Filipe Joel Soares	01/07/2020	01/11/2020

List of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	Perfis_Perdas_2021	José Nuno Fidalgo	28/05/2020	31/03/2021
SERV-NAC	NEGOCER	José Villar	01/06/2020	31/01/2021
SERV-NAC	PV_Morgado_Agre	Bernardo Silva	01/09/2020	01/03/2021
SERV-NAC	PV_OURIDIN	Bernardo Silva	15/09/2020	15/10/2020
SERV-NAC	PV_NISA	Bernardo Silva	10/09/2020	09/10/2020
SERV-NAC	Form_Energia	João Tomé Saraiva	01/09/2020	24/10/2020
SERV-NAC	Hyper_H2	Filipe Joel Soares	22/09/2020	22/11/2020
SERV-NAC	V2G_Azores	João Peças Lopes	01/07/2020	01/07/2021
SERV-NAC	SINESESTENSAO	João Peças Lopes	01/10/2020	01/01/2021
SERV-INT	PredAdvisor	Ricardo Jorge Bessa	01/05/2019	12/03/2020
SERV-INT	Long_Forecasting	José Nuno Fidalgo	01/03/2020	27/07/2020
SERV-INT	PEGO_COMP_SINC	João Peças Lopes	22/03/2020	31/03/2021
SERV-INT	SECRETS	Luís Seca	01/12/2013	31/12/2020
SERV-INT	Sglab_MA	Luís Seca	01/01/2019	30/06/2021
OP	VEARREN2030	João Peças Lopes	01/06/2019	31/12/2020
OP	SEST2019	Jorge Correia Pereira	01/05/2019	01/01/2020
OP	PSCC2020	João Peças Lopes	01/04/2019	01/10/2020
OP	Traning4Water	Ricardo Jorge Bessa	01/02/2020	01/03/2020
OP	eLearning_Energy	Ricardo Jorge Bessa	15/09/2020	15/01/2021
INT	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-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

10.5.2 List of publications

International Journals with Scientific Referees

1. Abedinia, O, Lotfi, M, Bagheri, M, Sobhani, B, Shafie khah, M, Catalao, JPS, "Improved EMD-Based Complex Prediction Model for Wind Power Forecasting", IEEE Transactions on Sustainable Energy, vol.11, pp.2790-2802, OCT, 2020
2. Aghapour, R, Sepasian, MS, Arasteh, H, Vahidinasab, V, Catalao, JPS, "Probabilistic planning of electric vehicles charging stations in an integrated electricity-transport system", Electric Power Systems Research, vol.189, 2020
3. Aliyan, E, Aghamohammadi, M, Kia, M, Heidari, A, Shafie khah, M, Catalao, JPS, "Decision tree analysis to identify harmful contingencies and estimate blackout indices for predicting system vulnerability", Electric Power Systems Research, vol.178, pp.106036, 2020
4. Arasteh, H, Kia, M, Vahidinasab, V, Shafie khah, M, Catalao, JPS, "Multiobjective generation and transmission expansion planning of renewable dominated power systems using stochastic normalized normal constraint", International Journal of Electrical Power & Energy Systems, vol.121, OCT, 2020

5. Azizivahed, A, Arefi, A, Ghavidel, S, Shafie khah, M, Li, L, Zhang, JF, Catalao, JPS, "Multiobjective generation and transmission expansion planning of renewable dominated power systems using stochastic normalized normal constrain", IEEE Transactions on Sustainable Energy, vol.11, pp.662-673, 2020

6. Azizivahed, A, Razavi, SE, Arefi, A, Ghadi, MJ, Li, L, Zhang, JF, Shafie khan, M, Catalao, JPS, "Risk-Oriented Multi-Area Economic Dispatch Solution With High Penetration of Wind Power Generation and Compressed Air Energy Storage System", IEEE Transactions on Sustainable Energy, vol.11, pp.1569-1578, JUL, 2020

7. Badakhshan, S, Ehsan, M, Shahidehpour, M, Hajibandeh, N, Shafie Khah, M, Catalao, JPS, "Security-Constrained Unit Commitment With Natural Gas Pipeline Transient Constraints", IEEE Transactions on Smart Grid, vol.11, pp.118-128, 2020

8. Bahramara, S, Mazza, A, Chicco, G, Shafie khah, M, Catalao, JPS, "Comprehensive review on the decision-making frameworks referring to the distribution network operation problem in the presence of distributed energy resources and microgrids", International Journal of Electrical Power and Energy Systems, vol.115, pp.105466, 2020

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10. Beirami, A, Vahidinasab, V, Shafie khah, M, Catalao, JPS, "Multiobjective ray optimization algorithm as a solution strategy for solving non-convex problems: A power generation scheduling case study", International Journal of Electrical Power & Energy Systems, vol.119, pp.105967, JUL, 2020

11. Beires, PP, Moreira, CL, Lopes, JP, Figueira, AG, "Defining connection requirements for autonomous power systems", IET Renewable Power Generation, 2020

12. Bostan, A, Nazar, MS, Shafie khah, M, Catalao, JPS, "An integrated optimization framework for combined heat and power units, distributed generation and plug-in electric vehicles", ENERGY, vol.202, 2020

13. Bostan, A, Nazar, MS, Shafie Khah, M, Catalao, JPS, "Optimal scheduling of distribution systems considering multiple downward energy hubs and demand response programs", Energy, pp.116349, 2020

14. Bregere, M, Bessa, RJ, "Simulating Tariff Impact in Electrical Energy Consumption Profiles With Conditional Variational Autoencoders", IEEE Access, vol.8, pp.131949-131966, 2020

15. Cao, Y, Wei, W, Mei, SW, Shafie Khah, M, Catalao, JPS, "Analyzing and Quantifying the Intrinsic Distributional Robustness of CVaR Reformulation for Chance-Constrained Stochastic Programs", IEEE Transactions on Power Systems, vol.35, pp.4908-4911, 2020

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17. Castanon, R, Campos, FA, Martinez, SD, Villar, J, "The Food Bank of Madrid: A Linear Model for Optimal Nutrition", International Journal of Environmental Research and Public Health, vol.17, pp.1-16, NOV, 2020

18. Castro, MV, Moreira, C, Carvalho, LM, "A Hierarchical Optimization Strategy for Energy Scheduling and Volt/var Control in Autonomous Clusters of Microgrids", IET Renewable Power Generation, 2020

19. Chandran, CV, Basu, M, Sunderland, K, Pukhrem, S, Catalao, JPS, "Application of demand response to improve voltage regulation with high DG penetration", Electric Power Systems Research, vol.189, pp.106722, 2020

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21. Coelho, A, Soares, F, Lopes, JP, "Flexibility assessment of multi-energy residential and commercial buildings", Energies, vol.13, pp.2704, 2020

22. Cruz, MRM, Fitiwi, DZ, Santos, SF, Mariano, SJPS, Catalao, JPS, "Multi Flexibility Options Integration to Cope with Large-Scale Integration of Renewables", IEEE Transactions on Sustainable Energy, pp.1-1, 2020

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24. Deotti, L, Guedes, W, Dias, B, Soares, T, "Technical and Economic Analysis of Battery Storage for Residential Solar Photovoltaic Systems in the Brazilian Regulatory Context", ENERGIES, vol.13, pp.6517, DEC, 2020

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49. Iria, J, Scott, P, Attarha, A, "Network-constrained bidding optimization strategy for aggregators of prosumers", Energy, vol.207, pp.118266, 2020

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52. Javadi, MS, Lotfi, M, Nezhad, AE, Anvari Moghaddam, A, Guerrero, JM, Catalao, JPS, "Optimal Operation of Energy Hubs Considering Uncertainties and Different Time Resolutions", IEEE Transactions on Industry Applications, vol.56, pp.5543-5552, 2020

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10.6 CESE – ACTIVITY RESULTS IN 2020

10.6.1 Activity indicators

The following tables present CESE research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.6.1 - CESE - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	17	21	21	0
		Academic Staff	7	5	4	-1
		Grant Holders and Trainees	37	30	16	-14
		Total Core Researchers	**61**	**56**	**41**	**-15**
		Total Core PhD	**12**	**15**	**13**	**-2**
	Affiliated Researchers		6	7	9	2
	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	**69**	**65**	**52**	**-13**
		Total Integrated PhD	**16**	**22**	**21**	**-1**

Table 10.6.2 - CESE - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes – FCT	156	231	159	-72
PN-PICT	National R&D Programmes - S&T Integrated Projects	173	17		-17
PN-COOP	National Cooperation Programmes with Industry	364	330	388	58
PUE-FP	EU Framework Programmes	501	576	473	-104
PUE-DIV	EU Cooperation Programmes – Other	67	38		-39
SERV-NAC	R&D Services and Consulting – National	510	487	342	-145
SERV-INT	R&D Services and Consulting - International	32	43	2	-41
OP	Other Funding Programmes				
	Total Funding	**1 806**	**1 720**	**1 363**	**-358**

Table 10.6.3 - CESE - S ummary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	14	15	18
Indexed Conferences	26	15	19
Books			
Book Chapters	3		1
Concluded PhD Theses - Members	4	4	2
Concluded PhD Theses - Supervised	5	3	2

Table 10.6.4 - CESE - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	1	0	2
Software copyright registrations	0	0	1
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	0	0	0
Granted patents	0	0	0
Licence agreements	1	1	2
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.6.5 – CESE - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	2
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	4
Participation in events such as fairs, exhibitions or similar	1
Conferences, workshops and scientific sessions organised by the Centre	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	159
Advanced training courses organised by the Centre	3

Table 10.6.6 – CESE - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DM4Manufacturing-1	César Toscano	01/11/2016	31/01/2021
PN-FCT	opti-MOVES	Tânia Daniela Fontes	26/07/2018	31/12/2021
PN-FCT	StoSS	Ana Maria Rodrigues	15/10/2018	14/10/2021
PN-FCT	Tec-FEL-1	Alexandra Sofia Marques	04/04/2018	03/11/2021
PN-FCT	COVID19_3D	António Lucas Soares	03/05/2020	02/02/2021
PN-COOP	PrecisionCork	Luís Guardão	15/05/2016	14/11/2018
PN-COOP	ADIRA_I4.0	António Correia Alves	01/09/2016	29/02/2020
PN-COOP	FAMEST	Rui Diogo Rebelo	01/11/2017	30/04/2021
PN-COOP	GOTECFOR-1	Alexandra Sofia Marques	13/06/2018	31/12/2020
PN-COOP	PRODUTECH_SIF	António Correia Alves	01/10/2017	31/03/2021
PN-COOP	CrossLOG	Luís Guardão	01/11/2019	31/10/2022
PN-COOP	TRF4p0	António Lucas Soares	01/07/2020	01/07/2023
PN-COOP	STVgoDigital40	César Toscano	01/07/2020	30/06/2023
PN-COOP	PRODUTECH4SC	António Correia Alves	01/07/2020	30/06/2023
PN-COOP	Replant	Alexandra Sofia Marques	01/07/2020	30/06/2023
PN-COOP	REV@CONSTRUCTION	Luís Guardão	01/07/2020	30/06/2023
PN-COOP	PAC-1	Vasco Bernardo Teles	01/07/2020	30/06/2023
PN-COOP	Greenshoes	Rui Diogo Rebelo	01/07/2020	30/06/2023
PUE-DIV	BIOTECFOR-1	Alexandra Sofia Marques	01/01/2017	31/12/2020
PUE-FP	BEinCPPS	César Toscano	01/11/2015	31/10/2018
PUE-FP	ScalABLE4.0-1	César Toscano	01/01/2017	30/06/2020
PUE-FP	Fasten	César Toscano	01/11/2017	30/04/2021
PUE-FP	MANU-SQUARE	António Lucas Soares	01/01/2018	30/06/2021
PUE-FP	NEXT-NET	Ana Cristina Barros	01/10/2017	31/12/2019
PUE-FP	DIVA-1	Alexandra Sofia Marques	01/04/2018	31/03/2021
PUE-FP	ZeroDefects40	Rui Correia Dias	01/01/2020	31/12/2020
PUE-FP	M_NEST_RIS	Ana Cristina Simões	01/01/2020	31/12/2020
PUE-FP	EIT_M_RIS_Hubs	Ana Cristina Barros	01/01/2020	31/12/2020
PUE-FP	ConnectedFactories2	Vasco Bernardo Teles	01/12/2019	30/11/2022
PUE-FP	DigTrafoRIS	Ana Cristina Barros	01/01/2020	31/12/2020
PUE-FP	M_NEST_I	Ana Cristina Simões	01/01/2020	31/12/2020
PUE-FP	AI_REGIO	César Toscano	01/10/2020	30/09/2023
PUE-FP	BetterFactory-1	César Toscano	01/10/2020	30/09/2024
PUE-FP	EIT_MAT40_BULH	António Correia Alves	18/07/2020	18/11/2020
PUE-FP	DTatQUALITY	António Correia Alves	15/07/2020	15/11/2020
PUE-FP	DTatENERTERMO	António Correia Alves	15/07/2020	15/11/2020
SERV-NAC	LM_Escalona	Luís Guardão	01/01/2018	31/12/2021
SERV-NAC	PFF_SIM18	Rui Diogo Rebelo	27/09/2018	24/09/2020
SERV-NAC	Refinacao4.0	Américo Azevedo	01/09/2018	31/01/2020
SERV-NAC	AI-PLN-F1	Luís Guardão	01/03/2019	31/08/2019
SERV-NAC	CMF_BH2019	Luís Guardão	01/03/2019	31/10/2020

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	ACCMES40III	Rui Diogo Rebelo	31/05/2019	30/06/2020
SERV-NAC	PortoAmbiente-1	José Soeiro Ferreira	01/03/2019	18/08/2020
SERV-NAC	AI_PLN_F2	Luís Guardão	01/04/2019	30/03/2020
SERV-NAC	AR40II	Rui Diogo Rebelo	28/06/2019	31/03/2020
SERV-NAC	T4CDTKC	Américo Azevedo	01/09/2019	20/12/2020
SERV-NAC	PSETSE	António Correia Alves	07/11/2019	30/12/2020
SERV-NAC	DesafioEM2022	Américo Azevedo	01/05/2019	27/02/2020
SERV-NAC	SIFOREST-1	Jorge Leite da Cunha	20/12/2019	31/05/2020
SERV-NAC	MES40ESPI	Rui Diogo Rebelo	06/01/2020	20/05/2020
SERV-NAC	ConsForestWise-1	Alexandra Sofia Marques	01/02/2019	30/06/2020
SERV-NAC	XPlantcode	Luís Guardão	05/03/2020	05/04/2020
SERV-NAC	ACCMES40IV	Rui Diogo Rebelo	01/02/2020	30/09/2020
SERV-NAC	AR40III	Rui Diogo Rebelo	30/01/2020	31/12/2020
SERV-NAC	ACC_APA_Shelf	Rui Diogo Rebelo	20/01/2020	20/02/2020
SERV-NAC	SOMESi40	Rui Diogo Rebelo	02/11/2020	02/01/2021
SERV-NAC	ACCMES40V	Rui Diogo Rebelo	06/10/2020	06/01/2021
SERV-NAC	BSLINESIM	Luís Guardão	01/11/2020	31/03/2021
SERV-NAC	MESPARTNERSHIP	Luís Guardão	25/11/2020	25/01/2026
SERV-NAC	APSPARTNERSHIP	Luís Guardão	15/11/2020	15/01/2026
SERV-NAC	PSD	Rui Diogo Rebelo	16/11/2020	16/12/2020
SERV-NAC	PFAI4.0	Américo Azevedo	01/10/2020	01/12/2020
SERV-INT	BM_Planning	Luís Guardão	02/12/2019	30/06/2021

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

10.6.2 List of publications

International Journals with Scientific Referees

1. Borges, MA, Dandolini, GA, Soares, AL, "O processo de formação de parcerias intersetoriais em iniciativas de inovação social em Portugal", Análise Social, vol.LV, pp.118-143, 2020
2. Costa, E, Soares, AL, Sousa, JP, "Industrial business associations improving the internationalisation of SMEs with digital platforms: A design science research approach", International Journal of Information Management, vol.53, pp.102070, 2020
3. Fonseca, LM, Azevedo, AL, "COVID- 19: outcomes for Global Supply Chains", Management & Marketing-Challenges for The Knowledge Society, vol.15, pp.424-438, OCT, 2020

4. Fontes, T, Correia, R, Ribeiro, J, Borges, JL, "A Deep Learning Approach for Predicting Bus Passenger Demand Based on Weather Conditions", Transport and Telecommunication Journal, vol.21, pp.255-264, 2020
5. Guimarães, LR, de Sousa, JP, Prata, BDA, "Variable fixing heuristics for the capacitated multicommodity network flow problem with multiple transport lines, a heterogeneous fleet and time windows", Transportation Letters, pp.1-10, 2020
6. Li, Q, Guo, JJ, Liu, W, Yue, XG, Duarte, N, Pereira, C, "How Knowledge Acquisition Diversity Affects Innovation Performance during the Technological Catch-Up in Emerging Economies: A Moderated Inverse U-Shape Relationship", SUSTAINABILITY, vol.12, pp.945, FEB, 2020
7. Marques, A, Cunha, J, De Meyer, A, Navare, K, "Contribution towards a comprehensive methodology for wood-based biomass material flow analysis in a circular economy setting", Forests, vol.11, pp.106, 2020
8. Marques, A, Soares, R, Santos, MJ, Amorim, P, "Integrated planning of inbound and outbound logistics with a Rich Vehicle Routing Problem with Backhauls", Omega, pp.102172, 2020
9. Marques, CM, Moniz, S, de Sousa, JP, Barbosa Povoa, AP, Reklaitis, G, "Decision-support challenges in the chemical-pharmaceutical industry: Findings and future research directions", Computers & Chemical Engineering, vol.134, 2020
10. Messina, D, Barros, AC, Soares, AL, Matopoulos, A, "An information management approach for supply chain disruption recovery", International Journal of Logistics Management, vol.ahead-of-print, 2020
11. Parente, M, Figueira, G, Amorim, P, Marques, A, "Production scheduling in the context of Industry 4.0: review and trends", International Journal of Production Research, pp.1-31, 2020
12. Santos, MJ, Amorim, P, Marques, A, Carvalho, A, Povoa, A, "The vehicle routing problem with backhauls towards a sustainability perspective: a review", TOP, 2020
13. Silva, D, Azevedo, A, "Sustainability as a driver of operational excellence - The relevance of variability in process operations", International Journal of Integrated Supply Management, vol.13, pp.210-233, 2020
14. Simoes, AC, Soares, AL, Barros, AC, "Factors influencing the intention of managers to adopt collaborative robots (cobots) in manufacturing organizations", Journal of Engineering and Technology Management - JET-M, vol.57, pp.101574, 2020
15. Zimmermann, R, Ferreira, LMDF, Moreira, AC, "An empirical analysis of the relationship between supply chain strategies, product characteristics, environmental uncertainty and performance", Supply Chain Management, vol.ahead-of-print, 2020
16. Zimmermann, R, Ferreira, LMDF, Moreira, AC, "How Supply Chain Strategies Moderate The Relationship Between Innovation Capabilities And Business Performance", Journal of Purchasing and Supply Management, pp.100658, 2020
17. Zimmermann, R, Moreira, AC, Ferreira, LMDF, "The effect of supply chain strategy on the relationship between innovation capabilities and business performance. A theoretical model", International Journal of Business Performance and Supply Chain Modelling, vol.11, pp.291, 2020
18. Zimmermann, R; Ferreira, LMDF; Moreira, AC; Barros, AC; Correa, HL., “The Impact of Supply Chain Fit on Business and Innovation Performance in Brazilian Companies”, International Journal of Logistics Management, vol.32, pp.141-167, 2020.

International Conference Proceedings with Scientific Referees

1. Carneiro, D, Nunes, D, Sousa, C, "A Decision-Support System for Preventive Maintenance in Street Lighting Networks", Advances in Intelligent Systems and Computing, vol.923, pp.272-281, 2020
2. Carvalho, L, de Sousa, JF, de Sousa, JP, "The Role of Collaboration for Sustainable and Efficient Urban Logistics", Boosting Collaborative Networks 4.0 - IFIP Advances in Information and Communication Technology, pp.475-484, 2020

3. de Sa, CR, Shekar, AK, Ferreira, H, Soares, C, "Building Robust Prediction Models for Defective Sensor Data Using Artificial Neural Networks", Advances in Intelligent Systems and Computing - 14th International Conference on Soft Computing Models in Industrial and Environmental Applications (SOCO 2019), pp.142-153, 2020
4. Dias, R, Fontes, T, Galvão, T, "Design of a Route-Planner for Urban Public Transport, Promoting Social Inclusion", Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST, vol.310 LNICST, pp.3-17, 2020
5. Fernandes, G, Leite, S, Araujo, M, Simoes, AC, "Organizational Enablers to the Governance of Collaborative University-Industry R&D Programs", 2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), 2020
6. Guimarães, LR, Athayde Prata, BD, De Sousa, JP, "Models and algorithms for network design in urban freight distribution systems", Transportation Research Procedia, vol.47, pp.291-298, 2020
7. Hernández, E, Senna, P, Silva, D, Rebelo, R, Barros, AC, Toscano, C, "Implementing RAMI4.0 in Production - A Multi-case Study", Lecture Notes in Mechanical Engineering - Progress in Digital and Physical Manufacturing, pp.49-56, 2020
8. Nunes, D, Teixeira, D, Carneiro, D, Sousa, C, Novais, P, "Decision intelligence in street lighting management", Advances in Intelligent Systems and Computing, vol.1160 AISC, pp.501-510, 2020
9. Oliveira, B, Ramos, AG, De Sousa, JP, "A classification of two-tier distribution systems based on mobile depots", Transportation Research Procedia, vol.47, pp.115-122, 2020
10. Oliveira, B, Ramos, AG, De Sousa, JP, "A generic mathematical formulation for two-echelon distribution systems based on mobile depots", Transportation Research Procedia, vol.52, pp.99-106, 2020
11. Pessot, E, Macchion, L, Marchiori, I, Fornasiero, R, Senna, P, Vinelli, A, "Collaborative Product and Service Customization in Fashion Companies", Boosting Collaborative Networks 4.0 - IFIP Advances in Information and Communication Technology, pp.440-449, 2020
12. Ramalho, FR, Soares, AL, Almeida, AH, "Immersive Systems in Human-Centered Manufacturing: The Informational Dimension", IFIP Advances in Information and Communication Technology, vol.598, pp.297-307, 2020
13. Ribeiro, J, Fontes, T, Soares, C, Borges, JL, "Accessibility as an indicator to estimate social exclusion in public transport", Transportation Research Procedia, vol.52, pp.740-747, 2020
14. Ribeiro, J, Fontes, T, Soares, C, Borges, JL, "Process discovery on geolocation data", Transportation Research Procedia, vol.47, pp.139-146, 2020
15. Senna, PP, Almeida, AH, Barros, AC, Bessa, RJ, Azevedo, AL, "Architecture Model for a Holistic and Interoperable Digital Energy Management Platform", Procedia Manufacturing, vol.51, pp.1117-1124, 2020
16. Silva, HD, Soares, AL, "From Digital Platforms to Ecosystems: A Review of Horizon 2020 Platform Projects", Boosting Collaborative Networks 4.0 - IFIP Advances in Information and Communication Technology, pp.111-120, 2020
17. Simoes, AC, Rodrigues, JC, Neto, P, "The impact of Industry 4.0 on work: A synthesis of the literature and reflection about the future", 2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), 2020
18. Soares, R, Marques, A, Gomes, R, Guardão, L, Hernández, E, Rebelo, R, "Exploring the Linkages Between the Internet of Things and Planning and Control Systems in Industrial Applications", Lecture Notes in Mechanical Engineering - Progress in Digital and Physical Manufacturing, pp.65-72, 2020
19. Torgal, M, Dias, TG, Fontes, T, "A multi objective approach for DRT service using tabu search", Transportation Research Procedia, vol.52, pp.91-98, 2020

Books

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Chapter/Paper in Books

1. Teymourifar, A, Rodrigues, AM, Ferreira, JS, "A Comparison Between Simultaneous and Hierarchical Approaches to Solve a Multi-Objective Location-Routing Problem", AIRO Springer Series - Graphs and Combinatorial Optimization: from Theory to Applications, pp.251-263, 2020

Publications (Editor)

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Dissertations (PhD)

1. Arguello, J., “A decision support system for policy design and assessment of sustainable mobility in emerging cities”.
2. Monteiro, M., “Adaptation of transnational short-term residents: understanding the factors influencing residential location choice and travel behavior”.

10.7 CRIIS – ACTIVITY RESULTS IN 2020

10.7.1 Activity indicators

The following tables present CRIIS research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.7.1 – CRIIS - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	6	8	13	5
		Academic Staff	12	12	12	0
		Grant Holders and Trainees	23	23	22	-1
		Total Core Researchers	**41**	**43**	**47**	**4**
		Total Core PhD	**15**	**18**	**18**	**0**
	Affiliated Researchers		5	5	6	1
	Administrative and Technical	Employees	3	2	2	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**3**	**2**	**2**	**0**
		Total Integrated HR	**49**	**50**	**55**	**5**
		Total Integrated PhD	**20**	**23**	**23**	**0**

Table 10.7.2 - CRIIS – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	169	202	269	67
PN-PICT	National R&D Programmes - S&T Integrated Projects	31	8		-8
PN-COOP	National Cooperation Programmes with Industry	133	78	48	-29
PUE-FP	EU Framework Programmes	357	505	535	30
PUE-DIV	EU Cooperation Programmes - Other	178	170	17	-153
SERV-NAC	R&D Services and Consulting - National	291	145	113	-33
SERV-INT	R&D Services and Consulting - International	41	5		-5
OP	Other Funding Programmes		32	4	-28
	Total Funding	**1 205**	**1 147**	**986**	**-161**

Table 10.7.3 – CRIIS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	29	34	38
Indexed Conferences	46	88	38
Books		2	1
Book Chapters	9		
Concluded PhD Theses - Members		3	0
Concluded PhD Theses - Supervised	5	6	1

Table 10.7.4 - CRIIS – Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	1	1	7
Software copyright registrations	0	0	4
Patent first priority filings (New inventions)	1	0	1
Patent applications (Internationalisation)	0	2	1
Granted patents	0	0	0
Licence agreements	0	0	1
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.7.5 - CRIIS – Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	3
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	4
International events in which INESC TEC members participate in the program committees	5
Participation in events such as fairs, exhibitions or similar	1
Conferences, workshops and scientific sessions organised by the Centre	6
Participants in the conferences, workshops and scientific sessions organised by the Centre	360
Advanced training courses organised by the Centre	0

Table 10.7.6 - CRIIS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DM4Manufacturing	António Paulo Moreira	01/11/2016	31/01/2021
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	24/07/2021
PN-FCT	RADAR	António Paulo Moreira	01/05/2020	31/07/2020
PN-FCT	PNEUMA	António Paulo Moreira	01/05/2020	31/07/2020
PN-COOP	ROMOVI	Filipe Neves Santos	07/01/2017	31/12/2019
PN-COOP	GOTECFOR	Filipe Neves Santos	13/06/2018	31/12/2020
PN-COOP	PRODUTECH_SIF-1	António Paulo Moreira	01/10/2017	31/03/2021
PN-COOP	FDControlo	Filipe Neves Santos	02/01/2018	31/12/2021
PN-COOP	CrossLOG-2	Manuel Santos Silva	01/11/2019	31/10/2022
PN-COOP	PRODUTECH4SC-1	Luís Freitas Rocha	01/07/2020	30/06/2023
PN-COOP	PAC	Germano Veiga	01/07/2020	30/06/2023
PUE-DIV	Water4Ever	Filipe Neves Santos	01/07/2017	31/12/2020
PUE-DIV	MANUFACTUR4.0	Luís Freitas Rocha	17/04/2017	31/12/2020
PUE-DIV	BIOTECFOR	Filipe Neves Santos	01/01/2017	31/12/2020
PUE-FP	ScalABLE4.0	Germano Veiga	01/01/2017	30/06/2020
PUE-FP	Fasten-1	Rafael Lírio Arrais	01/11/2017	30/04/2021
PUE-FP	HORSE	Rafael Lírio Arrais	01/10/2018	30/06/2020
PUE-FP	Rosin	Rafael Lírio Arrais	01/05/2019	31/12/2020
PUE-FP	AgRoBoFood	Filipe Neves Santos	01/06/2019	31/05/2023
PUE-FP	DEMETER	Filipe Neves Santos	01/09/2019	28/02/2023
PUE-FP	CPPS101	Marcelo Petry	01/01/2020	31/12/2020
PUE-FP	MirrorLabs	Marcelo Petry	01/01/2020	31/12/2020
PUE-FP	SAFECoating	Rafael Lírio Arrais	15/03/2020	15/02/2021
PUE-FP	AI_REGIO-1	Germano Veiga	01/10/2020	30/09/2023
PUE-FP	BetterFactory	Germano Veiga	01/10/2020	30/09/2024
PUE-FP	Agrobit	Filipe Neves Santos	01/05/2020	01/05/2021
PUE-FP	NOVATERRA	Filipe Neves Santos	01/10/2020	30/09/2024
PUE-FP	PRySM	Filipe Neves Santos	01/05/2020	31/10/2021
PUE-FP	XWeld	Luís Freitas Rocha	01/07/2020	30/06/2021
SERV-NAC	Smart-Fertilizers	Filipe Neves Santos	01/01/2019	31/08/2021
SERV-NAC	PIVOTBOT	Filipe Neves Santos	01/09/2019	01/03/2021
SERV-NAC	SMARTPVD	Hélio Mendonça	01/10/2019	01/10/2021
SERV-NAC	ROBOCARE	Filipe Neves Santos	01/03/2020	01/03/2022
SERV-NAC	Trilogy	Luís Freitas Rocha	01/09/2020	01/03/2021
SERV-NAC	PFAI4.0-2	Germano Veiga	01/10/2020	01/12/2020
OP	SAFE	António Valente	01/01/2019	31/12/2020

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

10.7.2 List of publications

International Journals with Scientific Referees

1. Afonso, J, Guedes, C, Santos, V, Morais, R, Silva, J, Teixeira, A, Silva, S, "Utilization of Bioelectrical Impedance to Predict Intramuscular Fat and Physicochemical Traits of the Beef Longissimus Thoracis et Lumborum Muscle", FOODS, vol.9, JUN, 2020
2. Aguiar, AS, dos Santos, FN, Cunha, JB, Sobreira, H, Sousa, AJ, "Localization and Mapping for Robots in Agriculture and Forestry: A Survey", Robotics, vol.9, pp.97, 2020
3. Aguiar, AS, Dos Santos, FN, Miranda De Sousa, AJM, Oliveira, PM, Santos, LC, "Visual Trunk Detection Using Transfer Learning and a Deep Learning-based Coprocessor", IEEE Access, pp.1-1, 2020
4. Arrais, R, Ribeiro, P, Domingos, H, Veiga, G, "ROBIN: An open-source middleware for plug'n'produce of Cyber-Physical Systems", International Journal of Advanced Robotic Systems, vol.17, pp.172988142091031, MAY, 2020
5. Brito, T, Pereira, AI, Lima, J, Valente, A, "Wireless Sensor Network for Ignitions Detection: An IoT approach", Electronics, vol.9, pp.893, 2020
6. Clemente, D, Rosa Santos, P, Taveira Pinto, F, Martins, P, Paulo Moreira, A, "Proof-of-concept study on a wave energy converter based on the roll oscillations of multipurpose offshore floating platforms", Energy Conversion and Management, vol.224, pp.113363, 2020
7. Cunha, M, Richter, C, "Climate-induced cyclical properties of regional wine production using a time-frequency approach in Douro and Minho Wine Regions", Ciência e Técnica Vitivinícola, vol.35, pp.16-29, 2020
8. de Moura Oliveira, PBD, Hedengren, JD, Solteiro Pires, EJS, "Swarm-Based Design of Proportional Integral and Derivative Controllers Using a Compromise Cost Function: An Arduino Temperature Laboratory Case Study", Algorithms, vol.13, pp.315, 2020
9. Duarte, AJ, Malheiro, B, Arno, E, Perat, I, Silva, MF, Fuentes Dura, P, Guedes, P, Ferreira, P, "Engineering Education for Sustainable Development: The European Project Semester Approach", IEEE Transactions on Education, pp.1-10, 2020
10. Fernandes, NO, Thurer, M, Pinho, TM, Torres, P, Carmo Silva, S, "Workload control and optimised order release: an assessment by simulation", International Journal of Production Research, 2020
11. Figueiredo, AB, Matos, AC, "MViDO: A high performance monocular vision-based system for docking a hovering AUV", Applied Sciences (Switzerland), vol.10, pp.2991, 2020
12. Guimaraes, N, Padua, L, Adao, T, Hruska, J, Peres, E, Sousa, JJ, "VisWebDrone: A Web Application for UAV Photogrammetry Based on Open-Source Software", ISPRS International Journal of Geo-Information, vol.9, pp.679, 2020
13. Guimaraes, N, Padua, L, Marques, P, Silva, N, Peres, E, Sousa, JJ, "Forestry Remote Sensing from Unmanned Aerial Vehicles: A Review Focusing on the Data, Processing and Potentialities", Remote Sensing, vol.12, pp.1046, 2020
14. Jurado, JM, Padua, L, Feito, FR, Sousa, JJ, "Automatic grapevine trunk detection on UAV-based point cloud", Remote Sensing, vol.12, pp.3043, 2020
15. Leao, G, Costa, CM, Sousa, A, Veiga, G, "Detecting and Solving Tube Entanglement in Bin Picking Operations", Applied Sciences, vol.10, pp.2264, 2020
16. Luis, N, Pereira, T, Fernandez, S, Moreira, A, Borrajo, D, Veloso, M, "Using Pre-Computed Knowledge for Goal Allocation in Multi-Agent Planning", Journal of Intelligent and Robotic Systems: Theory and Applications, 2020
17. Mananze, S, Pocas, I, Cunha, M, "Mapping and Assessing the Dynamics of Shifting Agricultural Landscapes Using Google Earth Engine Cloud Computing, a Case Study in Mozambique", Remote Sensing, vol.12, pp.1279, 2020

18. Mendes, J, Pinho, TM, dos Santos, FN, Sousa, JJ, Peres, E, Boaventura Cunha, J, Cunha, M, Morais, R, "Smartphone Applications Targeting Precision Agriculture Practices—A Systematic Review", Agronomy, vol.10, pp.855, 2020

19. Oliveira, J, Oliveira, PM, Boaventura Cunha, J, Pinho, T, "Evaluation of Hunting-Based Optimizers for a Quadrotor Sliding Mode Flight Controller", Robotics, vol.9, pp.22, 2020

20. Oliveira, PM, Pires, EJS, Boaventura Cunha, J, Pinho, TM, "Review of nature and biologically inspired metaheuristics for greenhouse environment control", Transactions of the Institute of Measurement and Control, pp.014233122090901, 2020

21. Padua, L, Adao, T, Sousa, A, Peres, E, Sousa, JJ, "Individual Grapevine Analysis in a Multi-Temporal Context Using UAV-Based Multi-Sensor Imagery", Remote Sensing, vol.12, pp.139, 2020

22. Padua, L, Guimaraes, N, Adao, T, Sousa, A, Peres, E, Sousa, JJ, "Effectiveness of Sentinel-2 in Multi-Temporal Post-Fire Monitoring When Compared with UAV Imagery", ISPRS International Journal of Geo-Information, vol.9, pp.225, 2020

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24. Padua, L, Sousa, J, Vanko, J, Hruska, J, Adao, T, Peres, E, Sousa, A, Sousa, JJ, "Digital Reconstitution of Road Traffic Accidents: A Flexible Methodology Relying on UAV Surveying and Complementary Strategies to Support Multiple Scenarios", International Journal of Environmental Research and Public Health, vol.17, pp.1868, 2020

25. Pinto de Aguiar, ASP, Neves dos Santos, FBN, Feliz dos Santos, LCF, de Jesus Filipe, VMD, Miranda de Sousa, AJM, "Vineyard trunk detection using deep learning – An experimental device benchmark", Computers and Electronics in Agriculture, vol.175, pp.105535, 2020

26. Pinto, VH, Gonçalves, J, Costa, P, "Modeling and Control of a DC Motor Coupled to a Non-Rigid Joint", Applied System Innovation, vol.3, pp.24, 2020

27. Pinto, VH, Gonçalves, J, Costa, P, "Towards a More Robust Non-Rigid Robotic Joint", Applied System Innovation, vol.3, pp.45, 2020

28. Pocas, I, Calera, A, Campos, I, Cunha, M, "Remote sensing for estimating and mapping single and basal crop coefficientes: A review on spectral vegetation indices approaches", Agricultural Water Management, vol.233, pp.106081, 2020

29. Pocas, I, Tosin, R, Goncalves, I, Cunha, M, "Toward a generalized predictive model of grapevine water status in Douro region from hyperspectral data", Agricultural and Forest Meteorology, vol.280, pp.107793, 2020

30. Santos, J, Oliveira, M, Arrais, R, Veiga, G, "Autonomous Scene Exploration for Robotics: A Conditional Random View-Sampling and Evaluation Using a Voxel-Sorting Mechanism for Efficient Ray Casting", SENSORS, vol.20, pp.1-30, AUG, 2020

31. Santos, L, Santos, F, Mendes, J, Costa, P, Lima, J, Reis, R, Shinde, P, "Path Planning Aware of Robot's Center of Mass for Steep Slope Vineyards", Robotica, pp.1-15, 2020

32. Santos, LC, Aguiar, AS, Santos, FN, Valente, A, Petry, M, "Occupancy Grid and Topological Maps Extraction from Satellite Images for Path Planning in Agricultural Robots", Robotics, vol.9, pp.77, 2020

33. Saraiva, AA, de Jesus Castro, FMD, Nascimento, RC, de Melo, RT, Moura Sousa, JVM, Valente, A, Fonseca Ferreira, NMF, "Electroencephalography applied compression algorithms qualitative analysis", Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization, pp.1-7, 2020

34. Souza, MBA, Honorio, LD, de Oliveira, EJ, Moreira, APGM, "Recursive Approach of Sub-Optimal Excitation Signal Generation and Optimal Parameter Estimation", International Journal of Control Automation and Systems, vol.18, pp.1965-1974, AUG, 2020

35. Tavares, P, Marques, D, Malaca, P, Veiga, G, Costa, P, Moreira, AP, "Optimal automatic path planner and design for high redundancy robotic systems", Industrial Robot-The International Journal of Robotics Research and Application, vol.47, pp.131-139, 2020

36. Tosin, R, Pocas, I, Goncalves, I, Cunha, M, "Estimation of grapevine predawn leaf water potential based on hyperspectral reflectance data in Douro wine region", VITIS, vol.59, pp.9-18, 2020

37. Valente, A, Silva, S, Duarte, D, Pinto, FC, Soares, S, "Low-Cost LoRaWAN Node for Agro-Intelligence IoT", ELECTRONICS, vol.9, pp.987, JUN, 2020

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2. Almeida de Araujo, FMA, Ferreira Viana Filho, PRF, Adad Filho, JA, Fonseca Ferreira, NMF, Valente, A, Soares, SFSP, "Motor Rehabilitation and Biotelemetry Data Acquisition with Kinect", Proceedings of the 13th International Joint Conference on Biomedical Engineering Systems and Technologies, 2020

3. Alves, JP, Fonseca Ferreira, NMF, Valente, A, Soares, S, Filipe, V, "Autonomous Driving Car Competition", Robotics in Education - Advances in Intelligent Systems and Computing, pp.356-363, 2020

4. Antão, L, Sousa, A, Reis, LP, Gonçalves, G, "Learning to Play Precision Ball Sports from scratch: a Deep Reinforcement Learning Approach", 2020 International Joint Conference on Neural Networks, IJCNN 2020, Glasgow, United Kingdom, July 19-24, 2020, pp.1-8, 2020

5. Aschenbrenner, D, Rieder, JSI, Tol, Dv, Dam, Jv, Rusák, Z, Blech, JO, Azangoo, M, Panu, S, Kruusamäe, K, Masnavi, H, Rybalskii, I, Aabloo, A, Petry, M, Teixeira, G, Thiede, B, Pedrazzoli, P, Ferrario, A, Foletti, M, Confalonieri, M, Bertaggia, D, Togias, T, Makris, S, "Mirrorlabs - creating accessible Digital Twins of robotic production environment with Mixed Reality", IEEE International Conference on Artificial Intelligence and Virtual Reality, AIVR 2020, Virtual Event, The Netherlands, December 14-18, 2020, pp.43-48, 2020

6. Baltazar, A, Petry, MR, Silva, MF, Moreira, AP, "Driverless Wheelchair for Patient's On-Demand Transportation in Hospital Environment*", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2020, Ponta Delgada, Portugal, April 15-17, 2020, pp.158-163, 2020

7. Barradas, R, Lencastre, JA, Soares, S, Valente, A, "Developing Computational Thinking in Early Ages: A Review of the code.org Platform", Proceedings of the 12th International Conference on Computer Supported Education, CSEDU 2020, Prague, Czech Republic, May 2-4, 2020, Volume 2., pp.157-168, 2020

8. Barroso, I, Soares, S, Rodrigues, V, Silva, S, Monteiro, MJ, Rainho, C, Duarte, D, Valente, A, "Assisted Caretaking System for Geriatric Home Care", HCI International 2020 - Late Breaking Papers: Universal Access and Inclusive Design - 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19-24, 2020, Proceedings, vol.12426, pp.439-449, 2020

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10. Cruz, AB, Sousa, A, Reis, LP, "Controller for Real and Simulated Wheelchair with a Multimodal Interface Using Gazebo and ROS", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2020, Ponta Delgada, Portugal, April 15-17, 2020, pp.164-169, 2020

11. Cruz, JA, Cardoso, HL, Reis, LP, Sousa, A, "Reinforcement Learning in Navigation and Cooperative Mapping", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2020, Ponta Delgada, Portugal, April 15-17, 2020, pp.200-205, 2020

12. de Araújo, FMA, Fonseca Ferreira, NM, Valente, A, Soares, SFSP, Trindade, GDdM, Pimentel, HIC, Bruno, LC, Neto, MJA, Nunes, MVCB, Macedo, SS, "Gamified platform to aid physiotherapeutic treatment of epicondylitis", 8th IEEE International Conference on Serious Games and Applications for Health, SeGAH 2020, Vancouver, BC, Canada, August 12-14, 2020, pp.1-5, 2020
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14. Duarte, D, Silva, S, Rodrigues, JM, Soares, SP, Valente, A, "Comparison of Embedded Linux Development Tools for the WiiPiiDo Distribution Development", Intelligent Computing - Proceedings of the 2020 Computing Conference, Volume 1, SAI 2020, London, UK, 16-17 July 2020., vol.1228, pp.42-53, 2020
15. Hruska, J, Pádua, L, Adão, T, Peres, E, Lourenço, JM, Sousa, JJ, "Target Influence on Ground Control Points (GCPs) Identification in Aerial Images", IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, 2020
16. Jesus, J, Santos, F, Gomes, A, Teodoro, AC, "Temporal analysis of the vineyard phenology from remote sensing data using Google Earth Engine", Remote Sensing for Agriculture, Ecosystems, and Hydrology XXII, 2020
17. Lima, J, Oliveira, V, Brito, T, Goncalves, J, Pinto, VH, Costan, P, Torrico, C, "An Industry 4.0 Approach for the Robot@Factory Lite Competition", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2020, pp.239-244, 2020
18. Magalhaes, SA, Moreira, AP, Costa, P, "Omnidirectional robot modeling and simulation", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2020, pp.251-256, 2020
19. Martins, A, Costelha, H, Neves, C, "Supporting the Design, Commissioning and Supervision of Smart Factory Components through their Digital Twin", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2020
20. Martins, PF, Costelha, H, Bento, LC, Neves, C, "Monocular Camera Calibration for Autonomous Driving — a comparative study", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2020
21. Moreira, J, H. Pinto, V, Gonçalves, J, Costa, P, "Using a low-cost robotic manipulator towards the study of over-sensored systems and state estimation", Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality, 2020
22. Moreira, TFM, Lima, J, Costa, P, Cunha, M, "Low Cost Binaural System Based on the Echolocation", Advances in Intelligent Systems and Computing, vol.1093 AISC, pp.60-71, 2020
23. Oliveira, LFP, Silva, MF, Moreira, AP, "Agricultural robotics: A state of the art survey", Robots in Human Life- Proceedings of the 23rd International Conference on Climbing and Walking Robots and the Support Technologies for Mobile Machines, CLAWAR 2020, pp.279-286, 2020
24. Padua, L, Adao, T, Hruska, J, Guimaraes, N, Marques, P, Peres, E, Sousa, JJ, "Vineyard Classification Using Machine Learning Techniques Applied to RGB-UAV Imagery", IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, 2020
25. Padua, L, Marques, P, Martins, L, Sousa, A, Peres, E, Sousa, JJ, "Estimation of Leaf Area Index in Chestnut Trees using Multispectral Data from an Unmanned Aerial Vehicle", IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, 2020
26. Pinto, VH, Amorim, A, Rocha, L, Moreira, AP, "Enhanced Performance Real-Time Industrial Robot Programming by Demonstration using Stereoscopic Vision and an IMU sensor", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2020
27. Reis, R, dos Santos, FN, Santos, L, "Forest Robot and Datasets for Biomass Collection", Advances in Intelligent Systems and Computing - Robot 2019: Fourth Iberian Robotics Conference, pp.152-163, 2020

28. Santos, F, Costa, L, "Multivariate analysis to assist decision-making in many-objective engineering optimization problems", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12251 LNCS, pp.274-288, 2020

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30. Santos, LC, Santos, FN, Solteiro Pires, EJS, Valente, A, Costa, P, Magalhaes, S, "Path Planning for ground robots in agriculture: a short review", 2020 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2020

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33. Saraiva, AA, Santos, DBS, Francisco, AA, Moura Sousa, JVM, Fonseca Ferreira, NMF, Soares, S, Valente, A, "Classification of Respiratory Sounds with Convolutional Neural Network", Proceedings of the 13th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2020) - Volume 3: BIOINFORMATICS, Valletta, Malta, February 24-26, 2020., pp.138-144, 2020

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35. Silva, MF, Luís Lima, J, Reis, LP, Sanfeliu, A, Tardioli, D, "Correction to: Robot 2019: Fourth Iberian Robotics Conference", Advances in Intelligent Systems and Computing, vol.1093 AISC, pp.C1, 2020

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38. Zhu, A, Beer, C, Juhandi, K, Orlov, M, Bacau, NL, Kádár, L, Duarte, AJ, Malheiro, B, Justo, J, Silva, MF, Ribeiro, MC, Ferreira, PD, Guedes, P, "Sail Car—An EPS©ISEP 2019 Project", 2020 IEEE Global Engineering Education Conference (EDUCON), 2020

Books

1. Silva, MF, Luís Lima, J, Reis, LP, Sanfeliu, A, Tardioli, D, "Robot 2019: Fourth Iberian Robotics Conference", Advances in Intelligent Systems and Computing, 2020

Chapter/Paper in Books

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Publications (Editor)

1. Silva, MF, Lima, JL, Reis, LP, Sanfeliu, A, Tardioli, D, "Robot 2019: Fourth Iberian Robotics Conference - Advances in Robotics, Volume 1, Porto, Portugal, 20-22 November, 2019", ROBOT (1), vol.1092, 2020
2. Silva, MF, Lima, JL, Reis, LP, Sanfeliu, A, Tardioli, D, "Robot 2019: Fourth Iberian Robotics Conference - Advances in Robotics, Volume 2, Porto, Portugal, 20-22 November, 2019", ROBOT (2), vol.1093, 2020

Dissertations (PhD)

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10.8 CEGI – ACTIVITY RESULTS IN 2020

10.8.1 Activity indicators

The following tables present CEGI research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.8.1 - CEGI – Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	4	8	10	2
		Academic Staff	13	13	15	2
		Grant Holders and Trainees	30	27	28	1
		Total Core Researchers	**47**	**48**	**53**	**5**
		Total Core PhD	**27**	**26**	**28**	**2**
	Affiliated Researchers		7	6	7	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		**55**	**55**	**61**	**6**
	Total Integrated PhD		**33**	**32**	**34**	**2**

Table 10.8.2 – CEGI – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	148	310	317	8
PN-PICT	National R&D Programmes - S&T Integrated Projects	210	35		-35
PN-COOP	National Cooperation Programmes with Industry	23	34	23	-11
PUE-FP	EU Framework Programmes		95	191	96
PUE-DIV	EU Cooperation Programmes - Other			20	20
SERV-NAC	R&D Services and Consulting - National	109	104	148	45
SERV-INT	R&D Services and Consulting - International			3	3
OP	Other Funding Programmes	12	4		-4
Total Funding		**504**	**581**	**702**	**121**

Table 10.8.3 - CEGI – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	30	26	33
Indexed Conferences	13	10	16
Books		1	
Book Chapters	2	1	3
Concluded PhD Theses - Members	3	2	4
Concluded PhD Theses - Supervised	4	5	5

Table 10.8.4- CEGI – Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	1	0	1
Software copyright registrations	0	0	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	0	0	0
Granted patents	0	0	0
Licence agreements	1	1	1
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.8.5 - CEGI – Summary of participation in dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	12
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	5
International events in which INESC TEC members participate in the program committees	12
Participation in events such as fairs, exhibitions or similar	0
Conferences, workshops and scientific sessions organised by the Centre	0
Participants in the conferences, workshops and scientific sessions organised by the Centre	0
Advanced training courses organised by the Centre	0

Table 10.8.7 - CEGI – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DM4Manufacturing-2	Pedro Amorim	01/11/2016	31/01/2021
PN-FCT	DoubleChain	Mário Amorim Lopes	01/09/2018	29/02/2020
PN-FCT	ASAP	Maria Antónia Carravilla	01/06/2018	31/05/2021
PN-FCT	LASTMILE	João Pedro Pedroso	26/07/2018	25/07/2021
PN-FCT	SiuSMS	Maria Antónia Carravilla	26/07/2018	25/07/2021
PN-FCT	DeltaC&P	José Fernando Oliveira	26/07/2018	25/07/2022
PN-FCT	Tec-FEL	Pedro Amorim	04/04/2018	03/11/2021
PN-FCT	opti-MOVES-1	Teresa Galvão	26/07/2018	31/12/2021
PN-FCT	PLASMA 4 COVID	Sofia Cruz Gomes	01/07/2020	31/03/2021
PN-COOP	KnowLOGIS	Ana Viana	01/04/2017	31/12/2019
PN-COOP	CrossLOG-1	Elsa Marília Silva	01/11/2019	31/10/2022
PN-COOP	TRF4p0-1	António Lucas Soares	01/07/2020	01/07/2023
PUE-DIV	ENCKEP	Ana Viana	07/05/2019	01/03/2021
PUE-DIV	WINDEXT-1	Luís Guimarães	01/01/2020	01/01/2023
PUE-FP	MANU-SQUARE-1	Mário Amorim Lopes	01/01/2018	30/06/2021
PUE-FP	XFLEX_HIDRO-1	Armando Leitão	01/09/2019	31/08/2023
PUE-FP	POCITYF-1	Lia Patrício	01/10/2019	30/09/2024
PUE-FP	InteGrid-4	Pedro Amorim	01/01/2017	31/10/2020
PUE-FP	TRUSTAI	Gonçalo Reis Figueira	01/10/2020	30/09/2024
SERV-NAC	OCP_STOCK	Ana Viana	01/04/2019	26/03/2020
SERV-NAC	PortoAmbiente	Ana Viana	01/03/2019	18/08/2020
SERV-NAC	MINE4HEALTH	Mário Amorim Lopes	01/01/2020	01/04/2021
SERV-NAC	KnowlogisII	Ana Viana	17/06/2018	30/04/2020
SERV-NAC	RM20	Beatriz Brito Oliveira	01/02/2019	31/10/2020
SERV-NAC	BestOrder	Ana Viana	01/10/2020	28/02/2021
SERV-INT	FPP	Beatriz Brito Oliveira	20/04/2020	28/04/2020
SERV-INT	FPP2	Beatriz Brito Oliveira	25/08/2020	31/12/2020

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

10.8.2 List of publications

International Journals with Scientific Referees

1. Abboud, L, As'ad, N, Bilstein, N, Costers, A, Henkens, B, Verleye, K, "From third party to significant other for service encounters: a systematic review on third-party roles and their implications", Journal of Service Management, 2020
2. Amorim Lopes, M, Oliveira, M, Raposo, M, Cardoso Grilo, T, Alvarenga, A, Barbas, M, Alves, M, Vieira, A, Barbosa Póvoa, A, "Enhancing optimization planning models for health human resources management with foresight", Omega (United Kingdom), pp.102384, 2020

3. Bezerra, VMR, Leao, AAS, Oliveira, JF, Santos, MO, "Models for the two-dimensional level strip packing problem - a review and a computational evaluation", Journal of the Operational Research Society, vol.71, pp.606-627, 2020
4. Bianchi Aguiar, T, Hübner, A, Carravilla, MA, Oliveira, JF, "Retail shelf space planning problems: A comprehensive review and classification framework", European Journal of Operational Research, 2020
5. Campos Ferreira, M, Dias, TG, Falcão e Cunha, J, "Is Bluetooth Low Energy feasible for mobile ticketing in urban passenger transport?", Transportation Research Interdisciplinary Perspectives, vol.5, pp.100120, 2020
6. De Regge, M, Van Baelen, F, Beirao, G, Den Ambtman, A, De Pourcq, K, Dias, JC, Kandampully, J, "Personal and Interpersonal Drivers that Contribute to the Intention to Use Gerontechnologies", Gerontology, pp.1-11, 2020
7. Fontes, T, Correia, R, Ribeiro, J, Borges, JL, "A Deep Learning Approach for Predicting Bus Passenger Demand Based on Weather Conditions", Transport and Telecommunication Journal, vol.21, pp.255-264, 2020
8. Gleixner, A, Maher, SJ, Mueller, B, Pedroso, JP, "Price-and-verify: a new algorithm for recursive circle packing using Dantzig–Wolfe decomposition", Annals of Operations Research, 2020
9. Henriques, AA, Camanho, AS, Amorim, P, Silva, JG, "Performance benchmarking using composite indicators to support regulation of the Portuguese wastewater sector", Utilities Policy, vol.66, OCT, 2020
10. Henriques, AA, Fontes, M, Camanho, A, Gabriel Silva, JG, Amorim, P, "Leveraging logistics flows to improve the sludge management process of wastewater treatment plants", Journal of Cleaner Production, vol.276, pp.122720, 2020
11. Jones, T, Drach Zahavy, A, Amorim Lopes, M, Willis, E, "Systems, economics, and neoliberal politics: Theories to understand missed nursing care", Nursing and Health Sciences, 2020
12. Klimentova, X, Viana, A, Pedroso, JP, Santos, N, "Fairness models for multi-agent kidney exchange programmes", Omega (United Kingdom), pp.102333, 2020
13. Korper, AK, Patricio, L, Holmlid, S, Witell, L, "Service design as an innovation approach in technology startups: a longitudinal multiple case study", Creativity and Innovation Management, vol.29, pp.303-323, JUN, 2020
14. Leao, AAS, Toledo, FMB, Oliveira, JF, Carravilla, MA, Alvarez Valdes, R, "Irregular packing problems: A review of mathematical models", European Journal of Operational Research, vol.282, pp.803-822, 2020
15. Lopes, RL, Figueira, G, Amorim, P, Almada Lobo, B, "Cooperative coevolution of expressions for (r,Q) inventory management policies using genetic programming", International Journal of Production Research, pp.1-17, 2020
16. Marques, A, Soares, R, Santos, MJ, Amorim, P, "Integrated planning of inbound and outbound logistics with a Rich Vehicle Routing Problem with Backhauls", Omega, pp.102172, 2020
17. Martins, MPG, Migueis, VL, Fonseca, DSB, Gouveia, PDF, "Prediction of academic dropout in a higher education institution using data mining [Previsão do abandono académico numa instituição de ensino superior com recurso a data mining]", RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao, vol.2020, pp.188-203, 2020
18. Mendes dos Reis, JGM, Amorim, PS, Sarsfield Pereira Cabral, JASP, Toloi, RC, "The impact of logistics performance on Argentina, Brazil, and the US soybean exports from 2012 to 2018: A gravity model approach", Agriculture (Switzerland), vol.10, pp.1-21, 2020
19. Neto, T, Constantino, M, Martins, I, Pedroso, JP, "A multi-objective Monte Carlo tree search for forest harvest scheduling", European Journal of Operational Research, 2020
20. Neves Moreira, F, Amorim Lopes, M, Amorim, P, "The multi-period vehicle routing problem with refueling decisions: Traveling further to decrease fuel cost?", Transportation Research Part E: Logistics and Transportation Review, vol.133, pp.101817, 2020

21. Oliveira, LT, Silva, EF, Oliveira, JF, Bragion Toledo, FMB, "Integrating irregular strip packing and cutting path determination problems: A discrete exact approach", Computers and Industrial Engineering, vol.149, 2020

22. Oliveira, R, Zanella, A, Camanho, AS, "A temporal progressive analysis of the social performance of mining firms based on a Malmquist index estimated with a Benefit-of-the-Doubt directional model", Journal of Cleaner Production, vol.267, pp.121807, 2020

23. Parente, M, Figueira, G, Amorim, P, Marques, A, "Production scheduling in the context of Industry 4.0: review and trends", International Journal of Production Research, pp.1-31, 2020

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25. Pedroso, JP, "Heuristics for Packing Semifluids", European Journal of Operational Research, vol.abs/1607.04403, 2020

26. Pereira, DF, Oliveira, JF, Carravilla, MA, "Tactical sales and operations planning: A holistic framework and a literature review of decision-making models", International Journal of Production Economics, vol.228, pp.107695, 2020

27. Pires, M, Camanho, A, Amorim, P, "Solving the grocery backroom sizing problem", International Journal of Production Research, 2020

28. Santos, MJ, Amorim, P, Marques, A, Carvalho, A, Povoa, A, "The vehicle routing problem with backhauls towards a sustainability perspective: a review", TOP, 2020

29. Santos, MJ, Curcio, E, Mulati, MH, Amorim, P, Miyazawa, FK, "A robust optimization approach for the vehicle routing problem with selective backhauls", Transportation Research Part E-Logistics and Transportation Review, vol.136, APR, 2020

30. Silva, MCA, Camanho, AS, Barbosa, F, "Benchmarking of secondary schools based on Students' results in higher education", Omega (United Kingdom), 2020

31. Sobral, T, Galvao, T, Borges, J, "An Ontology-based approach to Knowledge-assisted Integration and Visualization of Urban Mobility Data", Expert Systems with Applications, vol.150, pp.113260, 2020

32. Stumbriene, D, Camanho, AS, Jakaitiene, A, "The performance of education systems in the light of Europe 2020 strategy", Annals of Operations Research, 2020

33. Teixeira, S, Gama, J, Amorim, P, Figueira, G, "Trustability in Algorithmic Systems Based on Artificial Intelligence in the Public and Private Sectors", ERCIM News, vol.2020, 2020

International Conference Proceedings with Scientific Referees

1. Banica, B, Patricio, L, "Service Design for Business Process Reengineering", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.231-244, 2020

2. Biró, P, Gyetvai, M, Klimentova, X, Pedroso, JP, Pettersson, W, Viana, A, "Compensation Scheme With Shapley Value For Multi-Country Kidney Exchange Programmes", Proceedings of the 34th International ECMS Conference on Modelling and Simulation, ECMS 2020, Wildau, Germany, June 9-12, 2020 [the conference was canceled because of the coronavirus pandemic, the reviewed papers are published in this volume]., pp.129-136, 2020

3. Camanho, A, Silva, MC, Horta, IM, Barbosa, F, "Benchmarking the Metabolism of European Union Countries to Promote the Continuous Improvement of Service Ecosystems", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.319-333, 2020

4. Carvalho, AM, Ferreira, MC, Dias, TG, "Understanding mobility patterns and user activities from geo-tagged social networks data", Transportation Research Procedia, vol.52, pp.493-500, 2020

5. Carvalho, L, de Sousa, JF, de Sousa, JP, "The Role of Collaboration for Sustainable and Efficient Urban Logistics", Boosting Collaborative Networks 4.0 - IFIP Advances in Information and Communication Technology, pp.475-484, 2020
6. Castro, P, Rodrigues, JP, Teixeira, JG, "Understanding FinTech Ecosystem Evolution Through Service Innovation and Socio-technical System Perspective", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.187-201, 2020
7. Ferreira, P, Teixeira, JG, Teixeira, LF, "Understanding the Impact of Artificial Intelligence on Services", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.202-213, 2020
8. Hora, J, Galvão, T, Camanho, A, "Identifying Relevant Transfer-Connections from Entry-Only Automatic Fare Collection Data: The Case Study of Porto", Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST, vol.310 LNICST, pp.63-76, 2020
9. Lima, L, Teixeira, JG, "The SDCS Method: A New Service Design Method for Companies Undergoing a Servitization Process", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.245-258, 2020
10. Oliveira, B, Ramos, AG, De Sousa, JP, "A generic mathematical formulation for two-echelon distribution systems based on mobile depots", Transportation Research Procedia, vol.52, pp.99-106, 2020
11. Pimenta, D, Rodrigues, JC, Oliveira, JF, "The social impact of the use of cyber-physical systems in manufacturing: An initial approach", Studies in Computational Intelligence, vol.853, pp.72-84, 2020
12. Ribeiro, J, Fontes, T, Soares, C, Borges, JL, "Accessibility as an indicator to estimate social exclusion in public transport", Transportation Research Procedia, vol.52, pp.740-747, 2020
13. Ribeiro, J, Fontes, T, Soares, C, Borges, JL, "Process discovery on geolocation data", Transportation Research Procedia, vol.47, pp.139-146, 2020
14. Santos, S, Dias, TG, Sobral, T, "Automatic Generation of Spider Maps for Providing Public Transports Information", Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST, vol.310 LNICST, pp.131-149, 202
15. Teixeira, JG, Miguéis, V, Ferreira, MC, Nóvoa, H, Cunha, JF, "Ten Years Exploring Service Science: Looking Back to Move Forward", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.334-346, 2020
16. Torgal, M, Dias, TG, Fontes, T, "A multi objective approach for DRT service using tabu search", Transportation Research Procedia, vol.52, pp.91-98, 2020

Books

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Chapter/Paper in Books

1. Campos Ferreira, M, Galvão Dias, T, Falcão e Cunha, J, "An In-Depth Study of Mobile Ticketing Services in Urban Passenger Transport", Smart Systems Design, Applications, and Challenges - Advances in Computational Intelligence and Robotics, pp.145-165, 2020
2. Cardoso, S, Rosa, MJ, Miguéis, V, "Quality Assurance of Doctoral Education: Current Trends and Future Developments", Structural and Institutional Transformations in Doctoral Education, pp.105-139, 2020
3. Costa, V, Borges, JL, Dias, TG, "Average Speed of Public Transport Vehicles Based on Smartcard Data", Smart Systems Design, Applications, and Challenges - Advances in Computational Intelligence and Robotics, pp.123-144, 2020

Publications (Editor)

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Dissertations (PhD)

1. Franco, M., “Servitization of manufacturing firms over time: An empirical investigation in the elevator industry”.
2. Gomes, S., “The demand for healthcare services and resources: patterns, trends and challenges in healthcare delivery”.
3. Joly, M., “Integration of the multidisciplinary contributions on Service Design for Innovation”.
4. Santos, M., “Towards solving a robust and sustainable Vehicle Routing Problem with Backhauls”.

10.9 CITE – ACTIVITY RESULTS IN 2020

10.9.1 Activity indicators

The following tables present CITE research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.9.1 – CITE – Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	3	3	5	2
		Academic Staff	1	1	2	1
		Grant Holders and Trainees	4	3	1	-2
		Total Core Researchers	**8**	**7**	**8**	**1**
		Total Core PhD	**3**	**3**	**4**	**1**
	Affiliated Researchers		1	1	2	1
	Administrative and Technical	Employees	0	1	0	-1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**0**	**1**	**0**	**-1**
		Total Integrated HR	**9**	**9**	**10**	**1**
		Total Integrated PhD	**4**	**5**	**6**	**1**

Table 10.9.2 – CITE – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	15	16	8	-8
PN-PICT	National R&D Programmes - S&T Integrated Projects	53	4		-4
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	95	57	143	86
PUE-DIV	EU Cooperation Programmes - Other	77	81	19	-62
SERV-NAC	R&D Services and Consulting - National	46	37	53	16
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	18	2		-2
	Total Funding	**303**	**216**	**224**	**8**

Table 10.9.3 - CITE – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	10	16	11
Indexed Conferences	3	2	5
Books	1		
Book Chapters	5	2	7
Concluded PhD Theses - Members	2		
Concluded PhD Theses - Supervised	2	1	

Table 10.9.4 - CITE - Summary of participation in dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	1
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	6
Participation in events such as fairs, exhibitions or similar	17
Conferences, workshops and scientific sessions organised by the Centre	2
Participants in the conferences, workshops and scientific sessions organised by the Centre	144
Advanced training courses organised by the Centre	3

Table 10.9.6 - CITE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DigEcoBus	Vânia Guiomar Gonçalves	03/07/2018	02/07/2021
PUE-DIV	ScaleUp-PORTUGAL	Alexandra Xavier	01/07/2017	31/12/2018
PUE-DIV	TouriSMEShare	Alexandra Xavier	15/12/2017	29/02/2020
PUE-DIV	PROTOATLANTIC-1	Alexandra Xavier	01/11/2017	30/04/2021
PUE-DIV	EEN2019	Alexandra Xavier	01/01/2019	31/12/2019
PUE-FP	DIVA	Alexandra Xavier	01/04/2018	31/03/2021
PUE-FP	EEN-Innovate	Alexandra Xavier	01/01/2019	31/12/2019
PUE-FP	EENPortugal	Alexandra Xavier	01/01/2020	31/12/2021
PUE-FP	EENINNOVATION	Alexandra Xavier	01/01/2020	31/12/2021
PUE-FP	LL2fresh	Alexandra Xavier	01/07/2020	31/12/2020
PUE-FP	EIT Jumpstarter	Alexandra Xavier	01/09/2020	31/12/2020
SERV-NAC	ConsForestWise	Abílio Pereira Pacheco	01/02/2019	30/06/2020
SERV-NAC	IMSGIDI	Alexandra Xavier	15/03/2019	31/03/2021
SERV-NAC	MonitorizacaoCIR2019	Abílio Pereira Pacheco	27/11/2019	30/06/2020
SERV-NAC	SmartEcotec-1	Cristina Machado Guimarães	01/12/2019	31/10/2020
SERV-NAC	PLIS1asis	Abílio Pereira Pacheco	20/04/2020	06/11/2020

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

10.9.2 List of publications

International Journals with Scientific Referees

1. Almeida, F, "Adoption of a Serious Game in the Developing of Emotional Intelligence Skills", European Journal of Investigation in Health, Psychology and Education, vol.10, pp.30-43, 2020
2. Almeida, F, "The Concept Of Human2Human In The Response To COVID-19", International and Multidisciplinary Journal of Social Sciences, 2020
3. Almeida, F, Santos, JD, "The Role of Social Networks in the Internationalisation of Startups: LinkedIn in Portuguese Context", Management & Marketing. Challenges for the Knowledge Society, vol.15, pp.345-363, 2020
4. Almeida, F, Santos, JD, Monteiro, JA, "The Challenges and Opportunities in the Digitalization of Companies in a Post COVID-19 World", IEEE Engineering Management Review, pp.1-1, 2020
5. Almeida, F, Silva, O, "The impact of COVID-19 on tourism sustainability: evidence from Portugal", Advances in Hospitality and Tourism Research (AHTR), 2020
6. Castro, RN, Ferreira, JJP, "Project portfolio management in the front-end of innovation of research centers: A literature review", Technology Innovation Management Review, vol.10, pp.46-59, 2020
7. Farkat Diogenes, JRF, Claro, J, Rodrigues, JC, Loureiro, MV, "Barriers to onshore wind energy implementation: A systematic review", Energy Research & Social Science, vol.60, pp.101337, FEB, 2020
8. Farkat Diogenes, JRF, Rodrigues, JC, Farkat Diogenes, MCF, Claro, J, "Overcoming barriers to onshore wind farm implementation in Brazil", Energy Policy, vol.138, pp.111165, MAR, 2020
9. Neves, S, Brito, C, "Academic entrepreneurship intentions: a systematic literature review", Journal of Management Development, vol.ahead-of-print, 2020
10. Pereira, AR, Pinto Ferreira, JJP, Lopes, A, "A knowledge representation of the beginning of the innovation process: The Front End of Innovation Integrative Ontology (FEI2O)", Data & Knowledge Engineering, vol.125, JAN, 2020
11. Todaria, S, Azevedo, C, Ferreira, JJP, "Modelling the social business venture - an ontology-based approach", International Journal of Innovation and Learning, vol.28, pp.317-355, 2020

International Conference Proceedings with Scientific Referees

1. Abreu, P, Rodrigues, JC, "The influence of perceptions in adoption intention and behavior — a case study of a biomedical product", 2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), 2020
2. Castro, P, Rodrigues, JP, Teixeira, JG, "Understanding FinTech Ecosystem Evolution Through Service Innovation and Socio-technical System Perspective", Lecture Notes in Business Information Processing, vol.377 LNBIP, pp.187-201, 2020

3. Costa, J, Xavier, A, Pita, M, Guimarães, C, "Using hurdle models to appraise the non-linear effect of age in entrepreneurship", Proceedings of the European Conference on Research Methods in Business and Management Studies, vol.2020-June, pp.80-88, 2020
4. Pimenta, D, Rodrigues, JC, Oliveira, JF, "The social impact of the use of cyber-physical systems in manufacturing: An initial approach", Studies in Computational Intelligence, vol.853, pp.72-84, 2020
5. Simoes, AC, Rodrigues, JC, Neto, P, "The impact of Industry 4.0 on work: A synthesis of the literature and reflection about the future", 2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), 2020

Books

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Chapter/Paper in Books

1. Almeida, F, "The Contribution of Serious Games for the Success of Students in Entrepreneurship", IT Issues in Higher Education - Advances in Higher Education and Professional Development, pp.123-148, 2020
2. Almeida, F, Cunha, E, "A Framework for Longitudinal Analysis of University Spin-Offs", Advances in Electronic Government, Digital Divide, and Regional Development - Leveraging Digital Innovation for Governance, Public Administration, and Citizen Services, pp.1-24, 2020
3. Almeida, F, Lourenço, J, "Privacy and Security Challenges in the Internet of Things", Encyclopedia of Criminal Activities and the Deep Web, pp.749-762, 2020
4. Carvalho, I, Almeida, F, "Promoting Healthy Food Habits Through an mHealth Application", Advances in Medical Technologies and Clinical Practice - Mobile Devices and Smart Gadgets in Medical Sciences, pp.1-21, 2020
5. Lourenço, J, Almeida, F, "The Impact of Emergent Technologies in the Evolutionary Path for M-Commerce", Impact of Mobile Services on Business Development and E-Commerce - Advances in Electronic Commerce, pp.1-21, 2020
6. Roque, J, Santos, JD, Simões, J, Almeida, F, "Exploring the Organizational and Technological Implications on Strategic Business Model Change", Dynamic Strategic Thinking for Improved Competitiveness and Performance - Advances in Business Strategy and Competitive Advantage, pp.28-51, 2020
7. Sá, S, Morais, J, Almeida, F, "As Metodologias Ativas como Estratégias para o Desenvolvimento de Competências de Inteligência Emocional nos Estudantes do Ensino Superior", New Trends in Qualitative Research - Investigação Qualitativa em Educação: avanços e desafios, pp.55-68, 2020

Publications (Editor)

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Dissertations (PhD)

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10.10 CSIG – ACTIVITY RESULTS IN 2020

10.10.1 Activity indicators

The following tables present CSIG research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.10.1 - CSIG - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	13	13	14	1
		Academic Staff	24	25	27	2
		Grant Holders and Trainees	50	46	42	-4
		Total Core Researchers	**87**	**84**	**83**	**-1**
		Total Core PhD	**31**	**29**	**32**	**3**
	Affiliated Researchers		18	19	17	-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	**106**	**104**	**101**	**-3**
		Total Integrated PhD	**49**	**48**	**49**	**1**

Table 10.10.2 - CSIG – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	183	366	294	-72
PN-PICT	National R&D Programmes - S&T Integrated Projects	230	48		-48
PN-COOP	National Cooperation Programmes with Industry	126	68	45	-23
PUE-FP	EU Framework Programmes	350	371	443	73
PUE-DIV	EU Cooperation Programmes - Other	55	49	34	-15
SERV-NAC	R&D Services and Consulting - National	148	273	293	20
SERV-INT	R&D Services and Consulting - International	32	16	31	14
OP	Other Funding Programmes	123	110	55	-55
	Total Funding	**1 311**	**1 314**	**1 194**	**-120**

Table 10.10.3 - CSIG - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	34	41	48
Indexed Conferences	113	117	51
Books	1	1	
Book Chapters	6	3	2
Concluded PhD Theses - Members	9	1	8
Concluded PhD Theses - Supervised	16	1	20

Table 10.10.4 - CSIG - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	2	0	0
Software copyright registrations	0	0	0
Patent first priority filings (New inventions)	1	0	0
Patent applications (Internationalisation)	1	1	1
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs established	1	0	0
Spin-offs in development	0	0	0

Table 10.10.5 - CSIG - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	10
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	24
International events in which INESC TEC members participate in the program committees	44
Participation in events such as fairs, exhibitions or similar	9
Conferences, workshops and scientific sessions organised by the Centre	5
Participants in the conferences, workshops and scientific sessions organised by the Centre	210
Advanced training courses organised by the Centre	3

Table 10.10.6 – CSIG - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Icarefordepression	Artur Rocha	01/06/2016	29/02/2020
PN-FCT	C4G	Artur Rocha	15/06/2017	11/06/2021
PN-FCT	eCSAAP	Hugo Paredes	01/09/2018	29/02/2020
PN-FCT	MoST	Alexandre Carvalho	01/06/2018	30/09/2021
PN-FCT	PERFECT	Maximino Bessa	01/07/2018	30/06/2021
PN-FCT	PAINTER	Rui Pedro Rodrigues	01/07/2018	31/03/2022
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-FCT	Wex-Atlantic	João Barroso	20/07/2018	19/07/2021
PN-FCT	EPISA	Carla Lopes	01/01/2019	31/12/2021
PN-FCT	WalkingPAD	Hugo Paredes	11/11/2019	09/11/2021
PN-COOP	FDControlo-1	Lino Oliveira	02/01/2018	31/12/2021
PN-COOP	INFRAVINI	Lino Oliveira	01/07/2019	30/06/2021
PUE-DIV	MarRisk	Artur Rocha	01/07/2017	31/12/2020
PUE-DIV	RADARONRAIA	Lino Oliveira	01/01/2018	31/07/2022
PUE-DIV	TraceRadon	Susana Alexandra Barbosa	01/06/2020	31/05/2023
PUE-FP	RECAP	José Pedro Ornelas	01/01/2017	30/09/2021
PUE-FP	MELOA	Carlos Emanuel Almeida	01/12/2017	31/08/2021
PUE-FP	FEEdBACk-1	António Coelho	01/11/2017	30/04/2021
PUE-FP	InteGrid-2	António Gaspar	01/01/2017	31/10/2020
PUE-FP	RDA-pt	Cristina Ribeiro	15/02/2019	30/09/2020
PUE-FP	iReceptor+	Artur Rocha	01/01/2019	31/12/2022
PUE-FP	EUCAN_CONNECT	José Pedro Ornelas	01/01/2019	31/12/2023
PUE-FP	TIPES	Susana Alexandra Barbosa	01/09/2019	31/08/2023
PUE-FP	INCLUDING	Maximino Bessa	01/08/2019	31/07/2024
SERV-NAC	RUTE-1	Ana Cristina Paiva	01/10/2018	13/02/2020
SERV-NAC	VRTrainingIndustry	Leonel Morgado	13/02/2019	12/02/2021
SERV-NAC	MuseuPorto	António Coelho	15/11/2018	31/03/2020
SERV-NAC	consult_ARQT_EMPR	José Correia	11/06/2019	28/02/2020
SERV-NAC	MatosinhosDigital	Lino Oliveira	30/06/2019	31/05/2022
SERV-NAC	ICON	Gabriel David	13/05/2019	13/03/2020
SERV-NAC	T4CDTKC-4	António Coelho	01/09/2019	20/12/2020
SERV-NAC	SIGMAIA2	Ricardo Henriques	30/07/2019	30/01/2022
SERV-NAC	SIFOREST	José Correia	20/12/2019	31/05/2020
SERV-NAC	EYEFRYprototype2prod	José Correia	27/01/2020	27/07/2020
SERV-NAC	ARQNET2	José Correia	15/04/2020	30/11/2020
SERV-NAC	TRIMAPSTRACK	Lino Oliveira	06/01/2020	06/07/2021
SERV-NAC	DigCore	Henrique São Mamede	11/05/2020	31/03/2021
SERV-NAC	PLIS1asis-1	José Correia	20/04/2020	06/11/2020
SERV-NAC	Regulam2ITSUrb	José Correia	01/09/2020	31/01/2021
SERV-NAC	PGDADOS	Henrique São Mamede	01/09/2020	01/04/2021
SERV-INT	MBSupport	José Pedro Ornelas	18/10/2018	17/12/2020

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-INT	MBIntervention	José Pedro Ornelas	20/12/2018	17/01/2019
SERV-INT	MBTOOLS	José Pedro Ornelas	01/12/2019	01/03/2020
SERV-INT	MBSERVMAINTENANCE	José Pedro Ornelas	20/12/2019	20/12/2020
OP	HDR4RTT	Maximino Bessa	30/09/2016	30/09/2020
OP	AmbiVideo360	Rui Pedro Rodrigues	01/09/2019	01/11/2020
OP	CSCWD2019	Hugo Paredes	01/05/2018	30/04/2020
OP	TAROTSummerSchool	Ana Cristina Paiva	01/06/2020	31/12/2020

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

10.10.2 List of publications

International Journals with Scientific Referees

1. Afonso, L, Rodrigues, R, Castro, J, Parente, N, Teixeira, C, Fraga, A, Torres, S, "A Mobile-Based Tailored Recommendation System for Parents of Children with Overweight or Obesity: A New Tool for Health Care Centers", European Journal of Investigation in Health Psychology and Education, vol.10, pp.779-794, SEP, 2020
2. Afonso, L, Rodrigues, R, Reis, E, Miller, K, Castro, J, Parente, N, Teixeira, C, Fraga, A, Torres, S, "Fammeal: A Gamified Mobile Application for Parents and Children to Help Healthcare Centers Treat Childhood Obesity", IEEE Transactions on Games, vol.12, pp.351-360, DEC, 2020
3. Arabnejad, H, Bispo, J, Cardoso, JMP, Barbosa, JG, "Source-to-source compilation targeting OpenMP-based automatic parallelization of C applications", Journal of Supercomputing, 2020
4. Barbosa, S, "Ambient radioactivity and atmospheric electric field: A joint study in an urban environment", Journal of Environmental Radioactivity, vol.219, pp.106283, 2020
5. Beck, D, Morgado, L, O'Shea, P, "Finding the Gaps about Uses of Immersive Learning Environments: A Survey of Surveys", J. Univers. Comput. Sci., vol.26, pp.1043-1073, 2020
6. Becker, D, Bremer, V, Funk, B, Hoogendoorn, M, Rocha, A, Riper, H, "Evaluation of a temporal causal model for predicting the mood of clients in an online therapy", Evidence-Based Mental Health, vol.23, pp.27-33, FEB, 2020
7. Bispo, J, Cardoso, JMP, "Clava: C/C plus plus source-to-source compilation using LARA", SOFTWAREX, vol.12, pp.100565, 2020
8. Cardoso, P, Morgado, L, Coelho, A, "Authoring Game-Based Learning Activities that are Manageable by Teachers", ERCIM NEWS, pp.17-18, JAN, 2020
9. Christley, S, Aguiar, A, Blanck, G, Breden, F, Chan Bukhari, SA, Busse, CE, Jaglale, J, Harikrishnan, SL, Laserson, U, Peters, B, Rocha, A, Schramm, CA, Taylor, S, Vander Heiden, JA, Zimonja, B, Watson, CT, Corrie, B, Cowell, LG, "The ADC API: A Web API for the Programmatic Query of the AIRR Data Commons", Frontiers Big Data, vol.3, pp.22, 2020
10. Coelho, A, Rodrigues, R, Nóbrega, R, Jacob, J, Morgado, L, Cardoso, P, Zeller, Mv, Santos, L, de Sousa, AA, "Serious Pervasive Games", Frontiers in Computer Science, vol.2, 2020

11. Coelho, J, Vanhoucke, M, "Going to the core of hard resource-constrained project scheduling instances", Computers & Operations Research, vol.121, pp.104976, 2020

12. Crisostomo, L, Fonseca Ferreira, NMF, Filipe, V, "Robotics services at home support", International Journal of Advanced Robotic Systems, vol.17, pp.172988142092501, 2020

13. Devezas, JL, Nunes, S, "Characterizing the hypergraph-of-entity and the structural impact of its extensions", Applied Network Science, vol.5, 2020

14. Ferreira, PJS, Cardoso, JMP, Moreira, JM, "kNN Prototyping Schemes for Embedded Human Activity Recognition with Online Learning", Computers, vol.9, pp.96, 2020

15. Flores, N, Paiva, ACR, Cruz, N, "Teaching software engineering topics through pedagogical game design patterns: An empirical study", Information (Switzerland), vol.11, pp.153, 2020

16. Franzke, CLE, Barbosa, S, Blender, R, Fredriksen, HB, Laepple, T, Lambert, F, Nilsen, T, Rypdal, K, Rypdal, M, Scotto, MG, Vannitsem, S, Watkins, NW, Yang, LC, Yuan, NM, "The Structure of Climate Variability Across Scales", Reviews of Geophysics, 2020

17. Gaspar, H, Morgado, L, Mamede, H, Oliveira, T, Manjon, B, Gutl, C, "Research priorities in immersive learning technology: the perspectives of the iLRN community", Virtual Reality, 2020

18. Goncalves, G, Melo, M, Vasconcelos Raposo, J, Bessa, M, "A novel method to enhance the touristic 360° promotional video experience", Multimedia Tools and Applications, 2020

19. Goncalves, G, Melo, M, Vasconcelos Raposo, J, Bessa, M, "Impact of different sensory stimuli on presence in credible virtual environments", IEEE Transactions on Visualization and Computer Graphics, pp.1-1, 2020

20. Goncalves, G, Monteiro, P, Melo, M, Vasconcelos Raposo, J, Bessa, M, "A Comparative Study Between Wired and Wireless Virtual Reality Setups", IEEE Access, vol.8, pp.29249-29258, 2020

21. Guo, W, Vanhoucke, M, Coelho, J, Luo, J, "Automatic detection of the best performing priority rule for the resource-constrained project scheduling problem", Expert Systems with Applications, pp.114116, 2020

22. Iria, J, Fonseca, N, Cassola, F, Barbosa, A, Soares, F, Coelho, A, Ozdemir, A, "A gamification platform to foster energy efficiency in office buildings", Energy and Buildings, vol.222, pp.110101, 2020

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3. Khanal, S., “Facial image processing to monitor physical exercise intensity”.
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10.11 LIAAD – ACTIVITY RESULTS IN 2020

10.11.1 Activity indicators

The following tables present LIAADresearch team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.11.1 – LIAAD - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	3	3	8	5
		Academic Staff	22	22	24	2
		Grant Holders and Trainees	24	27	25	-2
		Total Core Researchers	**49**	**52**	**57**	**5**
		Total Core PhD	**30**	**29**	**33**	**4**
	Affiliated Researchers		4	5	7	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	**53**	**57**	**64**	**7**
		Total Integrated PhD	**34**	**34**	**40**	**6**

Table 10.11.2 – LIAAD - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	64	229	190	-39
PN-PICT	National R&D Programmes - S&T Integrated Projects	242	51		-51
PN-COOP	National Cooperation Programmes with Industry	41		38	38
PUE-FP	EU Framework Programmes	107	95	51	-44
PUE-DIV	EU Cooperation Programmes - Other			1	1
SERV-NAC	R&D Services and Consulting - National	93	141	239	99
SERV-INT	R&D Services and Consulting - International			1	1
OP	Other Funding Programmes	13	2	7	5
	Total Funding	**567**	**526**	**528**	**3**

Table 10.11.3 – LIAAD - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	44	50	38
Indexed Conferences	59	57	28
Books	4	1	
Book Chapters	6	2	3
Concluded PhD Theses - Members	2	2	4
Concluded PhD Theses - Supervised	3	5	6

Table 10.11.4 – LIAAD - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	1	0	0
Software copyright registrations	0	0	0
Patent first priority filings (New inventions)	1	0	0
Patent applications (Internationalisation)	1	0	0
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.11.5 – LIAAD - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	1
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	11
International events in which INESC TEC members participate in the program committees	40
Participation in events such as fairs, exhibitions or similar	6
Conferences, workshops and scientific sessions organised by the Centre	6
Participants in the conferences, workshops and scientific sessions organised by the Centre	200
Advanced training courses organised by the Centre	2

Table 10.11.6 – LIAAD - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
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	NITROLIMIT	Luís Torgo	01/10/2018	30/09/2021
PN-FCT	MaLPIS	Paula Brito	01/10/2018	30/09/2021
PN-FCT	FailStopper	Rita Paula Ribeiro	01/12/2018	31/05/2021
PN-FCT	Text2Story	Alípio Jorge	14/11/2019	13/11/2022
PN-COOP	SKORR-1	João Gama	01/09/2018	31/05/2021
PN-COOP	TRF4p0-2	Ricardo Teixeira Sousa	01/07/2020	01/07/2023
PN-COOP	AIDA-1	João Vinagre	12/05/2020	08/11/2022
PUE-FP	RECAP-1	Rui Camacho	01/01/2017	30/09/2021
PUE-FP	FIN-TECH	Alípio Jorge	01/01/2019	30/06/2021
PUE-FP	HumanE-AI-Net	João Gama	01/09/2020	31/08/2023
SERV-NAC	RUTE	Alípio Jorge	01/10/2018	13/02/2020
SERV-NAC	RISKSENS	João Mendes Moreira	01/07/2019	30/06/2020
SERV-NAC	RAMnet	João Gama	03/06/2019	31/07/2021
SERV-NAC	T4CDTKC-2	Alípio Jorge	01/09/2019	20/12/2020
SERV-NAC	MINE4HEALTH-1	Alípio Jorge	01/01/2020	01/04/2021
SERV-NAC	SLSNA	João Gama	15/02/2020	15/02/2021
SERV-NAC	PAFML	Alípio Jorge	01/03/2020	01/03/2023
SERV-NAC	MetaFLow	Alípio Jorge	01/08/2020	30/04/2021
SERV-NAC	Training4DS	Nuno Moniz	20/10/2020	20/11/2020
SERV-INT	PAIQAFSR	João Mendes Moreira	15/07/2020	29/07/2020
OP	Coop_India	João Gama	01/01/2018	30/06/2020
OP	DSAA2021	João Gama	01/01/2020	01/01/2022

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

10.11.2 List of publications

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2. Balado, J, Sousa, R, Diaz Vilarino, L, Arias, P, "Transfer Learning in urban object classification: Online images to recognize point clouds", Automation in Construction, vol.111, pp.103058, MAR, 2020
3. Balali, A, Asadpour, M, Campos, R, Jatowt, A, "Joint event extraction along shortest dependency paths using graph convolutional networks", Knowledge-Based Systems, pp.106492, 2020

4. Bardhan, R, Debnath, R, Gama, J, Vijay, U, "REST framework: A modelling approach towards cooling energy stress mitigation plans for future cities in warming Global South", Sustainable Cities and Society, vol.61, pp.102315, 2020

5. Campos, R, Mangaravite, V, Pasquali, A, Jorge, A, Nunes, C, Jatowt, A, "YAKE! Keyword extraction from single documents using multiple local features", Information Sciences, vol.509, pp.257-289, 2020

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2. Asevedo Nóbrega, FA, Jorge, AM, Brazdil, P, Pardo, TAS, "Sentence Compression for Portuguese", Computational Processing of the Portuguese Language - 14th International Conference, PROPOR 2020, Evora, Portugal, March 2-4, 2020, Proceedings, vol.12037, pp.270-280, 2020

3. Baghoussi, Y, Moreira, JM, Moniz, N, Soares, C, "Underground Train Tracking using Mobile Phone Accelerometer Data", 23rd IEEE International Conference on Intelligent Transportation Systems, ITSC 2020, Rhodes, Greece, September 20-23, 2020, pp.1-6, 2020

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12. Guimarães, N, Figueira, A, Torgo, L, "Knowledge-based Reliability Metrics for Social Media Accounts", Proceedings of the 16th International Conference on Web Information Systems and Technologies, 2020

13. Leal, F, Veloso, B, Malheiro, B, Vélez, HG, "Trust and Reputation Smart Contracts for Explainable Recommendations", Trends and Innovations in Information Systems and Technologies - Advances in Intelligent Systems and Computing, pp.124-133, 2020

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22. Silva, PR, "Multimodal deep learning based approach for cells state classification: Student research abstract", Proceedings of the ACM Symposium on Applied Computing, pp.20-23, 2020
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24. Vasconcelos, PB, Ribeiro, RP, "Using Property-Based Testing to Generate Feedback for C Programming Exercises", OpenAccess Series in Informatics, vol.81, 2020
25. Veloso, B, Gama, J, "Self Hyper-parameter Tuning for Stream Classification Algorithms", Communications in Computer and Information Science - IoT Streams for Data-Driven Predictive Maintenance and IoT, Edge, and Mobile for Embedded Machine Learning, pp.3-13, 2020
26. Veloso, B, Malheiro, B, Burguillo, JC, Gama, J, "Impact of Trust and Reputation Based Brokerage on the CloudAnchor Platform", Advances in Practical Applications of Agents, Multi-Agent Systems, and Trustworthiness. The PAAMS Collection - Lecture Notes in Computer Science, pp.303-314, 2020
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Blank

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1. Andrade, T, Gama, J, "Identifying Points of Interest and Similar Individuals from Raw GPS Data", Mobility Internet of Things 2018 - EAI/Springer Innovations in Communication and Computing, vol.abs/1904.09357, 2020
2. Roxo, MT, Brito, PQ, "Augmented Reality: What Motivates Late Millennials towards Fashion Mobile Apps?", Enlightened Marketing in Challenging Times - Developments in Marketing Science: Proceedings of the Academy of Marketing Science, pp.315-327, 2020
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Publications (Editor)

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2. Campos, R, Jorge, AM, Jatowt, A, Bhatia, S, "Proceedings of Text2Story - Third Workshop on Narrative Extraction From Texts co-located with 42nd European Conference on Information Retrieval, Text2Story@ECIR 2020, Lisbon, Portugal, April 14th, 2020 [online only]", Text2Story@ECIR, vol.2593, 2020
3. Jorge, AM, Campos, R, Jatowt, A, Aizawa, A, "Proceedings of AI4Narratives - Workshop on Artificial Intelligence for Narratives in conjunction with the 29th International Joint Conference on Artificial Intelligence and the 17th Pacific Rim International Conference on Artificial Intelligence (IJCAI 2020), Yokohama, Japan, January 7th and 8th, 2021 (online event due to Covid-19 outbreak)", AI4Narratives@IJCAI, vol.2794, 2020
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5. Vinagre, J, Jorge, AM, Ghossein, MA, Bifet, A, "Proceedings of the 3rd Workshop on Online Recommender Systems and User Modeling co-located with the 14th ACM Conference on Recommender Systems (RecSys 2020), Virtual Event, September 25, 2020", ORSUM@RecSys, vol.2715, 2020

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2. Fernandes, S., “Tensor-based Approaches for Evolving Social Network Analysis”.
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4. Tabassum, S., “Massive Scale Streaming Graphs: Evolving Network Analysis and Mining”.

10.12 CRACS – ACTIVITY RESULTS IN 2020

10.12.1 Activity indicators

The following tables present CRACS research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.12.1 – CRACS - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	1	1	1	0
		Academic Staff	14	15	17	2
		Grant Holders and Trainees	37	21	16	-5
		Total Core Researchers	**52**	**37**	**34**	**-3**
		Total Core PhD	**21**	**18**	**19**	**1**
	Affiliated Researchers		0	2	1	-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		**53**	**40**	**36**	**-4**
	Total Integrated PhD		**21**	**19**	**19**	**0**

Table 10.12.2 - CRACS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	81	65	16	-49
PN-PICT	National R&D Programmes - S&T Integrated Projects	295	25		-25
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	77	70	1	-69
PUE-DIV	EU Cooperation Programmes - Other		15	50	35
SERV-NAC	R&D Services and Consulting - National	45	49	94	46
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes			11	11
Total Funding		**499**	**229**	**173**	**-56**

Table 10.12.3 - CRACS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	11	17	15
Indexed Conferences	41	28	33
Books			
Book Chapters	1	2	
Concluded PhD Theses - Members	1	1	1
Concluded PhD Theses - Supervised	1	1	1

Table 10.12.4 – CRACS - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	1	1	0
Software copyright registrations	0	0	0
Patent first priority filings (New inventions)	1	0	0
Patent applications (Internationalisation)	1	1	3
Granted patents	0	0	0
Licence agreements	0	0	0
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.12.5 – CRACS - Summary of dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	5
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	7
International events in which INESC TEC members participate in the program committees	43
Participation in events such as fairs, exhibitions or similar	0
Conferences, workshops and scientific sessions organised by the Centre	3
Participants in the conferences, workshops and scientific sessions organised by the Centre	2 200
Advanced training courses organised by the Centre	1

Table 10.12.6 – CRACS - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	CRADLE	Vítor Santos Costa	15/06/2018	14/06/2021
PUE-DIV	FGPE	Ricardo Queirós	01/09/2018	31/05/2021
PUE-FP	Digi-NewB	Luís Filipe Antunes	01/03/2016	31/05/2020
SERV-NAC	PGODISSEIA	Manuel Eduardo Correia	24/07/2018	31/12/2019
SERV-NAC	EFA-Cloud	Luís Filipe Antunes	01/01/2019	15/02/2021
SERV-NAC	Authenticus19_20	Luís Filipe Antunes	01/09/2019	21/09/2020
SERV-NAC	Cortaderia	Eduardo Brandão Marques	01/01/2020	30/07/2020
SERV-NAC	T4CDTKC-6	Ricardo Rocha	01/09/2019	20/12/2020
OP	HLPP2020	Miguel Gonçalves Areias	09/07/2020	09/08/2020
OP	SMBQ2020	Miguel Gonçalves Areias	07/09/2020	30/11/2020
OP	SBACPAD2020	Miguel Gonçalves Areias	08/09/2020	30/11/2020

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

10.12.2 List of publications

International Journals with Scientific Referees

1. Alves, LQ, Ruivo, R, Fonseca, MM, Lopes Marques, M, Ribeiro, P, Castro, LFC, "PseudoChecker: an integrated online platform for gene inactivation inference", Nucleic Acids Research, 2020
2. Barrio, R, Carvalho, M, Castro, L, Rodrigues, AAP, "Experimentally Accessible Orbits Near a Bykov Cycle", International Journal of Bifurcation And Chaos, vol.30, AUG, 2020
3. Costa, J, Silva, C, Antunes, M, Ribeiro, B, "Boosting dynamic ensemble's performance in Twitter", Neural Computing and Applications, 2020
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5. Guimaraes, N, Miranda, F, Figueira, A, "Identifying journalistically relevant social media texts using human and automatic methodologies", International Journal of Grid and Utility Computing, vol.11, pp.72-83, 2020
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8. Leal, JP, "Visualization of path patterns in semantic graphs", Computer Science and Information Systems, vol.17, pp.229-252, JAN, 2020
9. Loff, B, Moreira, N, Reis, R, "The computational power of parsing expression grammars", Journal of Computer and System Sciences, 2020

10. Nabizadeh, AH, Leal, JP, Rafsanjani, HN, Shah, RR, "Learning path personalization and recommendation methods: A survey of the state-of-the-art", Expert Systems with Applications, vol.159, 2020
11. Paiva, JC, Leal, JP, Queiros, R, "Fostering Programming Practice through Games", Information, vol.11, pp.498, 2020
12. Pinto, E, Marcos, G, Walters, C, Goncalves, F, Sacarlal, J, Castro, L, Rego, G, "Palliative care in Mozambique: Physicians' knowledge, attitudes and practices", PLOS ONE, vol.15, pp.e0238023, 2020
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International Conference Proceedings with Scientific Referees

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2. Brandão, A, Resende, JS, Martins, R, "Employment of Secure Enclaves in Cheat Detection Hardening", Trust, Privacy and Security in Digital Business - Lecture Notes in Computer Science, pp.48-62, 2020
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1. Nwebonyi, F., “Establishing Trust and Confidence Among Entities in Distributed Networks”.

10.13 HASLAB – ACTIVITY RESULTS IN 2020

10.13.1 Activity indicators

The following tables present HASLab research team composition and evolution and the main indicators of its activity carried out in 2020 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2020 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 10.13.1 - HASLab - Research team composition

Type of Human Resources			2018	2019	2020	Δ 2019-20
Integrated HR	Core Research Team	Employees	6	7	9	2
		Academic Staff	14	16	19	3
		Grant Holders and Trainees	49	30	28	-2
		Total Core Researchers	**69**	**53**	**56**	**3**
		Total Core PhD	**30**	**27**	**26**	**-1**
	Affiliated Researchers		7	6	6	0
	Administrative and Technical	Employees	0	1	2	1
		Grant Holders and Trainees	3	1	0	-1
		Total Admin and Tech	**3**	**2**	**2**	**0**
		Total Integrated HR	**79**	**61**	**64**	**3**
		Total Integrated PhD	**37**	**33**	**32**	**-1**

Table 10.13.2 - HASLab - Project funding Table

Funding Source		Total Income (k€)			Δ (k€)
		2018	2019	2020	2019-20
PN-FCT	National R&D Programmes - FCT	68	228	206	-22
PN-PICT	National R&D Programmes - S&T Integrated Projects	195	34		-34
PN-COOP	National Cooperation Programmes with Industry	34	2	122	120
PUE-FP	EU Framework Programmes	566	452	148	-305
PUE-DIV	EU Cooperation Programmes - Other				0
SERV-NAC	R&D Services and Consulting - National	79	72	353	281
SERV-INT	R&D Services and Consulting - International	61	113	30	-83
OP	Other Funding Programmes	91	249	137	-112
	Total Funding	**1 094**	**1 158**	**997**	**-161**

10.13.3 - HASLab - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2018	2019	2020
Indexed Journals	15	12	13
Indexed Conferences	39	51	35
Books		1	
Book Chapters		3	
Concluded PhD Theses - Members	3	1	2
Concluded PhD Theses - Supervised	3	1	3

Table 10.13.4 - HASLab - Summary of IP protection, exploitation and technology transfer

Type of Result	2018	2019	2020
Invention disclosures	0	0	0
Software copyright registrations	1	0	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	0	0	0
Granted patents	0	0	1
Licence agreements	0	0	0
Spin-offs established	0	1	0
Spin-offs in development	1	0	0

Table 10.13.5 - HASLab - Summary of participation in dissemination activities

Type of Activity	2020
Participation as principal editor, editor or associated editor in journals	3
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	6
International events in which INESC TEC members participate in the program committees	32
Participation in events such as fairs, exhibitions or similar	2
Conferences, workshops and scientific sessions organised by the Centre	5
Participants in the conferences, workshops and scientific sessions organised by the Centre	50
Advanced training courses organised by the Centre	1

Table 10.13.6 - HASLab - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	KLEE	Luís Soares Barbosa	01/06/2018	30/11/2021
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-FCT	MaLPIS-1	Ricardo Morla	01/10/2018	30/09/2021
PN-FCT	PAStor	João Tiago Paulo	01/10/2020	30/09/2021
PN-FCT	StayAway	José Orlando Pereira	01/04/2020	30/06/2021
PN-COOP	BigHPC	João Tiago Paulo	31/03/2020	31/03/2023
PN-COOP	AIDA	Ricardo Pereira Vilaça	12/05/2020	08/11/2022
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	31/10/2020
PUE-FP	InterConnect-2	Fábio André Coelho	01/10/2019	30/09/2023
SERV-NAC	RCS	Fábio André Coelho	01/03/2018	29/02/2020
SERV-NAC	INCMchaves	José Bacelar Almeida	19/06/2019	30/06/2021
SERV-NAC	OLM2	José Creissac Campos	01/05/2019	30/06/2020
SERV-NAC	T4CDTKC-5	Alcino Cunha	01/09/2019	20/12/2020
SERV-NAC	MobileID	Vítor Francisco Fonte	01/10/2019	01/04/2021
SERV-NAC	AppOwl	Ricardo Morla	01/01/2020	01/09/2021
SERV-NAC	SLSNA-1	Paulo Jorge Azevedo	15/02/2020	15/02/2021
SERV-NAC	Collaboration	José Creissac Campos	14/05/2020	14/11/2020
SERV-NAC	ENSCOMP	José Nuno Oliveira	01/09/2020	30/06/2021
SERV-NAC	DigiLightRail	Alcino Cunha	01/10/2019	01/10/2021
SERV-INT	ECZK	Manuel Barbosa	21/08/2020	25/07/2021
OP	FM'19	José Nuno Oliveira	01/08/2018	31/12/2020
OP	BlockchainVerif	José Bacelar Almeida	01/01/2020	31/08/2021

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

10.13.2 List of publications

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3. Carvalho, P, Lima, SR, Sabucedo, LA, Santos Gago, JM, Silva, JMC, "Towards a holistic semantic support for context-aware network monitoring: An ontology-based approach", Computing, 2020
4. Cunha, A, Macedo, N, "Validating the Hybrid ERTMS/ETCS Level 3 concept with Electrum", International Journal on Software Tools for Technology Transfer, 2020

5. de Oliveira Dantas, ABD, de Carvalho Junior, FH, Barbosa, LS, "A component-based framework for certification of components in a cloud of HPC services", Science of Computer Programming, vol.191, 2020
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2. Al Lawati, AH, Barbosa, LS, "Towards a register-based census in Oman", ICEGOV 2020: 13th International Conference on Theory and Practice of Electronic Governance, Athens, Greece, 23-25 September, 2020, pp.823-826, 2020
3. Almeida, JB, Barbosa, M, Barthe, G, Gregoire, B, Koutsos, A, Laporte, V, Oliveira, T, Strub, PY, "The Last Mile: High-Assurance and High-Speed Cryptographic Implementations", 2020 IEEE Symposium on Security and Privacy, SP 2020, San Francisco, CA, USA, May 18-21, 2020, vol.2020-May, pp.965-982, 2020
4. Almeida, JB, Barbosa, M, Barthe, G, Laporte, V, Oliveira, T, "Certified Compilation for Cryptography: Extended x86 Instructions and Constant-Time Verification", Progress in Cryptology - INDOCRYPT 2020 - 21st International Conference on Cryptology in India, Bangalore, India, December 13-16, 2020, Proceedings, vol.12578, pp.107-127, 2020
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6. Carvalho, H, Cruz, D, Pontes, R, Paulo, J, Oliveira, R, "On the Trade-Offs of Combining Multiple Secure Processing Primitives for Data Analytics", Distributed Applications and Interoperable Systems - 20th IFIP WG 6.1 International Conference, DAIS 2020, Held as Part of the 15th International Federated Conference on Distributed Computing Techniques, DisCoTec 2020, Valletta, Malta, June 15-19, 2020, Proceedings, vol.12135, pp.3-20, 2020

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33. Rua, R, Fraga, T, Couto, M, Saraiva, J, "Greenspecting Android virtual keyboards", MOBILESoft '20: IEEE/ACM 7th International Conference on Mobile Software Engineering and Systems, Seoul, Republic of Korea, July 13-15, 2020, pp.98-108, 2020
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Chapter/Paper in Books

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Dissertations (PhD)

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