INSTITUTE FOR SYSTEMS
AND COMPUTER ENGINEERING,
TECHNOLOGY AND SCIENCE

INESCTEC

ACTIVITY REPORT 2021

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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 2021

EXECUTIVE SUMMARY

The year 2021 started with uncertainty. As the world got vaccinated, INESC TEC adapted to life amidst the disruption that the pandemic continued to bring, experiencing successes and setbacks as COVID-19 variants were emerging and lockdowns kept being enforced or lifted. As the year unfolded, challenges arose, but it also brought long-awaited reunions and a new sense of community.

Along the year, resilience was the new motto and we settled into a post-pandemic "new normal". There may be no doubt that the rapid digitisation pressed by the pandemic will shape the future and the full scope of its impact will probably take a long time to be fully understood. This emerging potential for value creation and improvement was a major driver for INESC TEC to help society in 2021, including companies and other organisations, in order for them to seize this opportunity for successful technological and innovative leaps.

The pandemic has not fundamentally changed our values and priorities. We continued to seek excellence in science and innovation, to address diversity and inclusion, our Code of Ethics was approved and came into force, and our title of Associate Laboratory was renewed for a period of 10 years, with a classification of excellent. In April, INESC TEC's new governing bodies were elected for the triennium 2021-2023, with a renewed impetus to tackle the challenges lying ahead.

Thus, notwithstanding the activities being conditioned by the COVID-19 pandemic, 2021 was a year of very good results and institutional accomplishments. Overall, INESC TEC implemented the main initiatives planned for 2021, with more or less extensive adaptations arising from the pandemic, depending on the nature of each initiative, leading to a meaningful increase of 10% in the size of the activity. We strove to strengthen our fundamentals and maintain our financial robustness, while reinforcing our intervention capacity in the national and international Science and Technology systems and our ability to carry out our mission for the benefit of society.

At the end of 2021, INESC TEC hosted more than 720 integrated researchers, 340+ with a PhD. As expected, the most noticeable evolution in Human Resources was the decrease in the number of Grant Holders and Trainees, as a result of the 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.

In scientific terms, with the contributions of our Scientific Advisory Board, who came to visit us in 2021, a progressive redefinition of our managed science model has been undertaken as a means to strengthen the Institution's scientific strategy. The results of the third call for Internal Seed Projects, aiming at supporting internal exploratory R&D activity were known in 2021. Five new projects were approved, two in the inter-centre research category, two in junior researcher development, and one in commercialisation proof-of-concept. The scientific areas covered Fingerprint Image Analysis, Hydroponics, Biomedical signal processing, Natural Language Processing, and Surface Electromagnetic Waves.

For the first of time in its history, INESC TEC reached 20 M€ of activity (a 10% increase when compared to the previous year), extending a period of more than a decade of continuous and sustainable growth. The institution increased its level of R&D contracts with industry (4.2 M€, representing an increase of 16%) and thus contributing to the advancement of science and technology, economic development and social progress in Portugal. In 2021, 39% of its total project funding (82 projects) came from European programmes (14% increase). By the end of the year, the institute's research teams participated intensively in the preparation and submission of manifestations of interest to the Mobilising Agendas for Enterprise Innovation, framed in the Recovery and Resilience Plan (PRR).

Another significant highlight of INESC TEC's activity was the design and participation in the meanwhile approved "Digital Innovation Hubs" initiatives, one-stop-shops that will aim to help companies to become more competitive with regard to their business/production processes, products or services using digital technologies. INESC TEC is the coordinator of the ATTRACT DIH on artificial intelligence and is participating also in the PRODUTECH DIH, DIH 4 GLOBAL Automotive, Portugal Blue Digital Hub, Azores Digital Innovation Hub (AzDIH), DIGITALbuilt and SFT Smart Sustainable Farms Foods and Trade DIH.

In terms of technology transfer, INESC TEC sold a patent family, C4MIR - Control Module for Multiple Mixed-signal Resources Management, a technology developed in partnership with the University of Porto (U.Porto). It is the first patent assignment agreement in its history and one of the few cases ever in Portugal. The technology was sold to Allied Security Trust, a world technology association established in the U.S.A., which represents some

of the largest tech companies in the world – Google, Meta, Microsoft, Spotify, Phillips or Sony. C4MiR may have a strong impact on the electronics industry, since it allows testing and calibrating sensors part of wearable devices, thus improving their lifetime while reducing time production and the costs of electronic chips.

In 2021, the participation of INESC TEC in the spinoff UGR (Hungary) was finally concluded. The company will pursue the commercial exploitation of an underwater robotic system developed within the scope of the H2020 UNEXMIN project, through the provision of geological services.

INESC TEC maintained the number of publications in indexed journals, with 440 articles, the institute's main overall publication priority, 66% of which in first quartile journals - an increase of 4% when compared to 2020. The number of PhD theses supervised by INESC TEC researchers that were completed in 2021 increased 26% to 58.

As for its contribution to public policies, INESC TEC provided contributions to draft legislation and funding programmes in preparation, participated in eleven Collaborative Laboratories (CoLABs) and was strongly involved in events promoted within the scope of the Portuguese Presidency of the Council of the EU.

Despite the restrictions, our initiatives to reach society and promote science did not falter. We were able to resume our Annual Autumn Forum, this year dedicated to the interaction of technologies with health. The second and third issues of the magazine "INESC TEC Science & Society" were launched, addressed to citizens interested in general knowledge about research, its possible applications and impact on society. The second issue's special topic was focused on "Resilient and Sustainable High Added-Value Industry" and the third one's on "Beyond 5G Communications". Some of our events were held in in a hybrid or fully remote format, and as a virtuous consequence, we were able to reach world-wide participants who otherwise would not have participated.

The lifting of some health restrictions also allowed some of our teams to resume field demonstrations and brought the opportunity to participate in various dissemination and outreach events, both at national and international levels. Also worthy of highlight was the presentation and launch of our research vessel "Mar Profundo" in April 2021, a vessel equipped to support multidisciplinary research at sea, up to 60 miles from shore, that will enable us quick access to deep sea and presents a new set of possibilities for the scientific and economic ecosystem, repositioning Portugal in this context.

Similarly to the rest of society, working routines changed at INESC TEC in 2021. Remote work was mandatory part of the year, but as restrictions were lifted, it was clear that a hybrid workplace, where each team could try its configuration would help to find the right balance for everyone.

As the year 2021 ended, disruption and uncertainty marked yet again the year's wrap up. Change is happening, although its forms and effects are still unclear. As in the past, INESC TEC's Community will face the unknown, strong of its shared values and its belief in science and humankind.

1 INTRODUCTION

This document presents the scientific and technological activities, as well as the results of INESC TEC during 2021.

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 2021, namely those regarding Human Resources, Activity in Projects and Publications.

Research at INESC TEC is developed by thirteen Research Centres covering four core scientific domains: Computer Science (CS), Industrial and Systems Engineering (ISE), Networked Intelligent Systems (NIS), and Power and Energy (PE). Section 4 presents these four Domains and their scientific outcomes in 2021.

Section 5 focuses on the TEC4 initiatives, platforms that articulate the activity towards economic and societal impacts, presenting their main achievements in 2021 for the following areas: 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, and Section 8, dedicated to special projects, introduces the coordination of the UT Austin Portugal Program.

Section 9 reports the activities of the Support Services, including the Business Development Services, the Management and Organisation Services and the Technical Support Services.

2 INESC TEC PRESENTATION

2.1 Profile, Vision and Mission

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

The University of Porto, INESC, the Polytechnic Institute of Porto, the University of Minho and the University of Trás-os-Montes e Alto Douro are INESC TEC's associates. INESC TEC's sites are located in the cities of Porto, Braga and Vila Real. By the end of 2021, INESC TEC's 13 R&D Centres hosted 724 integrated researchers (321 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 endeavours 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 new knowledge as part of its research, and leverages that knowledge in technology transfer projects, seeking impact through both value creation and social relevance.

The overarching mission of INESC TEC is to excel in research, while looking for its social, environmental and economic impact, with a unifying commitment to the scientific and technological contribution to foster pervasive intelligence.

The merit of INESC TEC in the accomplishment of its mission has been formally acknowledged by the Foundation for Science and Technology, with the institute's recognition as Associate Laboratory, and by 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 different technology transfer instruments (Figure 2.2.1).

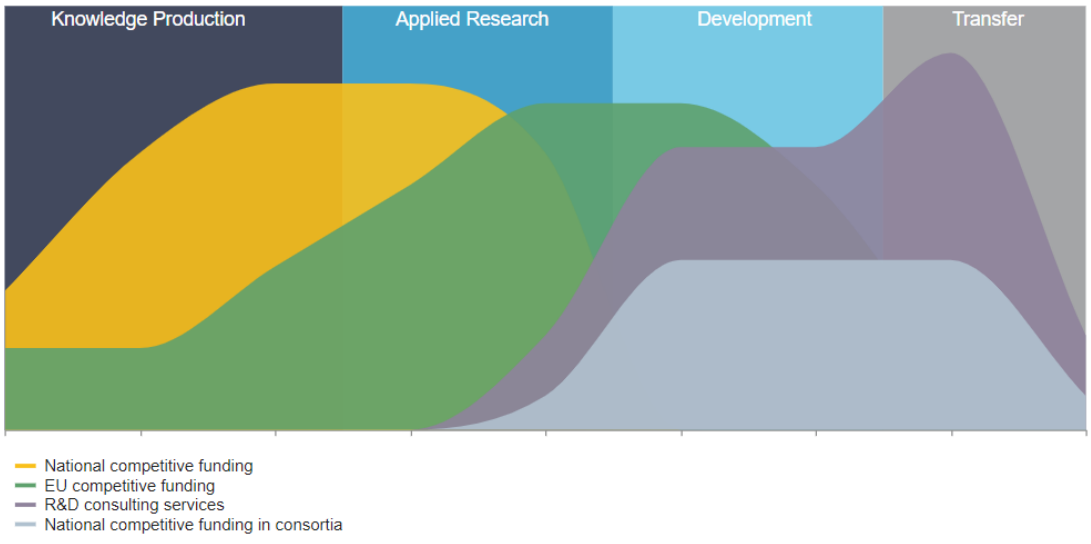


Figure 2.2.1 - End-to-end knowledge value chain: an integrated two-way pipeline

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 2021 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, Scientific Domains and TEC4s

Research at INESC TEC is undertaken in its 13 Research Centres and structured in four broad Scientific Domains: Computer Science (CS), Industrial and Systems Engineering (ISE), Networked Intelligent Systems (NIS), and Power and Energy (PE).

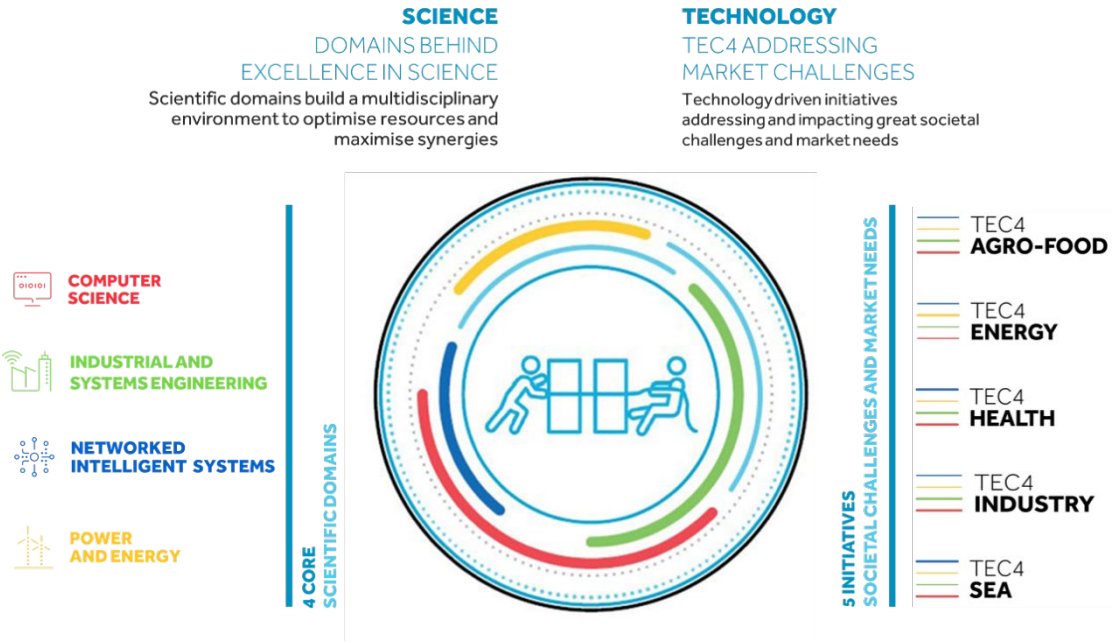


Figure 2.2.2 - Putting pervasive intelligence to work

The Research Centres are INESC TEC's R&D base organisational units, each focused on specific scientific and technological areas and responsible for its own planning, strategy and resources, reporting directly to the Board of Directors regarding budget and performance indicators.

The Scientific Domains structure the institute's research competences and challenges promoting strategic thinking, trajectory monitoring, and science communication.

The TEC4 initiatives (TEC4AGRO-FOOD, TEC4ENERGY, TEC4HEALTH, TEC4INDUSTRY and TEC4SEA) articulate INESC TEC's activity towards the main market sectors and address current societal challenges, defining market strategies and planning the interaction with major application areas. A TEC4 initiative establishes a network of external contacts and a dialogue with industrial and institutional partners and brings back major challenges and opportunities to multiple Centres.

2.3 Organisational Structure

Figure 2.3.1 presents a simplified view of the institution's organisational structure. The high-level management of INESC TEC is undertaken by a Board of Directors, composed of nine members, and an Executive Board, composed of five out of those nine members. Both Boards act in close coordination with the Council of R&D Centres, meeting every other week with the Centre Coordinators and the Managers of the different Support Services. This ensures institution-wide coherence in vision, policy and operations, and joint responsibility and commitment in both strategic and operational management decisions.

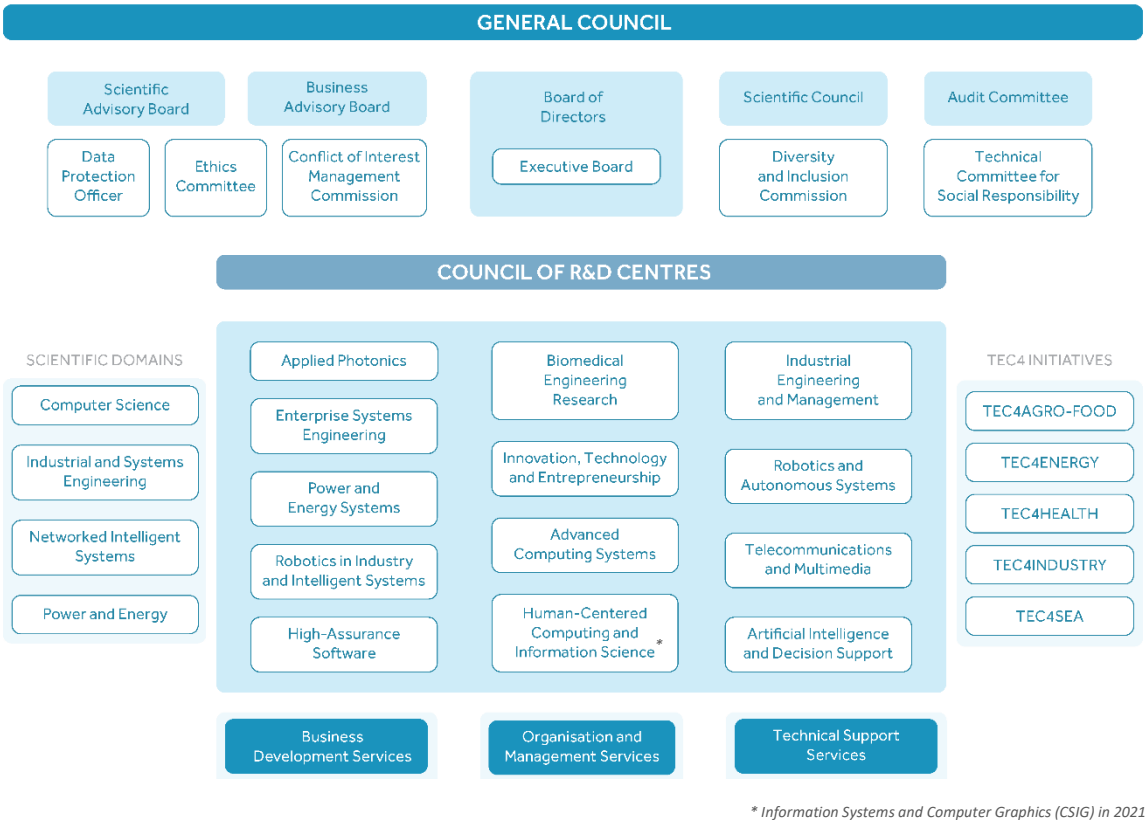


Figure 2.3.1 - Organisational Structure

The Scientific Advisory Board is composed of twelve internationally recognised scientists that support the institution in its search for excellence, building a vision for future research through a valuable benchmark at international level. The external monitoring, orientation and evaluation of the technology transfer and innovation activities are entrusted to the Business Advisory Board, whose members have knowledge and experience in several economic sectors of relevance to INESC TEC. The Scientific Council is an internal body responsible for monitoring and guiding scientific and technical activities, and it includes one representative from each Centre and three additional members appointed by the Board of Directors.

The Conflicts of Interest Management Commission and the Data Protection Officer are responsible for the implementation of the institute's Policy on Conflicts of Interest Management and the General Data Protection Regulation, respectively. The Technical Committee for Social Responsibility has the mission to incorporate social responsibility in the institution organisational culture and practice. The Diversity and Inclusion Commission will thrive to encourage the organisation to implement practices that promote diversity and inclusion and develop long-term work in this field, by proposing and implementing a D&I Program for INESC TEC, including the issue of gender balance as a priority. The Ethics Committee will implement the recently approved INESC TEC's Ethics Code. A new office will be created to promote and articulate the institution's contributions to public policies.

A streamlined and dynamic team of highly qualified technical and administrative personnel provides support to INESC TEC's activities, organised across the following areas: 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 Areas of Intervention and Responsibility of the Board of Directors

In order to better fulfil its responsibilities and meet the challenges inherent to the management of the institution, the Board of Directors of INESC TEC decided on a distribution of the areas of intervention and responsibility of its members for the 2021/2023 term.

The allocation of responsibilities considers criteria of effort balance, valorisation of the individual profiles of the Members of the Board, articulation between related areas, and proximity to the functions of the Executive Board. The distribution addresses the various aspects of the Board's activity, namely the areas of operational intervention of each Member of the Board, the missions for institutional change in strategic focused areas, and the responsibilities in the closer overseeing of the Centres, Support Services, Scientific Domains and TEC4s.

José Manuel Mendonça - Strategic leadership, institutional relations, public policies, articulation with the General Council, Public Policies Office, and strategic plan.

João Claro – Coordination of the ISE Domain and coordination of operational management. (Co-responsibility with José Manuel Mendonça: strategic leadership, institutional relations, public policies, articulation with the General Council, Public Policies Office, and strategic plan.)

Aníbal Matos - Coordination of the NIS Domain, articulation with education in Higher Education Institutions (Masters, PhD and non-degree programs). (Co-responsibility with Rui Oliveira: Science management model, institutional applications – science, Scientific Advisory Board and general coordination of the Scientific Domains).

Gabriel David - Relations with academic partners, data protection, advanced training, overseeing of the Centres CRACS, CSIG, LIAAD and HASLab, and overseeing of the Services AG, SAS, SIG and SRC. (Co-responsibility with João Claro: coordination of operational management.)

José Carlos Caldeira - Business Advisory Board, general coordination of the TEC4 initiatives, coordination of INESC Brussels Hub, articulation with spin-offs, and overseeing of the Service SAL. (Co-responsibility with Gabriel David: advanced training.)

Luís Carneiro - Institutional applications – innovation, participation in external entities, overseeing of the Centres CEGI, CESE, CITE and CRIIS, quality management, and overseeing of the Services CF and CG.

Luís Seca - Coordination of the PE Domain, social responsibility, management capacity building, overseeing of the Centres CAP, C-BER, CPES, CRAS and CTM, and overseeing of the Services RH, SAAF and SGI.

Graça Barbosa - Conflicts of interest, diversity and inclusion, ethics, consolidation of institutional bases and policies (rights and duties; researcher status; Governance, risk management and compliance (GRC), and overseeing of the Service AJ and Secretarial Coordination.

Rui Oliveira - Coordination of the CS Domain, science management model, institutional applications – science, Scientific Advisory Board, general coordination of the Scientific Domains, and overseeing of the Services SCOM and SRI.

2.5 Policy priorities

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

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

2.5.1 Excellence in research, talent development, and innovation

Knowledge generation at INESC TEC stems from a base of rigorous scientific research, and flourishes in a dynamic research environment that enables the institute to engage in and foster the development of excellent researchers. The involvement in PhD and Masters Programmes strengthens the institute's ability to attract and motivate young talent in conducting highly relevant research. The institute's focus on impactful research challenges, along with its culture of collaboration with industry, provides an ideal environment for innovators.

The reinforcement of its global excellence is a permanent priority for the institution, whose expansion in recent years has required a renewed attention to some of its fundamentals, in particular to the human resources management, the research careers, science management, as well as advanced training, research ethics, and diversity and inclusion policies.

2.5.2 Full coverage of the knowledge value chain

INESC TEC creates new knowledge and technology and supports companies innovating products, processes, services and business models, contributing to their competitiveness and ensuring economic and social impact. The success of INESC TEC's managed science model relies on the ability to establish upstream and downstream flows along the knowledge value chain, punctuated by feedbacks at multiple levels. The interaction and collaboration with industry is essential for the identification of new research challenges and the valorisation of research results is key to the economic sustainability of the institute.

To excel in these dynamics and to be able to fully fulfil its mission, INESC TEC is increasingly challenged to ensure that individual researchers focus where they feel more comfortable to perform at their best. The Research Centres are where the diverse activities and personal contributions are balanced under a common strategy. All the work is project based and quarterly monitored, from both research outcomes and economic sustainability perspectives. The Centres are expected to reach the critical mass that allows knowledge to flow not only within each Centre, but also among Centres.

2.5.3 Integration and multi-disciplinarity

INESC TEC pays constant attention to its integration dynamics, as the institution and its context undergo continuous changes, and its resources are accordingly renewed, strengthened, and recombined. The Scientific Domains 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 through fusion of knowledge and skills, and conducting 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.

2.5.4 Scale, density, and critical mass

INESC TEC's ambitious vision and mission require a level of scale and density that is nurtured by 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 future key priorities is a consistent effort to widen its activities and attract leading researchers to further reinforce its human capital.

2.5.5 International visibility and presence

Excellence in science and technology requires nowadays collaboration and strong partnerships with leading international research institutions and companies. INESC TEC's international projects and activities are crucial to secure its status of an 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, increasing the capacity to promote projects, secure funding, and attract human resources at an international level.

2.5.6 Ethics, social responsibility, gender equality, and diversity and inclusion

Ethics is core to INESC TEC's multiple endeavours and for many different reasons. The institute's community has a shared interest in protecting its research, education, and innovation environments, that the recently approved Code of Ethics reinforces, through the formalisation of the ethical principles, commitments and procedures that must guide individual and institutional conducts, in order to affirm a culture based on rigour, competence, transparency and respect for others, both in research and in management.

Institutionally, as a whole, 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 aligned with the stakeholder's strategy and outcomes. This shared realisation has been taking shape in the institute and has led to the appointment of a Social Responsibility Technical Committee and to 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, having recently signed the Portuguese Diversity Charter as a public commitment with this Policy. 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 equality, ethnic and cultural diversity and inclusion practices are among key priorities to be addressed by the recently appointed Diversity and Inclusion Commission.

2.6 Research and Innovation

INESC TEC's vision for research and innovation is that of a society increasingly assisted by human-centred, trustworthy, sustainable, smarter and autonomous computing systems. The conveyed image translates into the commitment to foster pervasive intelligence through the creation of new computer intelligence paradigms, their development and application. This is enabled by the institute's size, diversity and managed science model, fertile ground for multidisciplinary cooperation.

Current computer systems, pervading the society, in public administration, industry, earth observation, etc. and large-scale critical systems such as utilities, healthcare, transportation, and finance, present new opportunities and challenges that demand competences and capacity across multiple scientific domains and in all technology readiness levels.

INESC TEC's researchers cover more than forty scientific disciplines structured around four scientific domains and cooperate towards meeting sixteen short- to medium-term research challenges. The latter include achieving machine perception, making communication systems context-aware, creating all sorts of human-empowering computing, improving the quality and key non-functional properties of information and industrial systems,

increasing the autonomy of robotic systems, achieving full and resilient renewable energy systems, and achieving responsible and sustainable technology-driven innovation.

Research and development are complemented by knowledge valorisation and technology transfer activities, made credible by INESC TEC's sizeable portfolio of partners and customers. Currently, through TEC4 initiatives, business development focus on five socioeconomic areas: agriculture and food, energy, healthcare, industry and sea.

3 RESULTS ACHIEVED IN 2021

This section presents a short summary of the results INESC TEC achieved during 2021, including highlights of the activity and the main indicators for human resources, activity in projects, scientific publications, knowledge transfer and dissemination. The remaining sections of the document include detailed information for each Scientific Domain and R&D Centre, the TEC4 multidisciplinary initiatives, research infrastructures, special projects, and Support Services.

3.1 A year like no other

The second year of the COVID-19 pandemic was, as its predecessor, a year full of challenges, but it also brought long-awaited reunions and a new sense of community.

2021 started with uncertainty, the world got vaccinated, although not in equal levels. People adapted to life amidst the disruption that the pandemic continued to bring, experiencing successes and setbacks as COVID-19 variants were emerging and lockdowns kept being enforced or lifted.

At the same time, the year was a reminder that our world is more connected than ever, as evidenced by worldwide ongoing effects of the pandemic, the reverberations of extreme weather events, the consequences of Brexit, or even delays around the world caused by a mere container ship stuck in the Suez Canal. We were clearly reminded that tackling big problems requires collaborative work across borders and scientific areas.

As 2021 turned into a transition year, resilience was the new motto, and by its end, most were finally settling into a post-pandemic “new normal”. There may be no doubt that the rapid digitisation brought by the pandemic will shape the future and it is here to stay. Pandemic accelerated changes in the way technology is adopted and used that otherwise would have taken years, and the full scope of their impact will probably take a long time to be fully understood. This potential for value creation and improvement was a major driver for INESC TEC to help society in 2021, including companies and other organisations, in order for them to seize this opportunity for successful technological and innovative leaps.

Similarly to the rest of society, working routines changed at INESC TEC in 2021. Remote work was mandatory part of the year, due to legal impositions, and INESC TEC’s processes evolved to meet the new way of thinking productivity and presence in the workplace. As restrictions were lifted, it was clear that a hybrid workplace would emerge, where each team could try its configuration that would help to find the right balance for everyone. The positive results presented later are a good indicator that we might be on the right path.

As parts of the world began to open again, we were able to organise some of our institutional events. Although some of them had to be held fully digitally or in hybrid mode in times of heightened health concerns, like our annual multicultural party, on other occasions we finally had the chance to meet one another in person, in a sense of long wanted reunion, as was the case with the Autumn Forum or the Strategic Meeting.

The pandemic has not fundamentally changed our values and priorities. In such a turbulent year, we continued to focus on diversity and inclusion, our Code of Ethics was approved and came in force, and our title of Associate Laboratory was renewed for a period of 10 years, with a classification of excellent. In April, INESC TEC’s new governing bodies were elected for the triennium 2021-2023, with a renewed impetus to tackle the challenges lying ahead.

As the year 2021 ended, disruption and uncertainty marked yet again the year’s wrap up. Change is happening, although its forms and effects are still unclear. As in the past, INESC TEC’s Community will face the unknown, strong of its shared values and its belief in science and humankind.

3.2 Highlights in 2021

Notwithstanding having its activity conditioned by the COVID-19 Pandemic, the year of 2021 was yet again a year of very good results and institutional accomplishments for INESC TEC.

Overall, INESC TEC carried out the steps foreseen for the main initiatives planned for 2021, with more or less extensive adaptations arising from the pandemic depending on the nature of each initiative. INESC TEC has grown 10% in its activity level, while striving to strengthen its fundamentals and 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 and highlights in 2021 are summarised next, broadly under the same categories that were adopted for the 2021 plan: managed science model, excellence in research, partnership with HEI, structural initiatives, internationalisation, contributions to public policy, calls of strategic importance, openness to society, support structure/Infrastructure and internal measures to mitigate COVID-19 pandemic impacts.

- MANAGED SCIENCE MODEL

  (in line with the policy priorities "Full coverage of the knowledge value chain" and "Integration and multi-disciplinarity")

  - Progressive redefinition of the concept of Cluster to Scientific Domain as a means to strengthen the Institution's scientific strategy, grouping and characterising the developed activity in Research Challenges, which become the strategic scientific anchors of the organisation, both in the recognition of its current activity and in the development of future activity;
  - Consolidation of the TEC4 structure and activity;
  - A more balanced activity was achieved, with an increase of 14% in the activity funded by European programmes and an increase of 16% in contract research and consulting services.

- EXCELLENCE IN RESEARCH

  (in line with the policy priority "Excellence in research, talent development, and innovation")

  - Visit of INESC TEC's new Scientific Advisory Board, held in a hybrid format in November 2021, for the discussion of the institute's scientific strategy and goals, and in the preparation of the new FCT R&D Units Evaluation process to be held in 2022;
  - The results of the third call for Internal Seed Projects, aiming at supporting internal exploratory R&D activity were known in 2021. The Evaluation Committee (composed by Manuel Ricardo (Chair), João Gama, Francisco Moura, José Fernando Oliveira, José Nuno Fidalgo and João Canas Ferreira) selected two inter-centre research projects, two junior researcher development projects, and one commercialisation proof-of-concept project. The scientific areas covered Fingerprint Image Analysis, Hydroponics, Biomedical signal processing, Natural Language Processing, and Surface Electromagnetic Waves;
  - INESC TEC's involvement in PhD and Masters Programmes, essential to its ability to attract and involve young talent in conducting and disseminating excellent research while leveraging the intervention of Higher Education Institutions (typically assisting more than 20 PhD programmes, and involving over 300 PhD students and 600 master's students);
  - Reinforcement of the international recognition of researchers, through the encouragement of high impact publication profiles, and actions to support applications to international awards, and/or ACM and IEEE Fellowships. Particularly worthy of highlight is the fact that 11 INESC TEC researchers were among the most cited scientists worldwide, according to the World's Top 2% Scientists list, a ranking published by Stanford University, together with the Dutch publisher Elsevier BV.
  - Reinforcement of the research team with the recruitment of researchers for key strategic areas (overall 5% increase in R&D Employees), in line with the government policy for scientific employment.

- PARTNERSHIP WITH HIGHER EDUCATION INSTITUTIONS

  (in line with policy priorities "Excellence in research, talent development, and innovation" and "Scale, density, and critical mass")

- Collaboration in the implementation of an Advanced Studies Course with several Schools in the U.Porto, to offer post-graduate training in the scope of R&D projects, both through a structured introduction to transferrable skills (innovation, entrepreneurship, leadership, and time management, among others) and specialisation in technological areas;
- Deeper collaboration and sharing of good practices between INESC TEC and ISPUP - Instituto de Saúde Pública da Universidade do Porto in the area of data protection, with the implementation of screening instruments for R&D and Data Protection Impact Assessment (DPIA) project proposals, with a view to establishing internal audit procedures;
- Continued efforts in order to expand iiLab – Industry and Innovation Lab, a cross-Centre infrastructure covering areas such as Cyber Physical Systems & Internet of Things, Business Intelligence & Decision Support Systems, Advanced Automation & Industrial Robotics, Mobile Robotics & Internal Logistics, Industrial Vision Systems for Inspection and Quality Control, to new facilities to be located in a P. Porto building in the campus.

- STRUCTURAL INITIATIVES

  (in line with the policy priority "Ethics, social responsibility, and diversity and inclusion")

  - In 2021, 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.
  - Approval of INESC TEC's Code of Ethics and creation of INESC TEC's Ethics Committee that will start its activity in 2022;
  - Following the entry into force of the new Research Fellowship Holder Statute, INESC TEC decided to fund all of its grant holders in the amount of the registration, enrolment and tuition fees for grants leading to an academic degree or diploma (up to the pre-established amount provided for in the Regulations for Fellowships and Studentships of FCT - paid to the institution where the grant holder is enrolled);
  - Changes in some Centre Coordination and Support Services management, to renew leaderships and strengthen the structure for future challenges.

- INTERNATIONALISATION

  (in line with the policy priority "International visibility and presence")

  - Participation in the first calls of the new Horizon Europe programme, with 51 proposals submitted;
  - Continued hosting of the national Coordination of the UT Austin Portugal Program, as a key asset in the development of collaborations with the US, as presented in detail in Section 8;
  - Full operation of INESC Brussels Hub, the Brussels representation of INESC TEC, INESC Coimbra, INESC ID, INOV INESC and INESC MN, set up to reinforce the institutes' positions in European programmes, increase their visibility and credibility in key areas, represent them in European platforms, groups and structures, and provide their researchers a permanent physical space for support and representation. The year 2021 was focused on building internal capacity, representation and visibility, lobbying and networking;
  - Consolidation of INESC P&D Brasil, with the formal entry of three new associates. Thus, in 2021, INESC P&D Brasil counted 11 Associates (INESC TEC and 10 Brazilian Universities: Universidade Federal de Campina Grande, Universidade Federal de Goiás, Universidade Federal de Juiz de Fora, Universidade Federal do Maranhão, Universidade Federal do Pará, Universidade Federal do Rio Grande do Norte, Universidade Federal do Sergipe, Universidade Federal de Santa Catarina, Universidade Federal de Santa Maria, Universidade Tecnológica

Federal do Paraná) completed by the Network INESC BRASIL which gathers additional HEI. In spite of the pandemic, the cooperation between INESC P&D Brasil and INESC TEC continued to flourish in 2021. Eight projects were running under several distinct programmes and frameworks, and in both directions, i.e., participations of INESC TEC in Brazil and participations of INESC P&D Brasil in Europe;

- Intensification of the participation in projects and activities of the European Knowledge and Innovation Communities (KICs) EIT Raw Materials and EIT Manufacturing;
- Active participation in 15+ international associations. In 2021, INESC TEC joined the international Associations AIOTI - Alliance for Internet of Things Innovation, as well as ETSI - European Telecommunications Standards Institute;
- Hosting of the main networking event of the international network CENTRA – Collaborations to Enable Transnational Cyberinfrastructure Applications, held in a hybrid format in September 2021 with around 100 participants and focused on the "HPC and AI Convergence for Smart Connected Communities";
- Consolidation of INESC TEC's International Relations Service (SRI).

- CONTRIBUTIONS TO PUBLIC POLICY

  (in line with policy priority "Ethics, social responsibility, gender equality, and diversity and inclusion")

  - Support to the National Council for Science, Technology and Innovation (CNCTI) created in February 2021 to develop, reinforce and support the National Scientific and Technological System, ensuring scientific advice and fostering cross-cutting and inter-ministerial dialogue on science policies, technology and innovation, and working in close liaison with the Minister of State for the Economy and Digital Transition and the Minister of Science, Technology and Higher Education. The Council is composed by 20 renowned individuals in different fields of knowledge and economics, and led by INESC TEC's Chairman, Prof. José Manuel Mendonça;
  - Active participation in the Associated Laboratories Council and contribution to draft legislation and funding programmes in preparation (for example, Roadmap of Research infrastructures, PT2030, Recovery and Resilience Plan);
  - Strong involvement in events promoted within the scope of the Portuguese Presidency of the Council of the EU, promoted by EARTO, such as the international conference Green and Digital Transition in the Recovery Plans or the round table on the future of Research, Development and Innovation activities and the European Research Area;
  - Strong contribution to the CoLABs (Collaborative Laboratories) public policy objective through the participation in eleven institutions, with academic and business partners, in order to exploit knowledge created in research institutions and address major societal challenges. A more detailed review of their progress is provided at the end of this chapter.

- CALLS OF STRATEGIC IMPORTANCE

  (in line with policy priorities "Full coverage of the knowledge value chain" and "Integration and multi-disciplinarity")

  - Design and participation in the "Digital Innovation Hubs initiatives", one-stop-shops that will aim to help companies to become more competitive with regard to their business/production processes, products or services using digital technologies. INESC TEC was the coordinator of the ATTRACT DIH on artificial intelligence, and was also participating in the PRODUTECH DIH, DIH 4 GLOBAL Automotive, Portugal Blue Digital Hub, Azores Digital Innovation Hub (AzDIH), DIGITALbuilt and SFT Smart Sustainable Farms Foods and Trade DIH;
  - Preparation and submission of expressions of interest to the Mobilising Agendas for Business Innovation, framed in the Recovery and Resilience Plan, a programme integrated into the

extraordinary funding package approved by the European Commission to provide Eurozone countries with instruments for economic and social recovery: NextGenerationEU.

- Application submitted to the second institutional call to the scientific employment stimulus, with 2 positions awarded;
- Renewal of the title of Associate Laboratory and the corresponding additional funding awarded by FCT. The results of the call were disclosed early 2021 and INESC TEC received a classification of excellent and saw the title renewed for 10 years;
- Kick-off of Sustainable HPC, a project that aims to improve the sustainability of supercomputers' operation, coordinated by INESC TEC and performed with a consortium with INEGI and funded by the Innovation and Energy Efficiency Funds. Sustainable HPC is aligned with the National Strategy for Advanced Computing, it received €7.3M of funding, and will be applied to the Deucalion supercomputer, to be installed in the Minho Advanced Computing Centre (MACC) so that it may operate in the most sustainable way.

- OPENNESS TO SOCIETY

  (in line with policy priorities "Full coverage of the knowledge value chain" and "Ethics, social responsibility, gender equality, and diversity and inclusion")

  - Organisation of the annual Autumn Forum, dedicated to the interaction of technologies, Artificial Intelligence in particular, and Health, in co-organisation with ISPUP. This annual initiative could not be organised in 2020 due to the pandemic situation, but in 2021, it was resumed in a face-to-face format. This event, which is already an INESC TEC landmark, aims to promote a forum to debate issues of national interest, from the economic to the public policies points of view - in particular those that are strongly influenced by science and technology;
  - Launch of the 2nd and 3rd issues of the magazine "INESC TEC Science & Society", aimed at citizens interested in general knowledge about research, its possible applications and impact on society, as well as informed opinions on the public policies most influenced by technology. The second issue's special topic was focused on "Resilient and Sustainable High Added-Value Industry" and the third one's on "Beyond 5G Communications". The magazine publishes opinion articles by researchers and special guest authors on the topic of each issue, seeking to contextualise and clarify readers, highlighting solutions enabled by scientific and technological advances;
  - Worthy of special highlight is the organisation of the renowned international congress EUCNC2021 - European Conference on Networks and Communications, a flagship conference sponsored by the European Commission, that counted with the online presence of more than 2300 participants over four days, in June 2021;
  - Promotion of open days, organised by INESC TEC Centres, inviting society, academia, industry and media to visit the institute and become acquainted with its main science and innovation contributions, following a tradition of openness and accountability;
  - Active involvement in events promoting science and innovation, such as Ciência 2021 - the annual meeting of science, technology and innovation in Portugal, Mostra 2021 UPorto, the European Researchers' Night or FICA – International Science Festival, to name but a few.

- SUPPORT STRUCTURE/INFRASTRUCTURE

  (in line with the policy priority "Excellence in research, talent development, and innovation")

  - The implementation of a new model for Human Resources management continued in 2021. For that purpose, the work of the five specialised work groups - on performance appraisal, training, career development, recruitment, and employee life cycle – went on, as well as the foundational mapping of functions and skills. All should come to conclusion in 2022;

- Presentation and launching of the research vessel "*Mar Profundo*". The vessel is 19 meters long, with an autonomy for 3 days and a capacity for 12 people (scientists and crew). It is equipped to support multidisciplinary research at sea, up to 60 miles from shore – including remotely operated vehicles (ROVs), acoustic sensors or robotic landers. This investment (+850k€) enables quick access to deep sea and presents a new set of possibilities for the scientific and economic ecosystem, repositioning INESC TEC and Portugal in this context.

- INTERNAL MEASURES TO MITIGATE COVID-19 PANDEMIC IMPACTS

  (in line with the policy priority "Excellence in research, talent development, and innovation")

  - Support to hybrid and remote work: since INESC TEC operated in 2021 in a hybrid mode, with most research team members in remote work, while the pandemic situation so recommended, guidelines and support tools for researchers and project leaders were continuously updated and improved, including the aspects related with protection of personal data and confidential information when working remotely. Special attention was given to ensuring appropriate conditions at the workplace, as well as central support infrastructures. Physical spaces were adapted to this new reality, laptops and web conferencing equipment were made predominant, and digital repositories and processes reinforced. Laboratory work and other specific activities were conducted on-site, complying with the recommended safety rules;
  - Dedicated support lines remained operational, including those aiming at supporting INESC TEC members in practical questions related with COVID-19, self-care and well-being;
  - In order to foster some sense of community and belonging, some internal events were held. Although many activities were cancelled (On Foot or Team Building activities), there were three initiatives that took place: the Strategic (Re)Gathering and the Roasted Chestnuts party (in person), and the INESC TEC *Season Party* (online).

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

- Professor José Manuel Mendonça, Chairman of INESC TEC's Board of Directors, was awarded with the Medal of Scientific Merit, by the Minister for Science, Technology and Higher Education, for his vital role and particular impact on the development of Science in Portugal, namely as President of the Council of Associated Laboratories, on the establishment and guidance of several Collaborative Laboratories, and, most recently, as the Chairman of the National Council for Science, Technology and Innovation;
- The project IDINA - Inclusive Non-Authoritative Digital Identity – was the winner of the IN3+ Award, promoted by the Portuguese Mint and Official Printing Office (INCM), with an award of 600k€. This project aims to create an effective and inclusive identification platform open to all citizens, particularly, in countries with no encompassing central civil registration infrastructures.
- Researchers Fabien Heymann, Pedro Silva and Tiago Torres won the 26th edition of the REN Awards in the categories of best PhD thesis, best and second-best Master's theses, respectively. The researchers stood out for their contribution to the development of innovative solutions, ranging from the adaptation of grids to electric mobility and the integration of renewable energy sources, to the impact of energy storage in the electrical grid and efficiency of wind farms.
- The Project MINE4HEALTH (now IPO Gentil) won the Portugal Digital Awards 2021 in the "Best Future of Work Project" category. It aims to the development of a system capable of extracting and synthesizing dozens of pages of clinical diaries in a simple dashboard, which allows a quick analysis by health professionals. In addition to the clear benefit for clinical practice, the system also facilitates the extraction of indicators for research purposes, as well as management indicators for monitoring hospital management. A pre-production pilot will now begin in the Instituto Português de Oncologia's emergency department.

- João Gama, a full professor at the Faculty of Economics of the University of Porto and researcher at INESC TEC, was appointed Fellow of the IEEE - Institute of Electrical and Electronics Engineers, an acknowledgement of prominent academics, whose research projects have an impact on society.

3.3 Commissions and Working Groups

3.3.1 Conflicts of Interest Management Commission

Chairperson: José Carlos Marques dos Santos

Presentation

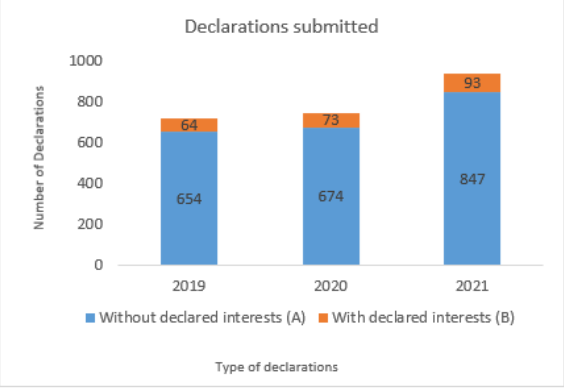
INESC TEC has a Conflicts of Interest Management Policy which applies to all integrated human resources. The Commission for Conflicts of Interest Management has the responsibility to ensure compliance throughout the Institution, namely by:

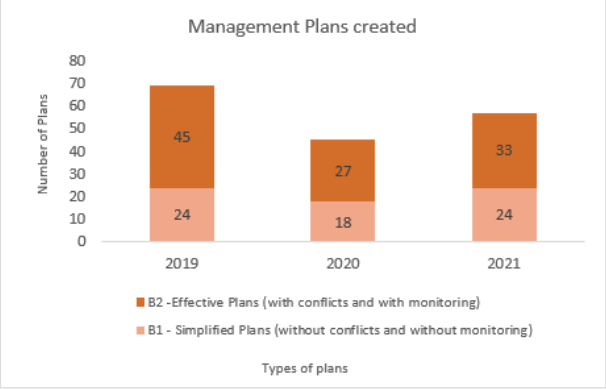
- Assessing the declarations of interests and identifying the conflicts of interest;
- Agreeing with the collaborator on the terms and proposing to the Board of Directors management plans for identified conflicts of interest, in order to reduce or eliminate those conflicts;
- Informing the collaborators of INESC TEC about the conclusion of 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 2021

During 2021, the Commission, within the scope of its mission, developed a set of activities, of which the following stand out:

- Monitoring compliance with the Policy throughout the Institution;
- Advising the Board of Directors and General Council Ad-hoc Committee;
- Preparation and dissemination of important guidelines regarding Conflicts of Interest Management Policy;
- Parameterisation and implementation of some improvements in the IT platform, in particular those aimed at simplifying its use and improving the process of managing and controlling conflicts of interest;
- Development of several documents related to the monitoring role of the Conflicts of Interest Management Plans (criteria for designation of monitors; monitoring report; guide for monitors);
- Declarations of Interest reception, assessment and handling as well as Conflict of Interest Management Plans processing and monitoring:





To be noted that there are declarations (type "with declared interests") which are submitted at the end of a given calendar year, so the plan may only be generated at the beginning of the following year. On the other hand, there are declarations classified by the author as having interests, which CGCI detect not to be the case, therefore not giving rise to any plan.

3.3.2 Diversity and Inclusion Commission

Chairperson: Beatriz Brito Oliveira

Presentation

Following the presentation of the Report of the Working Group for Gender Equality + Diversity and Inclusion, which took place on the 15th of July of 2021, the Board of Directors of INESC TEC established the Diversity and Inclusion (D&I) Commission in September 2021, whose main mission is to propose and implement a D&I program, with gender equality as a priority concern. The Diversity & Inclusion Commission is composed of five INESC TEC collaborators, working in R&D and in support services: Ana Lopes, Beatriz Brito Oliveira, Nuno Moniz, Sheila Habib e Tiago Silva.

Highlights in 2021

- **Signature of the Portuguese Diversity Charter.** In November, INESC TEC signed the Portuguese Diversity Charter, a commitment to diversity and inclusion ensuring non-discrimination and respect of the origin (cultural, ethnic and social), sexual orientation, gender, age, marital status, physical characteristics, personal style and religion of its collaborators. This was the first initiative promoted by the D&I Commission.
- **Creation of the Internal and External Advisory Groups for D&I.** To support the D&I Commission's work, two Advisory Groups have been created in 2021. The Internal Advisory Group is composed of ten collaborators (Ahmed Adel Fares, Duarte Dias, Francisco Azevedo, Joana Dumas, João Marco Silva, Mafalda Reis Pereira, Nabila A'sad, Nayara Freitas, Paula Raissa and Tiago Gonçalves) and has as objective discussing, validating and allowing its members to contribute to the D&I Commission's work and proposed lines of action, through monthly brainstorming sessions. The External Advisory Group is composed of experienced members in the diversity and inclusion field, for strategic and high-level discussion.
- **Launch of a D&I Survey to INESC TEC collaborators.** In December 2021, the D&I Commission launched a D&I survey to INESC TEC integrated collaborators, namely employees, academic staff and grant holders working on both R&D and support services. The main objective of this survey was to understand how collaborators feel about D&I and its practices at INESC TEC and whether that perception depends on specific diversity dimensions. The collected data will support the establishment of D&I priorities and actions for the future at INESC TEC, ensuring they support the reality of the collaborators.
- **Launch of an anonymous suggestion box.** In December 2021, the D&I Commission made an anonymous contact form available for all INESC TEC collaborators to share their comments, suggestions and views on D&I-related issues.

3.3.3 Data Protection Officer

Data Protection Officer: Vasco Rosa Dias

Presentation

According to its legal statute the DPOs 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 2021

- Monitoring of the implementation, updates and awareness raising of the approved data protection internal procedures, namely, those relative to external audits and inspections, the operation of CCTV Systems, the registration or projects' proposals and the performance of Data Protection Impact Assessments, Response to Personal Data Breaches and the Exercise of Data Subjects' Rights. Support in the design and adaptation of similar procedures for the ISPUP environment.
- Continued implantation of the cooperation agreement established with ISPUP in the field of Data Protection.
- Advise and follow up of Data Protection Impact Assessments performed in the context of R&D projects of INESC TEC and ISPUP, as well as in the wider context of their respective general internal operations.
- Presence in several data protection and ethics governance bodies in H2020 projects coordinated by INESC TEC.
- Conclusion of one prior consultation procedure before the Portuguese supervisory authority, regarding one ISPUP research project.
- Monitoring of data protection related aspects of Data Management Plans in several H2020 projects, in articulation with AG.
- Contributions to the Document Management Policy developed by AG.
- Preparation of an online course and several contents as part of the training and awareness plan for staff members and researchers.
- External data privacy workshop provided to the Human Resources department.
- Continuation of the awareness-raising initiatives at INESC TEC and ISPUP with the organisation of training Workshop addressing specific topics and publics within the organisation.
- Issuing and dissemination of guidelines and Policies, e.g. Good practices on sharing files containing personal data and data retention periods.
- DPO's opinions, recommendations and audits regarding: e.g. Cookies on the INESC TEC website; new tickets and CRM platforms; external students' enrolment procedure.
- A large number of data processing and joint controllership agreements was negotiated and implemented, including the establishment of a framework DPA with CHUSJ.
- Monitoring and auditing activities at INESC TEC and ISPUP: continuous update of the processing activities' Records and execution of regular programmed internal data protection related audits. Planning of complementary auditing activities.
- Participation in the Metared data protection Working Group's activities.

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 (CTRS) was created in November 2019 and aims to promote both internal and external 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.

Despite the work done together with INESC TEC Executive Board, the institution is still working to encompass Social Responsibility in its principles. Teleworking and changes caused by the COVID-19 pandemic still influence execution of actions proposed. Teleworking, virtual meetings and the fact that everyone is seeing their homes as the new workplace, also hardens implementation of some initiatives led by Technical Committee for Social Responsibility.

For the year of 2021 there was a better understanding of the pandemic situation and the plan was made according to the limitations envisioned.

Highlights in 2021

In 2021, CTRS launched initiatives whose implementation was neither dependent on people staying in the institution nor on physical relationships.

Recycling Campaigns:

- Collection of Plastic bottle caps, in a campaign called *Operação Tampinhas*, to be donated to institutions or individual families;
- Collection of Nespresso capsules to be recycled and used as rice fertilizer - rice crop donated to *Banco Alimentar*;

Mental Health:

- Celebration of World Mental Health Day by disseminating relevant information through social networks and BIP;
- Sharing of tools that can be used by employees to promote their well-being.

In the Society dimension, the following initiatives were promoted:

- Donation of a washing machine, by Centre CPES, to *Albergues Noturnos*;
- Organisation of a Christmas donation campaign that had as beneficiary the ACREDITAR association, which focuses on the rights and promotion of the quality of life in the area of pediatric oncology;
- Together with *Instituto Português de Sangue,* promotion of a blood donation campaign, in line with the growing need in Hospitals;
- Tech Converter campaign that allowed the donation of IT equipment to *Infante D. Henrique* schools in Porto;
- Spontaneous donations of office supplies to several local solidarity institutions.

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 2019. The number of researchers with PhDs is also shown (342 at the end of 2021).

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			2019	2020	2021	Δ 2020-21	
Integrated HR	Core Research Team	Employees	121	152	159	7	5%
		Academic Staff	160	169	174	5	3%
		Grant Holders and Trainees	351	334	324	-10	-3%
		Total Core Researchers	**632**	**655**	**657**	**2**	**0%**
		Total Core PhD	**257**	**264**	**255**	**-9**	**-3%**
	Affiliated Researchers		72	77	67	-10	-13%
	Administrative and Technical	Employees	84	94	102	8	9%
		Academic Staff	9	11	11		0%
		Grant Holders and Trainees	7	9	6	-3	-33%
		Total Mgmt, Admin and Tech	**100**	**114**	**119**	**5**	**4%**
	Total Integrated HR		**804**	**846**	**843**	**-3**	**0%**
	Total Integrated PhD		**341**	**354**	**342**	**-12**	**-3%**
Curricular Trainees			21	38	35	-3	-8%
External Research Collaborators			216	237	247	10	4%
External Administrative and Technical Staff			7	7	8	1	14%
External Students			138	141	169	28	20%
Total			**1186**	**1269**	**1302**	**33**	**3%**

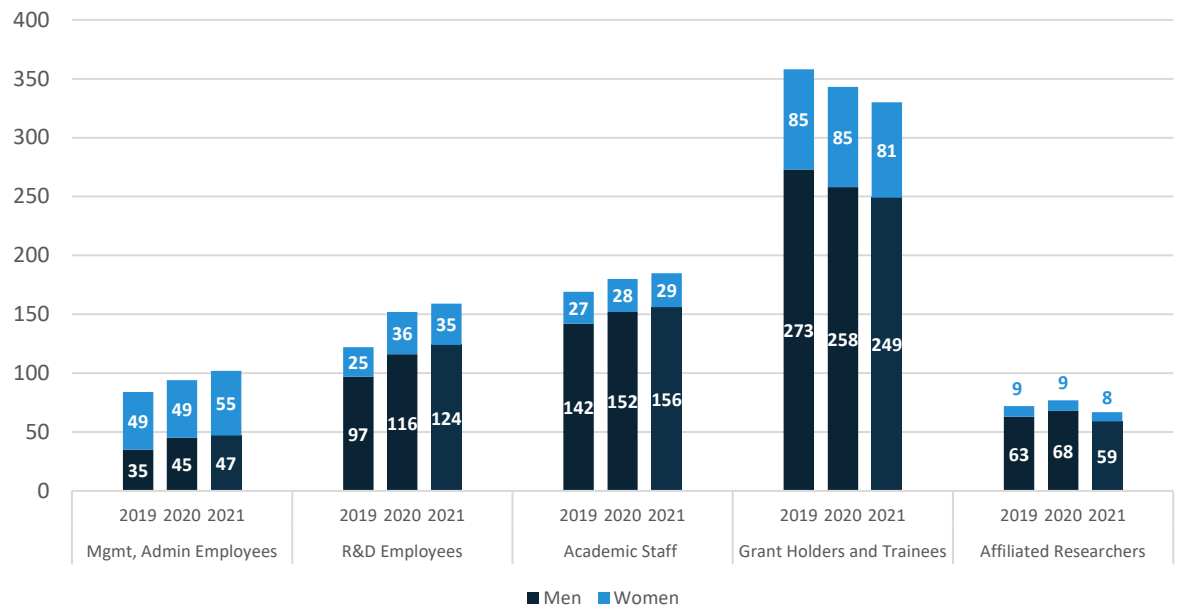


Figure 3.4.1 - Evolution of Human Resources

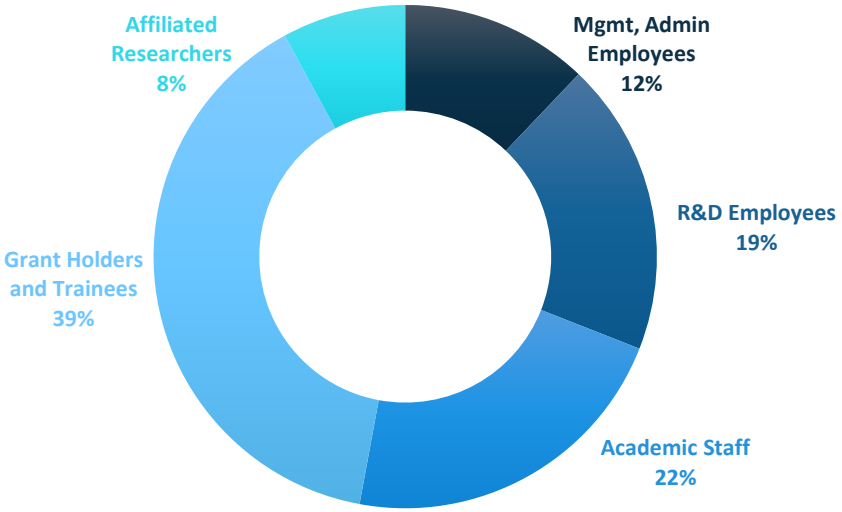


Figure 3.4.2 - Distribution of Human Resources

25% Women
> 25 Nationalities
> 70 Foreign Researchers

As seen in Figure 3.4.2, grant holders and trainees are still the largest group of human resources (39%) at INESC TEC, featuring, nevertheless, another decrease in 2021 (Figure 3.4.1). This reduction is mostly the result of the new national regulations for grants and 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 (159 in 2021), namely PhD researchers.

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 2019 and 2021. The team profile followed very closely the profile included in the 2021 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 percentages of women have remained almost unchanged (25% for Integrated HR and 23% for Integrated Researchers). This and other dimensions have been analysed by the Diversity and Inclusion Commission and will be the focus of the Gender Equality Plan to be implemented starting in 2022.

3.4.2 R&D Centres Indicators

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

Table 3.4.2 - 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	**159**	9	11	20	4	39	22	15	6	5	11	8	1	8
		Academic Staff	**174**	13	8	12	5	10	4	16	18	2	27	22	16	21
		Grant Holders and Trainees	**324**	45	11	38	14	33	14	24	24	1	43	26	19	32
		Total Core Researchers	**657**	**67**	**30**	**70**	**23**	**82**	**40**	**55**	**48**	**8**	**81**	**56**	**36**	**61**
		Total Core PhD	**255**	**21**	**16**	**16**	**8**	**25**	**14**	**22**	**26**	**4**	**31**	**29**	**17**	**26**
	Affiliated Researchers		**67**	8	5		1	4	8	2	6	2	16	8	1	6
	Administrative and Technical	Employees	**18**	1	1	4	1	2	2	2	1		1	1		2
		Total Admin and Tech	**18**	1	1	4	1	2	2	2	1		1	1		2
	Total Integrated HR		**742**	**76**	**36**	**74**	**25**	**88**	**50**	**59**	**55**	**10**	**98**	**65**	**37**	**69**
	Total Integrated PhD		**321**	**29**	**20**	**16**	**9**	**29**	**22**	**24**	**32**	**6**	**47**	**37**	**18**	**32**
Curricular Trainees			**34**		**2**		**4**		**20**	**1**		**5**	**1**		**1**	
External Researchers			**221**	**28**	**5**	**4**	**15**	**17**	**19**	**17**	**16**	**11**	**20**	**41**	**6**	**22**
External Administrative and Technical Staff			**5**					**1**		**1**	**2**					**1**
External Students			**168**	**32**	**14**		**12**	**7**	**3**	**5**	**13**	**1**	**27**	**26**	**2**	**26**
Total			**1 170**	**136**	**57**	**78**	**56**	**113**	**92**	**83**	**86**	**27**	**146**	**132**	**46**	**118**

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

3.4.3 Support Services Indicators

The Human Resources figures by the end of 2021 for the Board of Directors, the TEC4 teams, and the Support Services are provided in Table 3.4.4.

Table 3.4.3 - Human Resources by type and Service

Type of Human Resources		Total	Board and Advisors	Support Services															
						Organisation and Management Services					Business Development Services				Technical Support Services			
				TEC4	DPO	AG	AJ	CF	CG	RH	SAAF	SAL	SRI	SCOM	SRC	SIG	SAS	SGI
Integrated HR	Employees	82	11	6	2	2	2	9	11	6	2	3	5	6	2	5	4	6
	Academic Staff	11	8	3														
	Grant Holders and Trainees	6		1						1				1	1		2	
	Affiliated Researchers																	
	Total Integrated HR	**99**	**19**	**10**	**2**	**2**	**2**	**9**	**11**	**7**	**2**	**3**	**5**	**7**	**3**	**5**	**6**	**6**
	Total Integrated PhD	**21**	**11**	**5**		**1**	**1**	**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 2017 to 2021.

Table 3.5.1 - Funding sources and evolution

Sources			Value (k€)					Δ (k€ | %)	
			2017	2018	2019	2020	2021	2020-21	
Projects	PN-FCT	National R&D Programmes - FCT	1 143	2 279	3 677	3 524	2 295	-1 229	-35%
	PN-PICT	National R&D Programmes - S&T Integrated Projects	2 644	2 428	468	22	49	27	122%
	PN-COOP	National Cooperation Programmes with Industry	1 060	1 251	928	1 250	2 189	939	75%
	PUE-FP	EU Framework Programmes	3 306	3 628	3 910	4 903	5 529	626	13%
	PUE-DIV	EU Cooperation Programmes - Other	686	707	713	300	449	149	50%
	SERV-NAC	R&D Services and Consulting - National	2 538	2 525	2 527	2 899	3 519	621	21%
	SERV-INT	R&D Services and Consulting - International	355	509	410	547	678	131	24%
	OP	Other Funding Programmes	1 040	841	1 067	955	560	-394	-41%
	Closed Projects		140	309	185	0	0	0	
		Total Projects	**12 912**	**14 477**	**13 884**	**14 399**	**15 270**	**871**	**6%**
National Strategic Programme - Pluriannual			3 003	2 485	2 307	2 396	2 257	-139	-6%
National Strategic Programme - RHAQ			0	0	0	289	520	231	80%
National Strategic Programme - EEC			0	0	368	460	484	24	5%
National Strategic Programme - CIT			0	0	961	599	836	237	40%
National Strategic Programmes - Other			130	13	73	10	241	231	2402%
Other Revenues			260	170	375	102	520	418	410%
		Total Revenues	**16 305**	**17 145**	**17 966**	**18 255**	**20 127**	**1 872**	**10%**

Figure 3.5.1 illustrates the distribution of funding for the projects carried out in 2021, and its evolution since 2017. 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.

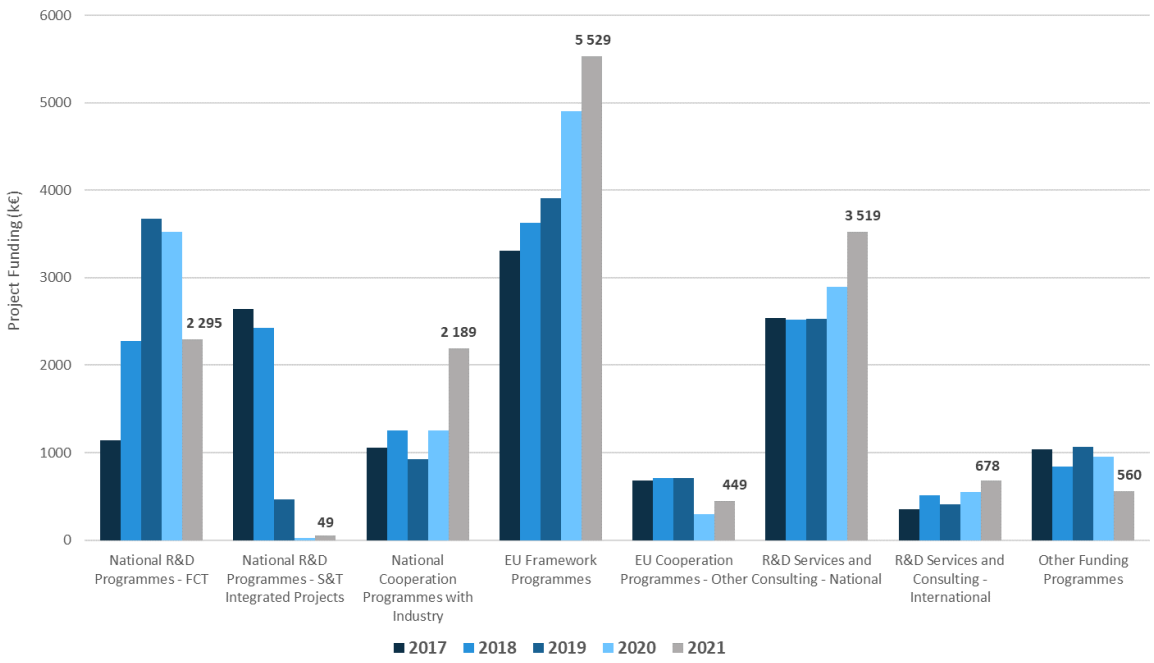


Figura 3.5.1 - Evolution of project funding by source (k€)

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

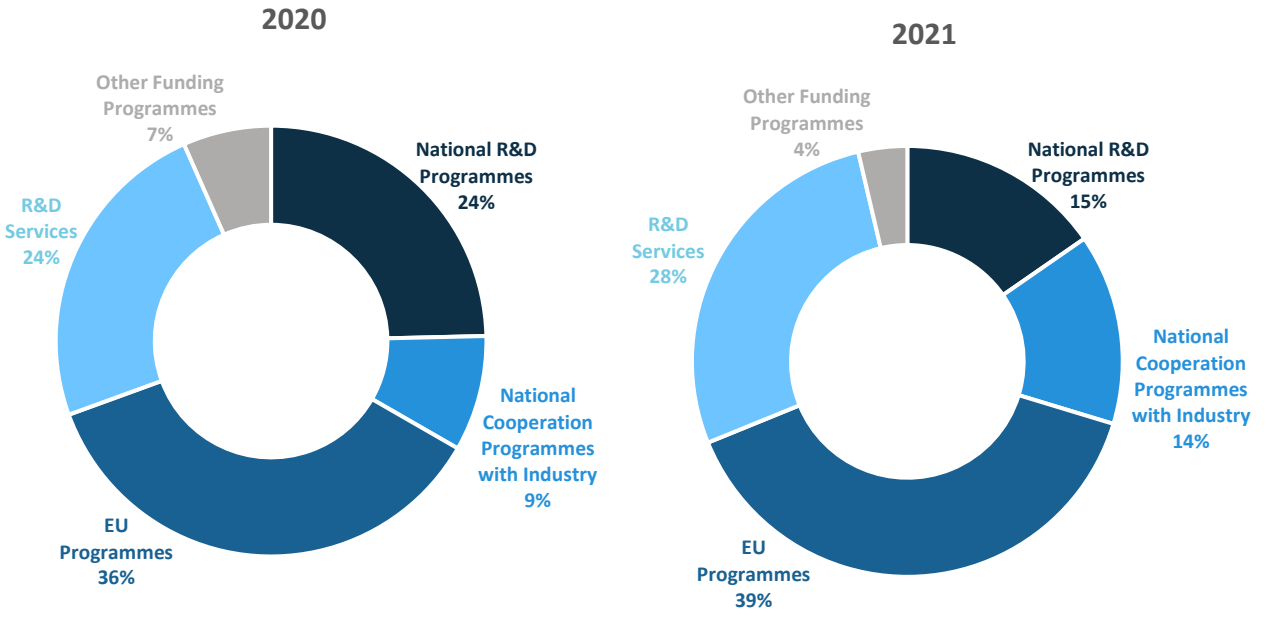


Figure 3.5.1 - Distribution of project funding by source – 2020 and 2021

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€)	
		2017	2018	2019	2020	2021	2020-21	2020	2021
PN-FCT	National R&D Programmes - FCT	28	66	74	68	61	-7	52	38
PN-PICT	National R&D Programmes - S&T Integrated Projects	10	10	10	0	1	1		49
PN-COOP	National Cooperation Programmes with Industry	22	23	21	33	46	13	38	48
PUE-FP	EU Framework Programmes	35	30	48	72	67	-5	68	83
PUE-DIV	EU Cooperation Programmes - Other	20	18	20	18	15	-3	17	30
SERV-NAC	R&D Services and Consulting - National	84	87	121	126	125	-1	23	28
SERV-INT	R&D Services and Consulting - International	10	19	13	20	20	0	27	34
OP	Other Funding Programmes	30	30	31	40	27	-13	24	21
	Total	**239**	**283**	**338**	**377**	**362**	**-15**	**38**	**42**

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, reaching for the first time in its history a total funding of 20 M€, consolidating the continuous growth observed in previous years;
- Despite the pandemic context, INESC TEC was able to increase its level of activity in about 10%, with 362 active R&D projects during the year, and 33% of its funding from international sources;
- A balance between the different funding sources was successfully maintained, 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 and in other funding programmes;

- The large increase in the National Cooperation Programmes with Industry is mainly related with the start of several of the large Portugal 2020 projects called *Mobilising Projects* (Projetos Mobilizadores);
- The decrease in FCT project funding is related with the completion of several projects and a smaller number of FCT projects started in 2021, since the funding available for the latest calls was considerably lower;
- The National Strategic Programme – "Pluriannual" – amounted to 11% of the total funding sources and it has a great importance due to its flexibility and stability – as a relatively small proportion of the total funding, it is greatly leveraged by the institution in its activity;
- The base funding for technology transfer activities, "CIT", accounted for 4% of the total revenues, and was of particular importance to strengthen the institute's technology transfer capabilities and activities;
- The National Strategic Programme for hiring Highly Qualified Human Resources represented 3% of the total funding while Infrastructures ("National Strategic Programmes - Other") accounted for 1%, both very relevant funding sources, complementing the funding for implementing the national scientific employment policies and strengthening INESC TEC's laboratories, respectively;
- EU Framework Projects remained the largest project category in terms of funding volume. At the opposite end, other EU Cooperation Programmes typically fund small projects (with complex and often highly specific rules) and R&D and Consulting Services are often short duration projects and therefore below average funding per project.

3.5.2 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 3.5.3 - 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	Special Projects
Projects	PN-FCT	**2 295**	396	191	355	95	179	126	-14	297	0	221	196	2	252	0
	PN-PICT	**49**	4	1	0	0	44	0	0	0	0	0	0	0	0	0
	PN-COOP	**2 189**	150	46	328	98	367	521	182	39	14	98	132	0	217	0
	PUE-FP	**5 529**	205	260	950	0	1 648	440	604	267	158	786	83	0	130	0
	PUE-DIV	**449**	0	47	262	0	8	0	9	3	0	45	15	60	0	0
	SERV-NAC	**3 519**	708	-3	30	24	850	272	365	119	17	354	283	35	459	6
	SERV-INT	**678**	37	17	312	0	123	40	0	0	30	26	8	0	85	0
	OP	**560**	59	9	1	2	11	1	4	2	0	6	22	8	29	405
Total Funding		**15 270**	**1 559**	**567**	**2 239**	**218**	**3 230**	**1 400**	**1 149**	**725**	**218**	**1 535**	**739**	**106**	**1 173**	**411**

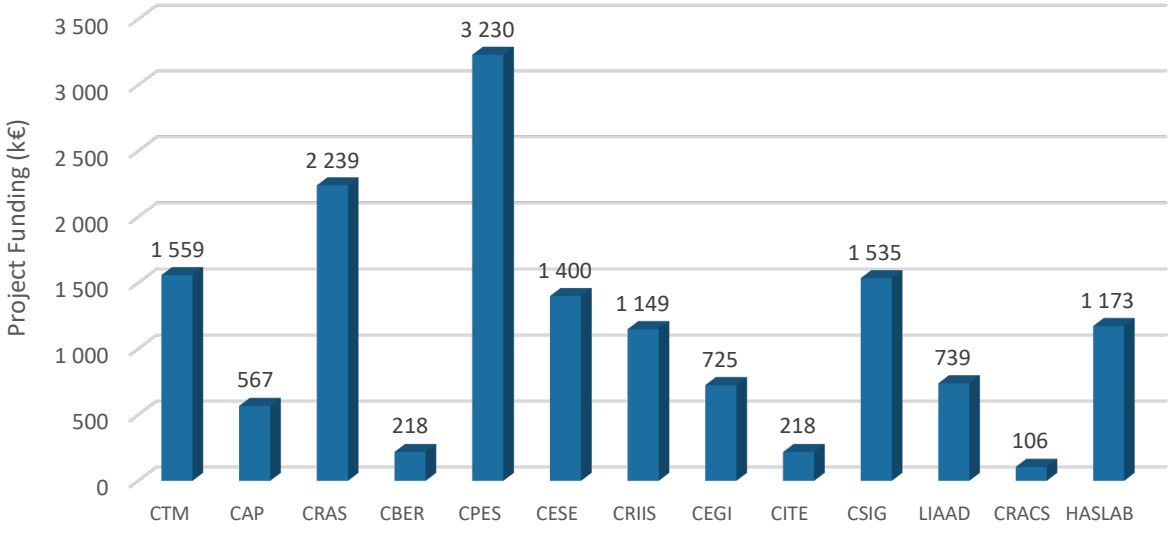


Figure 3.5.2 - Total Project Funding per R&D Centre (k€)

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 2017 and 2021.

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	2017	2018	2019	2020	2021
Indexed Journals	318	312	381	444	440
Indexed Conferences	492	494	570	413	362
Books	1	7	6	2	3
Book Chapters	27	40	29	25	34
PhD Theses - Members	34	38	19	28	30
PhD Theses - Supervised	56	56	33	46	58

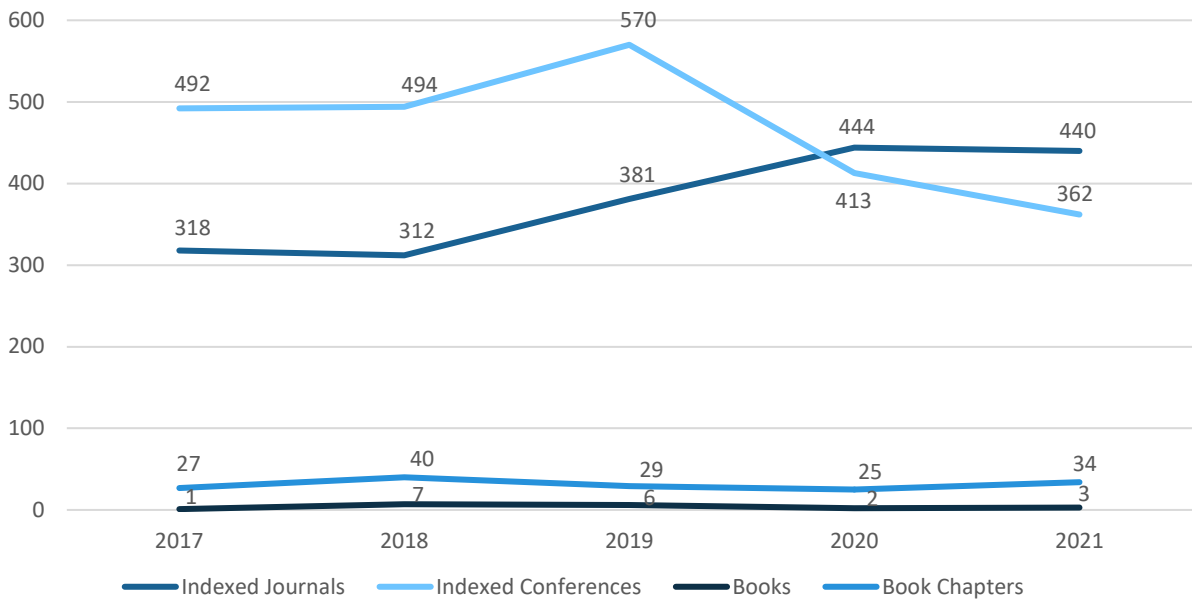


Figure 3.6.1 - Evolution of Publications

Surpassing the estimates included in the 2021 plan, INESC TEC maintained the number of publications in indexed journals, the institute's main overall publication priority, after the strong increase in 2020. It is important to highlight that, since the number of publications in a year will keep evolving during the following year as the indexing sources keep updating their data, when the final number of articles in indexed journals in 2021 is established in November 2022 (in preparation of the 2023 Activity Plan), the indicator will confidently be higher than the 2020 figure.

The number of publications in indexed conferences decreased again in 2021, mostly due to the remaining limitations caused by the pandemic.

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

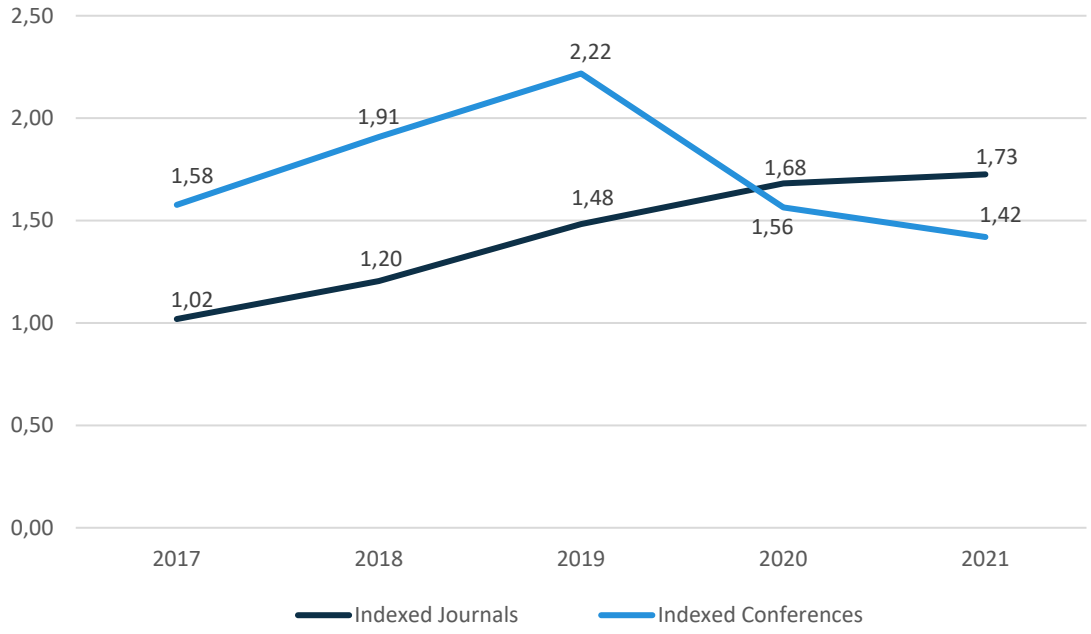


Figure 3.6.2 - Evolution of Publications per Core PhD

As for the publications in journals indexed by Scopus, Figure 3.6.3 shows their distribution per impact factor quartile: 292 of them were in First Quartile journals (compared to 245 articles in 2020) which correspond to 66% of the articles in indexed journals, corresponding to yet another improvement in terms of relevance of the publications when compared with the previous year (62% in 2020).

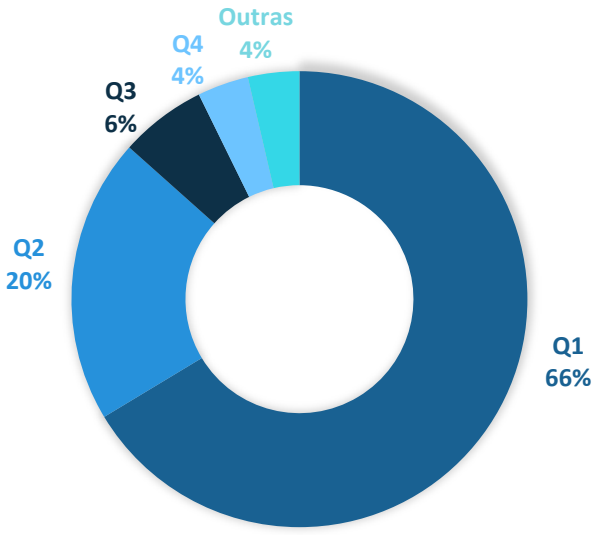


Figure 3.6.3 – Indexed Journal impact factor Quartile distribution (Scopus)

3.6.2 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.

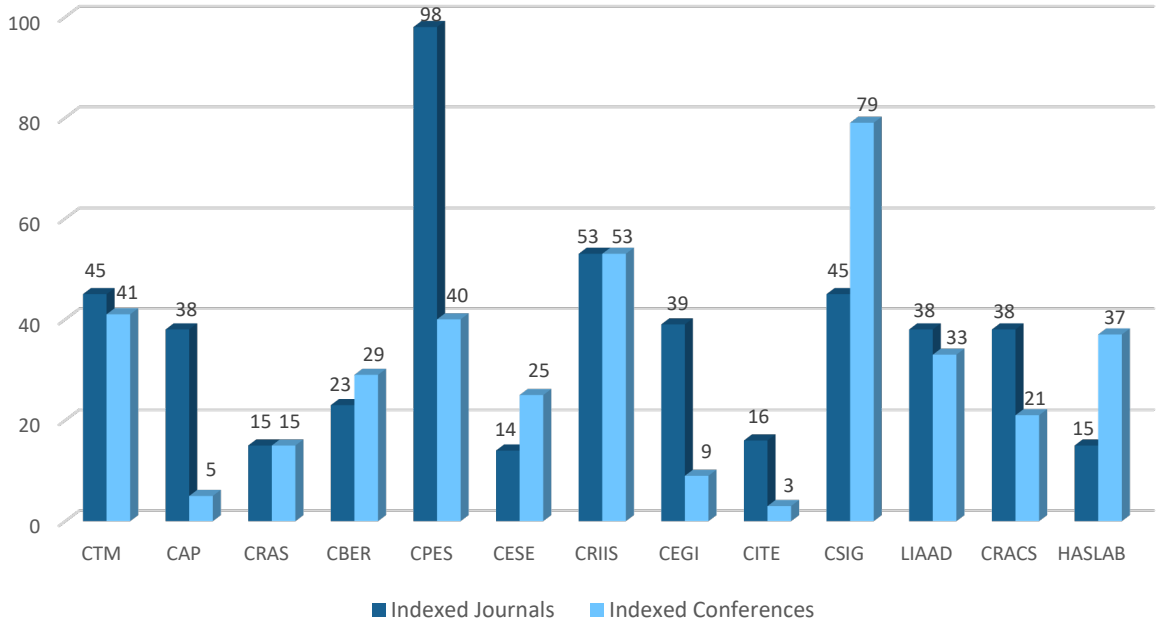


Figure 3.6.4 - Indexed Publications in Journals and Conferences by Centre

The breakdown of the publication indicators of each R&D Centre is presented in Chapter 10, in each Centre's section.

3.7 Technology Transfer

Overall, the results related with technology transfer (Table 3.7.1.) were above or in line with the estimates included in the 2021 plan. This was 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). On the other hand, the release of a short disclosure form at the end of 2020 contributed to simplify and improve initial communication phases, reflected in the number of invention disclosures.

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

Type of Result	2019	2020	2021
Invention disclosures	9	26	38
Software copyright registrations	2	6	3
Patent first priority filings (New inventions)	1	7	5
Patent applications (Internationalisation)	26	30	25
Granted patents	4	7	11
Licence agreements	3	5	3
Spin-offs established	2	0	1
Spin-offs in development	3	3	2

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.

Eleven patents were granted in 2021, reflecting the quality of the 2018 and 2019 patent applications and the joint work of SAL, inventors, and patent attorneys, in disputes with the various patent offices.

INESC TEC sold a patent family, C4MIR - Control Module for Multiple Mixed-signal Resources Management, a technology developed by INESC TEC in partnership with the University of Porto (U.Porto)). It is the first patent assignment agreement in its history and one of the few cases ever in Portugal. The technology was sold to Allied Security Trust, a world technology association established in the U.S.A., which represents some of the largest tech companies in the world – Google, Meta, Microsoft, Spotify, Phillips or Sony. C4MiR may have a strong impact on the electronics industry, since it allows testing and calibrating sensors part of wearable devices, thus improving their lifetime while reducing time production and the costs of electronic chips.

In 2021, the establishment of spinoff UGR was finally concluded. The company will pursue the commercial exploitation of an underwater robotic system developed within the scope of the H2020 UNEXMIN project, through the provision of geological services. Two other spin-offs remain in a development phase, iLoF and WeSenss. More information on INESC TEC's Spin-offs is presented in the next section.

Finally, INESC TEC joined the EPO network PATLIB, that helps SMEs to manage their intellectual property rights, complementing INESC TEC's participation in the European IP Helpdesk program backed by the European Commission.

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 2021.

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

Established Spin-offs				
Name and description	**Year of incor-poration**	**Sector**	**Employees (FTE)**	**Main developments in 2021**
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	Development of strategic partnerships and beginning of a new project within a logistics consortium. Exposure to new clients 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	inSignals secured a seed investment from Portugal Ventures to further progress with business activities and a grant from EIT Health for the Living Labs and Test Beds programme. A prototype with upgraded features is being developed. The patent rights were granted.
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	The city of Cascais (Portugal) migrated its mobility platform to the Pick Platform from Ubirider; Sodexo Portugal ordered to Ubirider its mobility platform to sell mobility services to companies as benefits to employees; The citizens of the Metropolitan Area of Lisbon can now renew their public transport monthly passes using just their smartphones through the app Pick Hub, from Ubirider.
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	Implementation projects using the core technology developed by MITMYNID and diversification for other industries on consulting and technology development.
UNEXMIN Georobotics Underwater mine exploration robotic system for commercial mine surveying, exploration and geoscientific purposes.	2018	Geological consulting	< 5	A total of 4 different sites were visited during 2021, and two of them were commercial sites. Urgeirica mine in Portugal, Csor water well in Hungary, Molnar Janos underground cave system in Hungary, and Solotvyno mine in Ukraine. Increased interest for commercial missions in Europe (a mission in the UK is already organised for the beginning of 2022) and outside. Also in 2021, the process of joining INESC TEC as the largest shareholder of UGR was finally formalised.

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 2021**
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	10-20	Created a new technology application to prognose covid-19 symptoms and initiated clinical studies with two major hospitals in Portugal.
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	Strong focus on a B2B strategy inside INESC TEC infrastructure, making use of C-BER outputs to try to create strong partnerships with companies for trials and a round of investment: 1) software licensing to a third-party company to explore new markets with WeSENSS; 2) mutual interest contract with EQS company for the development of a joint pilot application for the oil&gas market. New European and national project at INESC TEC to both improve the wearable devices and also to implement the technology in a new market jointly with an interested company: 1) H2020 project in the area of firefighters monitoring to evolve our wearable health devices and IoT system; 2) national project in the area of farm workers monitoring.

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	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	75	90	118
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	75	74	77
International events in which INESC TEC members participate in the program committees	330	273	259
Participation in events such as fairs, exhibitions or similar	66	63	82
Conferences, workshops and scientific sessions organised by the R&D Centres	54	41	75
Participants in the conferences, workshops and scientific sessions organised by the R&D Centres	4 549	5 488	7 239
Advanced training courses organised by the R&D Centres	19	20	15

Despite the effects of the Covid-19 Pandemic, INESC TEC's researchers were able to maintain a dynamic activity in scientific dissemination events and other formats. For this purpose, the virtual alternative provided in many events, as hybrid format or full remote participation, had an actually virtuous consequence: the possibility to reach world-wide participants who otherwise would not have participated.

Except for the organisation of advanced training courses, the results related with dissemination activity surpassed the estimates included in the 2021 plan in all dimensions.

Besides the INESC TEC Autumn Forum - not considered in the above numbers since those are limited to R&D Centres activities, a special mention is deserved by the organisation of the international congress "EUCNC2021 - European Conference on Networks and Communications" that counted with the online presence of more than 2300 participants over four days, in June 2021; the conference "DSAA 2021 – The 8th IEEE International Conference on Data Science and Advanced Analytics", the core A conference on Data Science and Advanced Analytics; and the 37th International Conference on Logic Programming (ICLP 2021), the most well-known and recognised international conference in Logic Programming (online event with 200 worldwide participants).

The lifting of some health restrictions also allowed some of our teams to resume field demonstrations and brought the opportunity to participate in various dissemination and outreach events, both at national and international levels.

3.9 Participation in other associations

In order to promote knowledge and competence sharing, INESC TEC is currently a full member of more than fifty Associations, at national and international levels. Other than the participation in the General Assemblies where network and benchmark are added values, INESC TEC actively participates in several Boards, Committees, and Working Groups, thus gathering and sharing knowledge with top-of-the art experts in it field of activity.

In 2021, INESC TEC joined 6 associations: PFP, BATPOWER, HYLAB, AIOTI, ETSI and APVE and formally requested to join +ATLANTIC and to exit EIT DIGITAL.

Table 3.9.1 - INESC TEC's participation in other Associations

NATIONAL ASSOCIATIONS		
National Competitiveness Clusters		ACPMR (Mineral Resources), ADVID (Vines&Wines), AEDCP (Space and Defence), APICCAPS (Footwear and Fashion), BATPOWER (Energy), CITEVE (Textile), Fórum Oceano (Sea), HCP (Health), MOBINOV (Automobile), PFP (railway), PRODUTECH (Manufacturing), TICE.PT (CIT)
Collaborative Laboratories *(See also Section 3.9.1)*		AQUAVALOR (Water technologies), B2E (Blue Economy), BUILT (Built Environment), FEEDINOV (Sustainable Animal Production), ForestWise (Fire and Forest), HYLAB (Hydrogen energy) SFColab (Smart Farming), Smart Energy lab (Energy Services), VG Colab (Energy storage), ADVID (Vineyard and Wine), VORTEX (Cyber-physical and cyber-safety systems)
Dedicated to specific fields of knowledge		AdEPorto IEP (Energy), APVE, ITS Portugal (Mobility), SPR (Robotics), APDIO, APGEI (Management), SmartWaste Portugal (circular economy)
Support industry/business		AEP
Promotion of science		Ciência Viva
INTERNATIONAL ASSOCIATIONS		
EIT Knowledge and Innovation Communities		EIT Raw Materials, EIT Manufacturing, EIT Digital (exit by the end of 2021)
Specific fields of knowledge	Energy	CIGRÉ, DERLab, EFFRA, EERA, EES-UETP, IEA Wind, WA4ES
	Industrial and Systems Engineering	EuRobotics, CERVIM, EtherCAT Technology Group, IDSA, ROS-INDUSTRIAL CONSORTIUM EUROPE
	Networked Intelligent Systems	EPIC, AIOTI, ETSI
	Computer Science	ERCIM, CENTRA
	Strategic Benchmark/network	INESC P&D Brasil, EARTO, ASTP Proton

3.9.1 Participation in Collaborative Laboratories

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 characteristics 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.

Alignment with INESC TEC's strategy and evolution in 2021

As demand-driven, business-centric, impact-oriented institutions, CoLABs focus their activities on high Technology Readiness Levels (TRL) 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 2021, INESC TEC was associated with eleven CoLABs. They all assumed a private non-profit association legal form and are presented in the tables below. INESC TEC's involvement with these CoLABs will, in the coming years, deepen the research oriented to the respective areas of application, intensify the sharing and valorisation of knowledge, and 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 will be especially important in accelerating the work in emerging areas for INESC TEC and stimulating new forms of interaction and a nonlinear relationship between research, innovation and social and economic development activities, by stimulating 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.

The tables below provide an overview of INESC TEC's participation in Collaborative Laboratories in 2021 and the main developments in these fruitful relationships.

Table 3.9-2 - 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 2021	15 / -
HR hired	16 HR hired by the CoLAB by the end of 2021
Base funding planned	1 078 k€
Competitive funding – submitted and approved proposals	Thirty proposals were submitted (eleven for international competitive funding, eleven for services and eight for national competitive funding). Nine of these proposals were approved. Major involvement in mobilizing proposals for the forest sector under the PRR: RN21, TransForm Innovation Agenda, Pinhal Interior. The volume of investment in these three proposals proposals is over 12 M€ for ForestWISE and more than 188 M€ in total.
Main activities and achievements in 2021	ForestWISE's activity in 2021 was focused on the reinforcement of the team with the recruitment of six persons. A very large effort has been put in attracting projects and partnerships, as well as consolidating ForestWISE's position in the national scene. As a result, the CoLAB's activity recorded a sharp growth in the number of projects, from 2 to 11, with the first consultancy services project's for ForestWISE associated companies and the first participation in a European project (Green Deal Call). ForestWISE participated in more than 25 national events, being recognised as a key partner for research and technology transfer in the area of integrated forest and fire management. The scientific output resulted in the publication of 19 papers in journals and conferences.
Activities to foster Associates' involvement	Relationship with associates was strengthened, through internal training and the operationalisation of the infrastructures, as well as the management and organisation model of the four lines of work that make up the workplan 2020-2025. Each of these lines has a dedicated team and already has projects either running or underway. The newsletter has been the vehicle for the dissemination of information and communication with both the community and 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 CoLAB Leadership during the first years and contributing also with a group of experienced senior researchers that were brought -up in INESC TEC and were the seed of the ForestWISE team. 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, engaging INESC TEC in many projects of its own initiative and leadership. INESC TEC participated in several proposals for new national and European projects.

Table 3.9-3 - 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 2021	14 / 1
HR hired	9
Base funding planned	636 k€
Competitive funding – submitted and approved proposals	Submitted: 11 | Approved: 2
Main activities and achievements in 2021	Development of the R&I agenda (with the associates). Preparation of an Intellectual Property Regulation. Connection with other CoLABs and international players. Active presence in media and social networks. Creation of 2 technology surveillance mechanisms. Presence in relevant fair and expositions (Aquaculture Europe 2021) involving the associates.
Activities to foster Associates' involvement	Regular engagement with associates (incl. regular meetings). Engagement of associates in new opportunities. Contribute to associates national and international visibility within the B2E sectors of intervention (incl. representation). Promote the associate's competencies and technologies towards innovation and tech transfer in the business sectors.
Fulfilment of INESC TEC's strategic objectives related to this participation	Dynamization of the Blue Bioeconomy sectors, sharing of knowledge and opportunities and attraction of funding and financing opportunities. Implementation of complementary initiatives in ocean literacy, consumer awareness campaigns as well as contribution to the definition, onset and implementation of common priorities, objectives, and targets to stimulate economic growth.

Table 3.9-4 - CoLAB AQUAVALOR

SFCoLAB	
Name	AQUAVALOR - Centro de Valorização e Transferência de Tecnologia da Água – Associação
Description	Aims to boost thermal and mineral waters as anchor products for regional development and promotion of tourism throughout the year, particularly in low-density territories.
Areas of expertise	Health; Water technologies; Digital transition
Year of establishment	2018
N.º of Associates / Accession of new Associates in 2021	28 / 3
HR hired	13
Base funding planned	
Competitive funding – submitted and approved proposals	4.516.670,86€
Main activities and achievements in 2021	Development pf a Thermal Activities Observatory; Preparation of proposals for several competitive funding programmes (ex: Mobilizing Agendas); Contract research and other activities related with the digital transition of the Agrofood sector; Development of new and innovative food products, based in the endogenous resources of the Alto Tamega region (ex: natural mineral water); Organisation of international scientific and technical events (ex: CISTI'2021).
Activities to foster Associates' involvement	Proposals to competitive funding programmes (ex: Agendas Mobilizadoras, Promove Futuro do Interior); Organisation of international scientific and technical events (ex: AquaForum'21).
Fulfilment of INESC TEC's strategic objectives related to this participation	INESC TEC main objectives with this participation are: 1. to support the COLAB's development with our competences and expertise in digital technologies; 2. To generate new opportunities and projects in that area; 3. To promote the development of low-density territories, mainly through the retention of highly qualified human resources and the development of higher added value economic activities. So far, the COLAB's development is completely aligned with these objectives, since several highly qualified human resources were hired for the organisation, INESC TEC was/is involved in several of its activities (namely projects and events) and the first services to the local economy are being provided.

Table 3.9-5 - 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 2021	19 / -
HR hired	27 HR were hired by the CoLAB by the end of 2021
Base funding planned	806 k€
Competitive funding – submitted and approved proposals	13 proposals for competitive were submitted (1 H2020, 3 Horizon Europe, 4 FCTs, 1 DIH, 2 Agendas (PRR), 1 ERA.NET, and 1 BOWI). The DIH was already approved but there are no certainties about the budget yet. Others are being evaluated.
Main activities and achievements in 2021	Activity start of BUILT CoLAB. The research team was created and research groups were formed. There are now 5 main research areas separated into 13 research topics. Several software developments were conducted and are now being used by construction companies. Several others were started and will be completed in 2022. Important partnerships were established and BUILT CoLAB is now involved in several National and European initiatives becoming, more and more, an important agent for the twin transition in Construction.
Activities to foster Associates' involvement	Meetings with the associates to present the skills, needs and promote co-creation/collaboration; Development of common competitive funding opportunities; Invitation to events, communication initiatives or business opportunities.
Fulfilment of INESC TEC's strategic objectives related to this participation	Open a new market for INESC TEC to apply its skills and apply technology already developed for other sectors. Participated in several large national and European project proposals.

Table 3.9-6 - 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 2021	5 / -
HR hired	PhDs: 6 | MSc: 9 | BSc: 4
Base funding planned	829K€
Competitive funding – submitted and approved proposals	17 proposals, 3 accepted (P2020 FLOYD, P2020 STEROID, InSecTT H2020-ECSEL)
Main activities and achievements in 2021	i. Creating a team of excellence: an active recruitment campaign was maintained to attract qualified talent. A total of 17 human resources were hired during 2021. However, retaining talent in an extremely competitive market proved to be a problem, which led to a total of 8 layoffs. ii. Strengthen market sales capacity: One of the main priorities for 2021 was the capture of new commercial contracts for R&D activity. A considerable effort in the implementation of a relevant Go-To-Market strategy allowed VORTEX to explore a total of 16 Leads & Commercial Opportunities, which resulted in the contracting of 4 new commercial projects, totalling €207k. iii. Kick-off competitive financing projects: During 2021, 2 new R&D projects financed by structural funds kicked off: FLOYD (PT2020, CMU) and STEROID (PT2020). Together with the InSecTT project (H2020-ECSEL, FCT), whose kick-off was in June 2020, these 3 projects allowed the CoLAB to grow its technical and scientific capacity, as well as strengthen its market offer iv. Capturing new funding mechanisms: The use of structural funds is crucial to ensure financial sustainability and an adequate level of resources capable of implementing an R&I agenda of excellence. During 2021, VORTEX participated in a total of 12 applications for Horizon Europe and PRR funds.
Activities to foster Associates' involvement	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 Capgemini identifies new market opportunities at the international level, where expertise and knowledge available in academic partners is a crucial enabler. Capgemini'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 materialised in new projects.

Table 3.9-7 - 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 2021	7 / -
HR hired	Thirteen (13) new HR have been hired in 2021
Base funding planned	Subsidies (state and other public entities): 777 853,14 € Donations: 596 366 €
Competitive funding – submitted and approved proposals	Submitted proposals: 17 / Approved proposals: 12 (with a total budget: 540 k€). Additionally, 10 proposals were submitted to PRR, involving a total budget of 19 M€.
Main activities and achievements in 2021	SEL continued developing the main projects started in 2020 related with non-intrusive load management, EV charging solutions, the Living Lab, load flexibility, and provision of services to the grids. At the same time SEL has been involved in the preparation of several EU funded projects and in the application to PRR projects. Some of the approved EU funded projects started also in 2021 leading to a considerable activity in this forefront.
Activities to foster Associates' involvement	Ideation meetings and scientific council meetings were organised, leveraging the multi-disciplinary knowledge of the Associates
Fulfilment of INESC TEC's strategic objectives related to this participation	Collaboration between INESC TEC and SEL is expected to increase in 2022 through collaborative projects, EU funded projects and sub-contracting of advanced consulting and development projects.

Table 3.9-8 - 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 2021	10 / 2
HR hired	19 (Transversal: 2 HRs | Pillar 1 (Redox Flow Batteries): 7 HRs | Pillar 2 (Supercapacitors): 5 HRs | Pillar 3 (Power Electronics and Energy Management): 5 HRs)
Base funding planned	383 k€
Competitive funding – submitted and approved proposals	10 proposals submitted, 2 were approved. 3 expressions of interest for PRR agendas were also pre-approved.
Main activities and achievements in 2021	In 2021, VG COLAB has started its activy in three main Pillars and corresponding cross R&D&I: 1) Redox Flow Batteries (RFB); 2) Supercapacitors (SC) and 3) Power Electronics (PE) and intelligent Energy Management Systems (iEMS). Besides studies and experimentations conducted, review papers and several reports have already been submitted, as well as project proposals to national and European fundings.
Activities to foster Associates' involvement	VG CoLAB organised Scientific internal training programs oriented to all the Associates.
Fulfilment of INESC TEC's strategic objectives related to this participation	INESC TEC has benefited from the extensive knowledge of VGCoLAB partners in storage solutions, namely Redox Flow and Supercacapcitor, learning on the technical constrains of the most recent solutions, that can influence the design of requirements for network interface equipment, to be tested in the near future in INESC TEC laboratory facilities.

Table 3.9-9 - CoLAB HYLAB

SFCoLAB	
Name	HYLAB – Green Hydrogen Collaborative Laboratory
Description	Aims to set up a network of competencies in R&D and new technologies aimed at the scientific and technological development of Green Hydrogen, covering the various components of the value chain.
Areas of expertise	Green hydrogen
Year of establishment	2021
N.º of Associates / Accession of new Associates in 2021	12 / 0
HR hired	0
Base funding planned	N/A
Competitive funding – submitted and approved proposals	HyLab applied for 4 projects under the PRR C05-i01
Main activities and achievements in 2021	As HyLab hasn't started its scientific activities, there are no relevant achievements to report
Activities to foster Associates' involvement	In Dec 2021, the first formal meetings of the Board of Directors, Supervisory Board and General Meeting took place
Fulfilment of INESC TEC's strategic objectives related to this participation	INESC TEC has been looking at the opportunities hydrogen offers to foster the energy transition, namely regarding energy storage and security of supply of electric power systems, balancing ancillary services provision through eletrolysers and exploitation of gas networks with blended H2. HyLab provides the network of competences and synergies to develop further this strategic vision.

Table 3.9-10 - 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 2021	20
HR hired	47
Base funding planned	276 k€
Competitive funding – submitted and approved proposals	13 proposals submitted | 4 proposals approved
Main activities and achievements in 2021	Ongoing activities: - ReWine, an educational program to promote good practices in Circular Economy already implemented by some companies from the wine sector. - Evaluation of the climate in the Douro Region, a study and analysis of how climate works in the Douro region, with the objective of looking for local and regional solutions to answer the climate change problem, to project future scenarios and to anticipate the adequate approach to this new climate reality.
Activities to foster Associates' involvement	Frequent communications with the Associates related with results/databases compiled by the CoLAB.
Fulfilment of INESC TEC's strategic objectives related to this participation	The participation in the CoLAB, namely in its Strategic Board, allows to be closer to the wine companies and consequently increasing the chances for collaborative R&I projects in this sector, with countless examples of this fruitful collaboration.

Table 3.9-11 - 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 2021	19 / 1
HR hired	2 assigned by the associates and 2 hired by the CoLAB
Base funding planned	388 k€
Competitive funding – submitted and approved proposals	7 proposals submitted
Main activities and achievements in 2021	Ongoing activities: - Analysis of trends in the consumption of animal origin products. - Optimisation of the efficiency of nutritional resources. - Evaluation of residues of pharmacologically active substances in non-target feed – determine the maximum level of crossed contamination by active substances in non-targeted feed
Activities to foster Associates' involvement	All associates have a place on the General Assembly. 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.
Fulfilment of INESC TEC's strategic objectives related to this participation	Until INESC TEC joined the CoLAB, there wasn't a relevant activity regarding Zootechny in a broad sense. The participation in this CoLAB seems to be changing the situation, as results of the collaboration are starting to appear.

Table 3.9-12 - 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 2021	18
HR hired	8
Base funding planned	573 k€
Competitive funding – submitted and approved proposals	15 proposals submitted | 2 proposals approved
Main activities and achievements in 2021	Smart use activities focused on the development of a carbon and hydric fingerprint metrics measurement, including the definition of the best methodologies (and validation) for vineyards and apple orchards from Western Region. Smart Equipment: activities are being developed within the Smart Farm 4.0, project Mobilizador. Smart Control & Monitoring: as started in 2020, SFCOLAB developed SOFIS, a Smart Orchard Fertiirrigation System, a customised and low-cost sensor and implemented in different agronomic fields across. Smart Product activities started in 2021 with the preparation of proposals, and in the field with the yield. Some training programs were performed during 2021in particular for producers (calibration of sprayers and efficient application of fertilizers), as well as Dia Aberto and SFCOLAB goes to school, a pedagogical program of SFCOLAB with Agrarian and high Schools.
Activities to foster Associates' involvement	SFCoLAB organised 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 is already being fulfilled, with "Programa Mobilizador" Smart Farm 4.0 and SFT-EDIH (DIH already recognised nationally and being evaluated at a European level). Due to its nature (digital innovation in agriculture), a continued effort will be placed in ensuring activity complementarity.

4 INESC TEC SCIENTIFIC DOMAINS

As mentioned in Section 2, research at INESC TEC is structured in four Scientific Domains - Computer Science (CS), Industrial and Systems Engineering (ISE), Networked Intelligent Systems (NIS), and Power and Energy (PE). The next section presents those four Scientific Domains, their objectives and results during 2021.

4.1 NETWORKED INTELLIGENT SYSTEMS

Coordinator: Aníbal Matos
Assistant to the Domain Coordinator: Andry Maykol Pinto

4.1.1 Presentation of the Scientific Domain

The **Networked Intelligent Systems (NIS)** domain envisions to work "towards autonomous networked intelligent hybrid systems enabled by ubiquitous sensing and processing of information". These systems are obtained by interconnecting agents which interact and communicate mainly over wireless networks. Intelligence is achieved by developing the capability of agents to sense, perceive, communicate, navigate, and learn from past experiences, in order to enhance the ability to meet objectives. Such systems are expected to be low power and locally intelligent, to act as reconfigurable networks, to be tolerant to external disturbances, allowing them to sense and operate under extreme conditions or environments.

To accomplish such goal, the domain gathers researchers with competences in instrumentation, optics, photonics, reconfigurable hardware, communications, electronics, biomedical engineering, artificial Intelligence, signal processing, computer vision, robotics, and control.

Research activities within this domain are organised along four major research challenges:

- **Novel perception tools**, addressing the development of new sensing mechanisms and devices, together with signal processing to act as enablers of networked intelligent systems. Novel scientific approaches include combining smart spectroscopy, low power implantable sensing and neurostimulation microsystems, wearable and human implementable devices, imaging techniques, compressive sensing techniques, and its integration with hybrid microfabricated devices.
- **Beyond human vision**, addressing the development of computer vision architectures achieving functionalities and performances surpassing humans. The main research goals associated to this challenge are never ending learning capabilities, multi-objective perception, generic artificial vision, and causal models: from correlations to causality.
- **Context-aware communication systems**, addressing the design communications systems able to dynamically adapt to the context, including physical environment, communicating peers, and users involved.
- **Autonomy of robotic systems**, aiming at making robotic and other autonomous systems able to operate in complex, unstructured and dynamic environments with increasing levels of autonomy, by enhancing their perception, understanding, reasoning, decision, and interaction capabilities.

4.1.2 Scientific outcomes in 2021

Novel perception tools

During 2021, and contributing to this challenge, 44 journal papers were published, and 3 PhD and 11 MSc theses were successfully defended. The main scientific outcomes produced during 2021 were the following:

- Monolithic fabrication of an integrated device with femtosecond lasers for the excitation of whispery gallery modes through a suspended waveguide. 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 fibre tapers.

- Development of different sensors and a microphone for large bandwidth, based on graphene applications.
- Fabrication and testing of fibre-based interferometers using the Vernier effect. Two world records were established comprising giant sensitivities for strain and refractive index measurements.
- Optimisation of a sputtering deposition system to the development of new optical sensing structures based on different types of surface waves to achieve high sensitivity and resolution. These sensing structures are made from high quality thin films of special materials produced on steady planar substrates and around rotary optical fibres to be used in different applications.
- Development of a method for fast classification of cells and microparticles was using optical tweezers systems, equipped with position sensitive quadrant photodetectors and advanced signal processing applied in the frequency domain.
- Implementation of advanced signal processing and analysis to unscramble spectral interference and matrix effects in Vitis vinifera Vis-NIR spectroscopy, paving the way to the quantification of non-dominant absorbance constituents with analytical precision 'in-vivo', opening the possibility of real-time and high-throughput metabolomics and plant physiology in precision agriculture.
- Development and full characterisation of gold and silver nanoparticles with a wide range of sizes and shapes, with resonances at telecom wavelengths, to be used in optical fibres to the development of optical sensors for biological applications.
- Development of new methodologies to measure optical properties of liquids and solids including the polymers curing process monitoring in real-time. This can be applied in a wide range of applications using a single optical fibre.
- Design, simulation, fabrication and testing of metal-dielectric structures and new metamaterials for optical sensing based on nano-plasmonics and nano-structured optical material (hydrogen sensors).
- Publication of an open-source dataset for the 2022 George B. Moody PhysioNet Challenge, a competition on digital auscultation co-organised by INESC TEC researchers.
- Development of a deep learning approach for foot trajectory estimation in gait analysis using inertial sensors.
- New synchronisation method for an innovative system that combines 3DVideo-EEG and Percept PC deep brain neurostimulator, a pioneering result in the creation of neurotechnologies for neurological diseases monitoring and diagnosis support.

Beyond human vision

During 2021, and contributing to this challenge, 38 journal papers were published, and 5 PhD and 34 MSc theses were successfully defended. The main scientific outcomes produced during 2021 were the following:

- Activity and emotion recognition in shared vehicles based on a strategy for efficient multimodal approach and the assessment of the impact of different types of visual noise in the obtained models.
- Achieving Cancelability and Non-Linkability in End-to-End Deep Biometrics, based on the Secure Triplet Loss, focused on template cancelability, which was reformulated to address the problem of template linkability on biometric verification and face images.
- Privacy-Preserving Generative Adversarial Network for Case-Based Explainability in Medical Image Analysis.
- Retina CAD: Development of a new method for the segmentation of retinal layers in optical coherence tomography images.
- Lung CAD: Further developments in the TAMI project and two ongoing PhD theses, with three new publications (one journal paper of Q1 and two proceeding papers).

Context-aware communication systems

During 2021, and contributing to this challenge, 7 journal papers were published, and 1 PhD and 14 MSc theses were successfully defended. The main scientific outcomes produced during 2021 were the following:

- Method for designing an efficient 300 GHz planar antenna on III-V substrates, suitable for a true time delay microwave photonics based sub-THz transceiver with wide scanning angle.
- Traffic-aware placement algorithms for aerial networks that enable significant performance gains (higher throughput, lower delay) when compared to state-of-the-art counterparts.
- Reinforcement learning algorithms for UAV positioning in aerial networks and link adaptation in Wi-Fi networks that enable significant performance gains with respect to their state-of-the-art counterparts.
- Simulation platform for underwater communications enabling faster evaluation of underwater data muling oriented communications solutions and offline replication of real-world experiments.
- New trace-driven ns-3 simulation models that enable 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.

Autonomy of robotic systems

During 2021, and contributing to this challenge, 16 journal papers were published, and 4 MSc theses were successfully defended. The main scientific outcomes produced during 2021 were the following:

- Algorithms for close range underwater navigation fusing visual information with acoustic-based range and bearing for docking manoeuvres with autonomous underwater vehicles.
- Design and control of unconventional marine surface platforms, combining aerial azimuthal propulsion systems with surface and underwater components.
- Development of feature extraction algorithms in underwater images for use in positioning and navigation systems.
- Design and deployment of custom robotic for localisation and retrieval of fishing nets.
- Development of innovative methods in hyperspectral image processing for autonomous detection of microplastics.
- Development of 3D mapping procedures of GNSS denied environments integrating LiDAR and structure from motion data
- Prototype of vision-based system for the estimation and characterisation of fish growth in aquaculture tanks.

4.2 INDUSTRIAL AND SYSTEMS ENGINEERING

Coordinator: João Claro
Assistant to the Domain Coordinator: Ricardo Zimmermann

4.2.1 Presentation of the Scientific Domain

In the domain of Industrial and Systems Engineering (ISE), INESC TEC researches and innovates systems and services applied to the management of value streams. The goal is to lead complex decision-making in end-to-end, customer-centric, agile supply chains across different industries (e.g., manufacturing, retail, health and mobility). To improve business performance, innovation, productivity, and environmental and social sustainability, our intervention in this domain ranges from local optimisation of individual organisations to complex system optimisation of networks and chains. Our activities cover the design, implementation and improvement of systems for decision support, operations human-centred automation, management and intelligence, as well as innovation and technology management.

Five main challenges have been the strategic focus of our research in this domain in recent and for upcoming years: Operations Management for Responsive, Resilient and Sustainable Systems; Operations Research for Decision Support in a Digitised World; Cognitive, Aware and Collaborative Robotic and Autonomous Systems; Responsible and Sustainable Technology Driven Innovation; Industrial Information Systems Supporting Circularity and Sustainability.

Our activity in this domain (Figure 4.2.1) focuses on the following main areas of competence:

- Asset Management, Collaborative Networks & Supply Chain Management, Factories Design, Logistics & Transportation Systems & Mobility, Production Planning & Scheduling;
- Decision Support Systems, Optimisation Solution Methods, and Performance Assessment;
- 2D/3D Visual Perception & Advanced Sensing, Collaborative Robots, Control of Dynamic Systems, Navigation & Control;
- Engineering & Public Policy, Entrepreneurship, Innovation Management, Service Design, Technology Adoption & Implementation;
- Data & Information Management, Digital Enterprise Architectures, Industrial Information Systems Design.

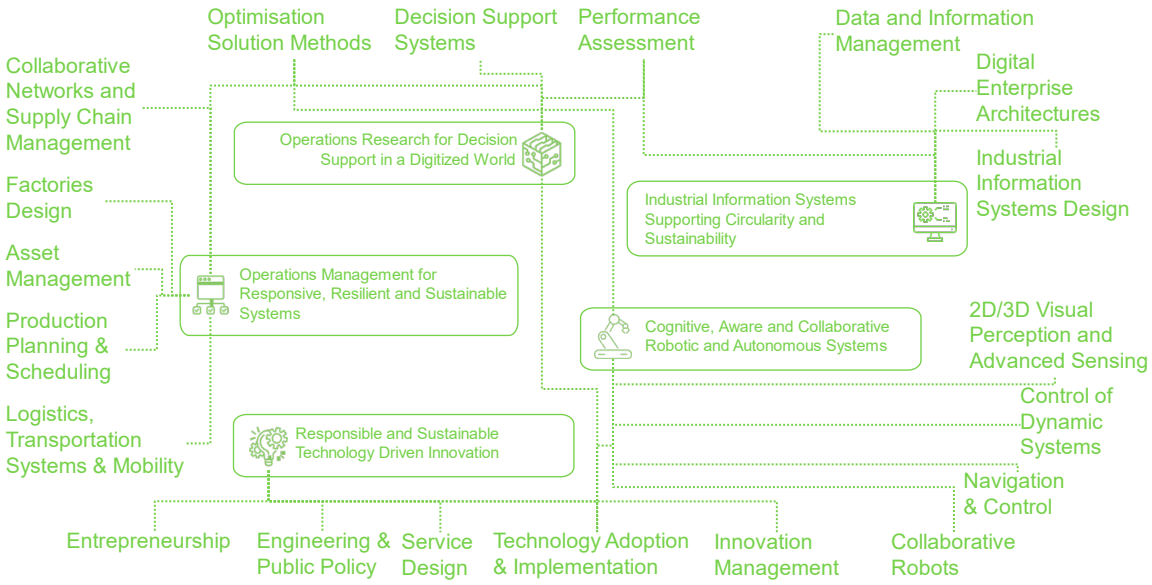


Figure 4.2.1 - Interaction between research lines and areas of competence in the ISE domain

4.2.2 Scientific outcomes in 2021

Operations Management for Responsive, Resilient and Sustainable Systems

This challenge focuses on the design, planning, control, and improvement of value-adding processes that lead to more efficient, effective and sustainable creation and delivery of goods and services, leveraging our deep applied research experience in different sectors; from Manufacturing and Retail to Health and Mobility. The most used research methods range from quantitative modelling to empirical studies, from operations research, artificial intelligence and statistics to social sciences and exploratory research.

The main topics addressed include: flexible, responsive and sustainable operations and industrial systems; collaborative networks and supply chain design and management; asset management; production planning and scheduling; logistics, intelligent transportation systems and mobility; and marketing analytics (consumer behaviour, product line design, demand forecast, revenue management and product variety management).

From INESC TEC's activity in 2021, the following scientific outcomes in the scope of this challenge are worthy of highlight: the institute's first publication in an FT50 journal, MIT Sloan Management Review, with an analysis of online customer data, revealing that other delivery attributes matter more than how quickly an order is received; approaches integrating Data Science and Artificial Intelligence, namely Reinforcement Learning, into decision support systems to address complex manufacturing challenges; combined optimisation and simulation to manage manufacturing operations facing unexpected events; several publications, namely the book "Next Generation Supply Chains", published by Springer, on contemporary challenges faced by supply chains, and strategies to increase their resilience and sustainability; visualisation and data mining to efficiently identify patterns that affect the quality of urban mobility services, and optimisation techniques (meta-heuristics) to improve their quality levels.

Operations Research for Decision Support in a Digitised World

This challenge seeks to contribute to the methodology of operations research and to the practice of decision-making, leveraging the science of optimal decision-making support, especially under uncertainty. It builds on a strong critical mass and deep involvement in national and international associations (e.g., APDIO, EURO and IFORS), the visibility of several researchers in the European Operational Research community, and the coordination of European projects such as TRUST-AI, which aims at developing next-generation explainable artificial intelligence methods.

The main research topics are: mathematical programming, constraint programming and metaheuristics; hybrid solution methods (Matheuristics, Simulation-Optimisation, Machine Learning and Optimisation); decision-making under uncertainty; policy learning methods and real-time decision making; multi-objective optimisation; decision support systems, and performance assessment.

Among the 2021 scientific outcomes associated with this challenge, the following are highlighted: the combination of Machine Learning and Monte Carlo simulation with a branch-and-bound algorithm and heuristics, to study a variant of the Probabilistic Travelling Salesman Problem arising when retailers crowdsource last-mile deliveries to their own customers; and the in-depth study of symbolic learning algorithms, based on genetic programming, and comparison of different grammar-based variants, such as context-free grammar and grammatical evolution, looking at applications in online retail, with the algorithms being used to predict the customers' willingness to pay.

Cognitive, Aware and Collaborative Robotic and Autonomous Systems

The main focus of the research in this challenge is the design and implementation of innovative solutions within the areas of industrial robotics and intelligent systems, having at its core the development of cognitive, sensitive, collaborative and safe robotic-based and automated systems. The main research topics addressed are: Collaborative Robots; 2D/3D Visual Perception and Advanced Sensing; Navigation and Control and Control of Dynamic Systems.

The following 2021 scientific outcomes in the scope of this challenge are worthy of note: a multi-robot coordination system considering communication failures; a 3D Robot Perception Framework to allow object pick up in complex scenarios; machine vision and deep learning-based systems for inspection and quality control tailored to support human operators, and to improve natural collaborations with human partners, interpreting

implicit communication cues; an AI-based digital representation of manufacturing environments, relying on robotic systems sensor data with local, edge, and cloud processing; datasets for deep learning training; enhancement of the vertical integration layer of the OSPS framework with cloud support and integration with the Robotics and Automation MarketPlace; robotic perception modules for agricultural monitoring, spraying and harvesting; a module for robots to follow individuals performing agricultural tasks; the upgrade of the AgRobPP and VineSlam modules with agriculture-relevant features; and the expansion of the AgIoT module features, improving the SmartTrap hardware's agricultural disease vector detection capability.

Responsible and Sustainable Technology Driven Innovation

This research challenge is concerned with the study and development of theories, methods and models to support technology enabled, sustainable innovation. With this purpose, the methods used in this challenge include conceptual development, qualitative methods, quantitative methods, action research and design science research. The main research topics addressed are: Innovation management and the front-end of innovation; Service design for technology enable service innovation; Design for transformation toward sustainable service ecosystems; Co-creation and citizen engagement with sustainable transition; Technology management and policy; Technology adoption and implementation; Value chain strategies for emerging technologies; Technology-based business model design and entrepreneurship; and Technology transfer and exploitation.

Among the 2021 scientific outcomes associated with this challenge, the following are worthy of note: three new frameworks were proposed for the Front End of Innovation, focusing on different stakeholder perspectives on investments, and on ontologies in technology commercialisation; the Journal of Innovation Management, which counts with an INESC TEC researcher as co-editor-in-chief, became indexed in Scopus in January 2021; creation of training courses for professionals to support industrial companies in digital transformation, and development of an immersive training platform, which aims to be the European reference marketplace for Augmented and Virtual Reality; and the publication of a book chapter on the "Challenges in Managing Large-Scale Collaborative R&D Projects", based on the institute's relevant experience in that area.

Industrial Information Systems Supporting Circularity and Sustainability

This research challenge aims to develop new concepts of information systems for industrial management, integrating emerging technologies and methods, aiming to support a sustainable transformation of industrial organisations. It also focuses on industrial data and information management models and systems addressing the challenges and opportunities of an industrial context characterised by data dependency and an intensive digital transformation. Furthermore, it pursues the design of theories to maximise the adoption and impact of new industrial information systems addressing the sustainability and circularity needs of industrial organisations, networks and chains. The research is conducted using, in particular, design science research, systems development methods and socio-technical systems design.

The main research topics addressed are: Digital enterprise architectures – Digital twin information models; Industrial reference models and architectures; IOT-based architectures; Industrial data & information management – Semantic information organisation & integration; Industrial data management (data spaces); Industrial data business models; and Design and impact of IIS – Design theory for industrial platforms; Industrial digital platforms adoption and impact; Socio-technical design theory.

The following scientific outcomes in the scope of the challenge are worthy of highlight: preliminary results on the exploration of the product digital-twin concept, both in the architectural and the data/information management dimensions; first steps towards a design theory for the development of digital-twin based architectures; a study of Horizon 2020 platform projects, with relevant insights for architecture design; and a study of the informational dimension of immersive systems and knowledge management for street lighting management.

4.3 COMPUTER SCIENCE

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

4.3.1 Presentation of the Scientific Domain

Computing became fully decentralised, mobile, increasingly ubiquitous, smarter and autonomous.

Current computer systems, especially in critical realms such as utilities, health care, transportation and finance, present new, and often unanticipated, sorts of risks that **defy our best practices of software engineering and human-computer interaction** and present hard and intricate **challenges associated to interoperability, scalability, security and criticality**. Computer systems in organizations account for over 10% of the global energy consumption and approximately 2% of global CO_2 emissions, which makes the sustainability of much of our innovation also a major challenge.

The ever-increasing data generated presents a never seen opportunity for real world artificial intelligence solutions to **filter, curate, store, process, query and visualise unprecedented volumes** of data from diverse sources and formats. However, complying with the demanding levels of **privacy and liability** poses enormous and novel challenges for software systems and their engineering.

Internally, the Domain structure has evolved to a logical organisation based on scientific domains, to better capture, involve and foster synergies among anyone doing basic or applied research in the domain's topics. Within the Computer Science domain, Research Lines gave way to a set of Research Challenges, further specified to enable a better assessment of our contributions towards each challenge.

While this evolution was not in full effect during 2021, this report already frames the achieved scientific outcomes within the new model.

Research in this domain is strategically focused on four main short- to medium-term challenges as described next. To this end, INESC TEC amasses a large group of researchers with competences in Artificial Intelligence, Computer Graphics, Cybersecurity, Human-Computer Interaction, Immersive Environments, Information Management, Information Systems, Mathematics of Computing, Parallel and Distributed Systems, Programming Languages, and Software Engineering.

4.3.2 Scientific outcomes in 2021

An overarching objective for the domain in 2021 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 was involved in organising several international events (conferences, workshops, webinars and tutorials): the 21st IEEE International Conference on Software Quality, Reliability, and Security (QRS 2021); the 13th Symposium on Search-Based Software Engineering (SSBSE 2021); the Agility with Microservices Programming (AMP 2021); the 14th International Conference on the Quality of Information and Communications Technology (QUATIC 2021); the 28th International Conference on Pattern Languages of Programs (PLoP 2021); the 22nd International Conference on Agile Software Development (XP 2021); the organization, as General and Local Chairs, of the 37th International Conference on Logic Programming (ICLP 2021), the most well-know and recognized international conference in Logic Programming (online event with 200 participants); the DSAA 2021, the core A conference on Data Science and Advanced Analytics; the International Conference of Innovative Technologies and Learning; REC2021, XVII Jornadas sobre Sistemas Reconfiguráveis; Text2Story2021, a workshop with 70 online participants; AI4Narratives at IJCAI; the ORSUM workshop at RecSys; new editions of the Data Streams track at ACM SAC 2021; the IoT Stream for Predictive Maintenance and SoGood workshops at ECML PKDD 2021; Linked Archives'21, a very successful international workshop (over 100 participants) with TPDL'21; four webinars as part of the BigHPC and AIDA projects (on Big Data, HPC, and 5G, edge computing and privacy); and one tutorial at a top international conference.

Jácome Cunha was elected as chair of the IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC) Steering Committee, a premier international forum for research on this topic.

A MSc student received a grant from the New Talents in Quantum Technologies programme, an initiative promoted by the Calouste Gulbenkian Foundation in 2021.

INESC TEC researchers were also awarded with second place in the 2021 Autopsy Module Development Contest, for detecting manipulated photos, namely deep fakes, splicing and copy-move manipulation types[2].

A continued effort has been to improve the average publication impact while increasingly targeting the very best venues. This means focusing on CORE A and A* conferences and Q1 journals. To this end, during 2020, researchers in this domain produced 88 (up from 59) Q1 journal papers, 20 (up from 16) CORE A and 4 (down from 5) CORE A* conference papers. These figures were mostly above 2020's. As a whole, in 2021, researchers in this domain published 136 (up from 114) papers in indexed journals and 170 (up from 147) papers in indexed conferences.

On the specific topics of the domain's research challenges we highlight the following outcomes. These were either published or made available to the community as software packages.

Computing systems to empower human capabilities

Within the European **Network of Excellence on Artificial Intelligence**, INESC TEC researchers have been involved in a few micro projects on semantic recommendation, AutoML and causal reasoning.

Research on **Large Scale ML**, **Auto ML** and **User Modeling and Natural Language Processing** accounted for 26 journal papers with publications at ECIR, SIGIR Forum, DSAA and the Computational Linguistics Journal. Ricardo Campos received the Vannevar Bush Best Paper Award at JCDL 2021. Bruno Veloso and Pedro Campos received best paper awards in two different events.

ImmuneML[3], a DSL for Machine Learning on the Immunology application domain, was published on Nature Machine Intelligence (Q1).

European project XPM (Chist-Era), on explainable predictive maintenance, was officially launched. Other contributions include a novel language for the generation of neural networks, with corresponding parameter and structure learning algorithms, and the development of sampling techniques for the evaluation of rare events. On immersive training, an authoring tool, able to integrate multisensory immersive environments, was developed to allow easy and intuitive training activities and a recommendation engine was developed to assist companies in deciding the best training approach. European project Feedback, including a gamification framework that helps companies reduce energy costs by promoting behaviour change in their collaborators, has concluded. In project Walking PAD (granted by NORTE2020, UE, FCT), the development of a virtual assistant is currently work in progress. Project Theia contributions include the implementation and validation of perception algorithms based on sensor data for smart mobility.

Methods and tools to boost the quality of future software systems

Alloy 6 was released, a new version of the popular formal specification language that incorporates major contributions from INESC TEC researchers in collaboration with ONERA, the French aerospace lab.

On compilers, contributions include the continued exploration of the generation of accelerator circuits from binary instruction traces for several instruction set architectures, analysis of memory access patterns based on dependency graphs, and source-to-source compilation. Also, a new approach for robust multi-language analysis was validated with a use case based on code metrics. On C/C++, advanced techniques for the application of memoization, detection of code vulnerabilities and restructuring of source code to a streaming paradigm, were explored. On reconfigurable computing, research on automatic restructuring of C code for HLS targeting FPGAs continued, including a viability analysis of using HLS for graph algorithms, in an HPC context, and automated hardware/software co-design, in an embedded context. Contributions to Prolog included stabilization, developments on a type system and Docker integration. Other contributions include a novel lock-free elastic design for a trie-based hash map that effectively improves search operations; a proof that under a given complexity-theoretic assumption, the best possible quantum speed-up is quadratic and thus that currently

[2] https://www.osdfcon.org/2021-event/2021-module-development-contest/
[3] https://immuneml.uio.no/

known quantum algorithms are the best possible; and the development of a static type system and type inference algorithm for polymorphic record calculus with extensible records, based on extensible types.

Two new FCT projects in fundamental research on formal methods were funded.

Performance, interoperability, and dependability of critical information systems

Contributions on novel storage solutions included SGX- and similarity-based deduplication[4] (Q1), optimizations for deep learning frameworks, realistic fault assessment and the implementation of block devices in user space. Projects PASTor and BigHPC, in collaboration with UT Austin, TACC, Hood College (USA), and AIST (Japan) have led to several papers, including one CORE A[5]. Ongoing work on leaderless state-machine replication led to another CORE A paper (EuroSys'21). Other contributions to transaction processing include: a novel isolation criterion for better performance and on-going work on polystores, namely by implementing generic and fine-grained transaction isolation. On the analysis of distributed systems, contributions focused on both content-aware tracing and black-box tracing. We highlight the acceptance of a new FCT funded project, on energy efficient networking, which will focus on fundamental research at low level TRLs. On interoperability, project InterConnect is ongoing, and project CircThread has officially started.

Trustworthy control of data confidentiality and provenance

We highlight the progress on the long term goal of deploying structures and cryptographic protocols whose security properties are formally proven, leading to three CORE A* papers[6] published at the ACM Conference on Computer and Communications Security (CCS), with key international partners, SRI International (USA) and the Max Planck Institute for Security and Privacy (Germany).

Other key contributions include the design and implementation of novel architectures using federated repositories, privacy-preserving mechanisms to support federated machine learning, and blockchain-based mechanisms for tracing data transformations. Other contributions on trust, privacy and security include: using secure enclaves for hardening cryptographic secrets and the Apache WebServer; a novel architecture for adaptive causal network coding; fault injection for distributed protocols (best paper at NSS'21); confidential sharing of information using encrypted search and a shared encrypted reverse-index; and an efficient, secure, distributed K-Means algorithm.

[4] https://doi.org/10.1109/TC.2020.2994774
[5] https://doi.org/10.1145/3464298.3493396
[6] https://doi.org/10.1145/3460120.3484548, https://doi.org/10.1145/3460120.3484567, https://doi.org/10.1145/3460120.3484771

4.4 POWER AND ANERGY

Coordinator: Luís Seca
Assistant to the Domain Coordinator: David Rua

4.4.1 Presentation of the Scientific Domain

The **Power and Energy (PE)** domain addresses INESC TEC scientific strategy in the Energy field, 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 System of the future requires the strong knowledge on the Power System operation and planning, a competence that is held by the researchers of CPES, that are the main anchor of this domain. 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.

Research activities within this domain are organised along five major applicational research challenges: Massive RES integration through power electronic-based interfaces, Large-scale modelling and optimization of energy systems, Data-driven methodologies for energy systems, Health Conditions of Electrical Assets under Smart Grid Operation and Cybersecurity and IoT for Electrical infrastructures.

4.4.2 Scientific outcomes in 2021

Massive RES integration through power electronic-based interfaces

During 2021, and contributing to this challenge, 27 journal papers were published, and 2 PhD and 17 MSc theses were successfully defended. The main scientific outcomes produced during 2021 were the following:

- Development of an approach for improving the dynamic security in islanded power systems based on the quantification of minimum synchronous inertia considering fault-induced frequency deviations – H2020 Smart4RES project.
- Advanced control strategies for improving fault ride through performance of smart power transformers feeding hybrid (AC/DC) microgrids. Published in *MDPI Energies* journal.
- Development of a methodology to define the best model and experiment design for battery parameter estimation. These models were tested as a state of charge estimator on a battery applied on an electric forklift. Published in *MDPI Energies*.

Large-scale modelling and optimization of energy systems

During 2021, and contributing to this challenge, 50 journal papers were published, and 2 PhD and 19 MSc theses were successfully defended. The main scientific outcomes produced during 2021 were the following:

- Novel two-stage Constructive Heuristic Algorithm (CHA) to handle integer investment variables in transmission network expansion planning, published in the *Electric Power Systems Research* journal.
- Development and testing of a conceptual model to detect and mitigate extreme losses in electrical distribution networks, namely as a consequence of the connection of large amounts of small generation units at this voltage level.
- Development of a functional model for quantifying consumption elasticity of the demand response (DR) contracted consumers. The model aims to determine the load adjustment the DR consumers can provide to the retailers or utilities for different price levels. This work was published in the *Energy and Buildings* journal.

Data-driven methodologies for energy systems

During 2021, and contributing to this challenge, 16 journal papers were published, and 2 PhD and 6 MSc theses were successfully defended. The main scientific outcomes produced during 2021 were the following:

- Development of novel federated learning and data markets algorithms for renewable energy time series forecasting, co-funded by H2020 Smart4RES project and VALOREM (seed project). The algorithms were published in two IEEE Trans. on Sustainable Energy papers and a mathematical analysis of the state-of-the-art methods published in the International Journal of Forecasting. A PhD thesis (Carla Gonçalves) about this topic was concluded in 2021, and an international patent application PCT/EP2021/080427 was made in November 2021. Moreover, the federated learning protocol was applied to distributed learning of sensitivity indices in low voltage electrical networks and the work accepted in PSCC 2022 conference.
- Participation in a peer-reviewed encyclopaedic journal paper titled “Forecasting: theory and practice” with more than 70 co-authors, 167 pages, covering all the topics in time series forecasting, published in *International Journal of Forecasting*.
- Development of two data-driven functions for smart alarm processing with two main goals: (i) identify the complexity of an occurrence in the distribution grid, (ii) provide fast advice to the human operator on how to solve it, which takes a sequence of alarm information from the occurrence and shows the operator which switch or OCR (Remote Cutting Organ) he needs to close or open, in order to locate the problem on the power line.
- Bid optimisation algorithms for multi-energy aggregators participation in electricity and gas markets were developed – published in *Applied Energy* journal. Methodologies to increase the observability over the gas network were developed, together with algorithms to optimise the injection of green hydrogen in the public network.

Health conditions of electrical assets under smart grid operation

During 2021, and contributing to this challenge, 2 journal papers were published. Being a RC that was identified only this year, there are still no major contributions beyond the presented publications. Considering the ongoing activity, we expect to have significant outcomes in 2022.

Cybersecurity and IOT for electrical infrastructures

During 2021, and contributing to this challenge, 5 journal papers and 3 papers in Conference/proceedings were published. Being a RC that was identified only this year, there are still no major contributions beyond the presented publications. Considering the ongoing activity, we expect to have significant outcomes in 2022.

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-Domain 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 TEC and support its innovation cycle and establish collaboration plans with some of them;
- Definition/alignment of the strategic agenda of each TEC4 and the creation of its advisory board;

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 5.3 to 5.7 present a short description of the scope and objectives of the current TEC4 initiatives and the main outcomes of 2021's activity.

5.2 Main achievements in 2021

The following table presents the most relevant KPIs of the activity of the TEC4s, in its various actions:

	TOTAL
COMPANIES MEETINGS/CONTACTS	651
NATIONAL COMPANIES MEETINGS/CONTACTS	480
New entities	190
Entities already existing in our database	290
INTERNATIONAL COMPANIES MEETINGS/CONTACTS	218
New entities	120
Entities already existing in our database	98
PROPOSALS (excluding PRR proposals/projects)	569
DIRECT CONTRACT SUBMITTED PROPOSALS	79
Single centre proposals	67
Inter centre proposals	12
INESC TEC Global value (K€)	2.842,55
DIRECT CONTRACT AWARDED PROPOSALS	49
Single centre proposals	38
Inter centre proposals	11
INESC TEC Global value (K€)	2.232,55
EUROPEAN PROGRAMS SUBMITTED PROPOSALS	55
Single centre proposals	29
Inter centre proposals	26
INESC TEC Global value (K€)	27.513,9
EUROPEAN PROGRAMS AWARDED PROPOSALS	12
Single centre proposals	7
Inter centre proposals	5
INESC TEC Global value (K€)	2.689,35
NATIONAL I&D SUBMITTED PROPOSALS	20
Single centre proposals	13
Inter centre proposals	7
INESC TEC Global value (K€)	2.666,3
NATIONAL I&D AWARDED PROPOSALS	11
Single centre proposals	6
Inter centre proposals	5
INESC TEC Global value (K€)	2.045,3
EVENTS PARTICIPATION/ORGANISATION (conferences, trade fairs, etc.)	251
ACTIVITY WITH OTHER INSTITUTIONS (Clusters, CoLABs, PPPs, etc.)	214
INTERNAL MEETINGS	215
OTHER INITIATIVES (internal and external)	194

5.3 TEC4AGRO-FOOD

Business Developer: André Sá

5.3.1 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 digital technologies and robotics, for the creation of long-term value for INESC TEC from customers, markets, and relationships. TEC4AGRO-FOOD's vision is to become a relevant international player, regarding research and technological development in digital technologies and robotics for agro-food and forestry.

TECAGRO-FOOD's application areas are smart (digitalisation) precision ("right time, right amount, right place") agriculture and forestry, food security and bioeconomy.

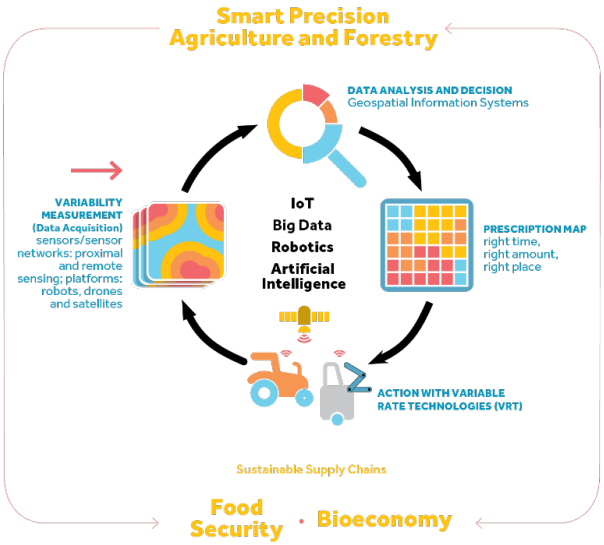


Figure 5.3.1 - Precision Agriculture/Forestry Action Cycle

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.

5.3.2 Main achievements in 2021

Following the strategy of full implementation of portfolio projects and redoubling efforts with companies and at international level, in 2021 TEC4AGRO-FOOD continued its consolidation as the main national research and technological development partner in the scope of digital technologies and robotics for agro-food and forestry. At the same time, at European level, TEC4AGRO-FOOD has reached a sustainable position regarding research and innovation programmes, namely H2020 and HEurope. Should also be highlighted the increased visibility (press, events, etc.) and the contribution to the public policies (RIS3 and CoLABs - INESC TEC participates in 4 CoLABs in the scope of TEC4AGRO-FOOD).

TEC4AGRO-FOOD's main achievements in 2021 are present below:

- National R&D - Co-Promotion Projects - **approval SMARTCUT** (111,4k€; CRIIS and HumanISE (CSIG in 2021)), **SPIN** (96,1k€; CRIIS) and **SMARTDRYING** (177,0k€; CRIIS);
- **Approval SpecTOM_BIPProof2020** (BIP PROOF; 10,0k€; CAP and SAL);
- Award of contract CholdaDigital (46,0k€; HumanISE (CSIG in 2021) and CTM);
- **Signature of Collaboration Protocol with Sograpе Vinhos** for testing, demonstrations and experimentation of robotic and IoT prototype systems in viticulture operational environment;
- **Approval 2nd Stage PRYSM** (European R&D - H2020; 48,0k€; CRIIS);
- European R&D - H2020 - European Green Deal Call - **approval FIRE-RES** (781,4k€; CITE, C-BER and CEGI) and **FIRELOGUE** (120,3k€; CRAS);
- Release of TEC4AGRO-FOOD´s video for Tech 3 (RTP3);
- Co-organisation of Workshop "Enhancing science-based knowledge on EU forests - its influence in decision making" (INESC Brussels HUB Annual Event);
- Co-organisation of the European Event Agriculture 4.0 - Driving Sustainability for the European Wine Sector (ADVID COLAB VINES&WINES);
- Co-organisation of AgroIN 2021 (INESC TEC RTD Partner);
- **Approval MyNPK** (INESC TEC Seed Project Contest 2021; 12,0k€; CAP and CRIIS);
- National R&D - Co-Promotion Projects for Inland Territories - **approval AgWearCare** (78,4k€; C-BER and LIAAD) and **InOlive** (163,3k€; HumanISE (CSIG in 2021) and CRIIS);
- National R&D - FCT - **approval OmicBots** (123,0k€; CRIIS and CAP) and **BeFresh** (239,1k€; CEGI);
- **Signature of Memorandum of Understanding Climate Action** (National Competence Centre for Climate Change in the Agroforestry Sector (CNCACSA));
- **Participation** at Agro-Inov (Technology Pavilion) **in AgroGlobal 2021**;
- Membership in Living Lab Agrotech 4.0;
- Selection for finalists of the Prémio Crédito Agrícola 2021 of the projects SpecTOM and Smart Trap.
- **Approval SFT-EDIH** (Recognition of Digital Innovation Hubs and access to the European Network; CRIIS);
- National R&D - 1st Stage Contest of Ideas Agendas of the Recovery and Resilience Plan - **approval Vine and Wine PT** (1,2M€; CRIIS), **transForm** (1,7M€; CESE, CRIIS, HumanISE (CSIG in 2021), CEGI, CITE e CAP), **OESTEFRUTA4.0** (4,0M€; CRIIS, CAP e CESE) and **InsectERA** (1,4M€; CRIIS, CESE and CEGI);
- **Signature of Collaboration Protocol with National Fruit Growing Station Vieira Natividade (INIAV)** for testing, demonstrations and experimentation of robotic and IoT prototype systems in fruit growing operational environment;
- Delivery of Context Analysis Report of TEC4AGRO-FOOD's Strategic Plan.

5.4 TEC4ENERGY

Coordinator: João Peças Lopes

Business Developer: Nuno Campos

5.4.1 TEC4ENERGY Presentation

TEC4ENERGY is INESC TEC's initiative towards a Decarbonised Economy, aiming to stimulate energy related industries and partners to overcome the main future challenges in this domain. TEC4ENERGY brings together R&D&I Institutions, businesses and associations, increasing synergies and critical mass.

TEC4ENERGY monitors INESC TEC's R&D results, in all the TRL (Technology Readiness Levels) spectrum, potentiating a market-pull valorisation focused on applied research that can lead to products, processes and services transferable to all the energy sector actors.

To accomplish this, TEC4ENERGY aims to explore the activities within the energy sector where business/technology necessities/limitations demonstrate a high potential for applying INESC TEC's competences, resources and experience in order to accomplish successful projects, contracts and technology/knowledge transfer, fostering transformation towards a decarbonised economy. The main types of collaboration between TEC4ENERGY and the industry are advanced consultancy services, contract-based R&D and strategic partnerships, promoted both at a national and international levels.

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 Europe and Brazil. This adds credibility to a broader effort on harvesting projects in the energy domain dealing also with challenges in industry, transportation and buildings.

TEC4ENERGY develops solutions that contribute for the Societal Challenges and Innovation Strategies for Smart Specialisation defined by EU policies. The energy sector is increasingly more 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 identifies new potential projects with the industry and the society, through a multidisciplinary scientific based approach to overcome the limitations that stakeholders find in the existing market solutions, conveying these projects for further development to the Centres closer to the technological requirements.

TEC4ENERGY impacts INESC TEC activity by fostering the generation of new contract programs and specific projects joining in this response different Centres of the institution.

5.4.2 Main achievements in 2021

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 in the Energy domain and related fields, 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, 2021 was a consistent year in what regards to new flagship projects. It can be highlighted the approved European funded projects *GREENH2ATLANTIC (H2020)*, *MAGPIE (H2020)*, *Asprela + Sustentável (EEA Grants)*, representing a total revenue of 1,44 M€ where TEC4Energy played a relevant role. In 2021 there was also the materialisation of two important National funded projects, *Sustainable HPC (Fundo de Eficiência Energética & Fundo de Apoio à Inovação)* and *SmartGlow (PT2020 - Co-promoção)*, with an accumulated revenue of 740 k€.

TEC4ENERGY has also made a considerable effort fostering direct R&D and consultancy contracts, in the national and international panorama, contributing to the energy transition, to the decarbonisation of the society and to the digitisation of the national and international energy sector.

In 2021, 43 national direct R&D contract proposals were submitted to the energy sector (25 of which successfully approved and 17 still waiting for decision). These national direct R&D contract proposals amounted to 1,35 M€. The 27 approved projects lead to an income of more than 754 k€.

At an international dimension it was leveraged the emergence of some direct R&D and consultancy proposals such as *PV_Karavasta (Voltalia, Albania)*, *CleanEU_Island (3E, Belgium)* and *Helas_ExtremeRES (HEDNO, Greece)*, that constitutes a total of 118 k€.

Finally, TEC4ENERGY promoted two important Contract Programs with FINERGE and Mota-Engil Renewing, embodying a long-term collaborative relationship with these promising institutions of the energy sector, and have participated, with an exhibition stand, in ENLIT 2021 - the largest and most complete event for the international energy sector, showing INESC TEC's latest technologies for the sector.

In total, TEC4Energy successfully leverage in 2021 a set of national and EU funded projects that will lead to a total of expected income for INESC TEC in the amount of 2.934 k€.

5.5 TEC4HEALTH

Coordinator: Miguel Coimbra

Business Developer: Carlos A. Ferreira

5.5.1 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 (breast, lung, colorectal, stomach, uteri and esophagus), disease prevention/screening (chronic, disabilities and ageing) and neuro diseases (epilepsy, depression, Parkinson, Alzheimer and autism). INESC TEC's innovation services in artificial intelligence, biomedical instrumentation, information systems, medical robotics, health management and public policies 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), CBER (Biomedical Engineering Research), CEGI (Management and Industrial Engineering), CITE (Innovation, Technology and Entrepreneurship), CTM (Telecommunications and Multimedia), HumanISE (Human-Centred Computing and Information Science; CSIG in 2021) and LIAAD (Artificial Intelligence and Decision Support).

5.5.2 Main achievements in 2021

With the reformulation of the TEC4 structure at the end of 2019, 2020 was mainly a year to better perceive the ideal internal and external positioning, and in 2021 it was already possible to promote and somehow grow the health technologies area at INESC TEC.

Thinking and described below, the activity of a TEC4 can be summarised in three main achievements: **internal** - with dissemination, brainstorming, mentoring and development of activities and beneficial practices; **external** - knowing the state of the art, meeting with established and new partners, being represented at events and in clusters and looking for new partnerships; coming as the last part the realisation of **projects**.

Internal:

- Contact points: Promotion of regular meetings between contact points of the different Centres for the discussion of relevant topics and project submissions in the health technology area;
- New subsectors: Characterisation, search and presentation of new opportunities in the social, sports, dental, pharmacy and pharmaceutical sectors;
- Production of the health technology sector intelligence report;
- TEC4 materials: Preparation of the TECH4Health brochure and presentation video (TECH3 program);
- Participation in the WG of Health Technologies of the INESC Brussels Hub: participation in meetings to prepare a strategic roadmap for the next 10 years, co-organisation of the Winter Meeting, lead of "The Insider" podcast about point of care ultrasound and production of an article about the Cancer Mission (Science Business).

External:

- Organisation of the Autumn Forum on artificial intelligence and health: challenges and opportunities.
- Hospitals: Consolidation of relations with some of the main hospitals in the northern region of Portugal, namely the Centro Hospitalar Universitário de São João (CHUSJ), IPO Porto and Centro Hospitalar Vila Nova Gaia/Espinho (CHVNG/E). In the case of CHUSJ, a collaboration protocol was also established and signed so that cooperation could be as profitable as possible;
- Companies: new strong connections in dental clinics, sports analytics, providers of health information systems, packaging and health outcomes;
- Representing INESC TEC: Health Cluster Portugal general assemblies, EUGLOH events, AICIB clarification sessions, EARTO health WG, eHealth Summit and CCDR-N workshops;
- Promoting INESC TEC: MEDICA fair, Doing Business Networking event (Scale UP Porto), B2B Health Innovation Market (ANI), Tech-Brokerage Norte de Portugal – Galicia (ANI), eHealth Match 2021 (EU), Bio Speed Dating (Bioga) and Horizon Europe Brokerage Event 2022 (EU);
- Participation in the consultation and review of the European Commission's funding programmes: Horizon Europe (2023-2024), EU4Health and ERA4Health.

Projects:

- National: i) Match contacts and needs with competences within the institution so that several submissions of national projects with different national entities emerged, ii) mediation of INESC TEC's intervention in mobilizing health agendas (PRR);
- European: Dissemination of information, support in the preparation of proposals and presentation of missing partners in order to increase the quality of applications submitted by different researchers to European Commission programs (*i.e.* Horizon Europa, EIC and EIT Health);
- Other projects: R&D consultancy proposals (as was the case with Promptly), preparation for participation in the AgeTech CoLAB and Health Digital Innovation Hub.

Although 2021 was a year of growth, there is still some difficulty in establishing R&D projects with companies, perhaps due to the uncertainty caused by the covid-19 pandemic, the bets are not in that direction, there is complementary internal competence or strong external competition.

5.6 TEC4INDUSTRY

Coordinator: Américo Azevedo

Business Developer: António Almeida

5.6.1 TEC4INDUSTRY Presentation

TEC4INDUSTRY has the objective to leverage the science-based cross-sectoral innovation by promoting new added-value interactions and partnerships between INESC TEC and the industry, and INESC TEC and these new consultancy and technology companies, towards a more competitive and sovereign national industrial ecosystem.

In this sense, the TEC4Industry presents a double role, both internally within the INESC TEC ecosystem and externally for the national industrial ecosystem. At the internal level, the TEC4INDUSTRY must perform as the INESC TEC driver for added-value science-based research, promoting vision alignment between the 13 research centres and the industry needs. Externally, the Tec4Industry promotes a more vital national industrial ecosystem composed of added-value industrial companies and disruptive and unique technologies and consultancy companies.

5.6.2 Main achievements in 2021

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

PRR Initiatives

The TEC4Industry was very active during 2021 in the preparation and setup of the different project ideas to be submitted in the first phase of the PRR, mainly in the bioeconomy and industry calls. Mainly in the bioeconomy call the TEC4Industry participated in the setup of the shoe initiative. In the Industry call the TEC4INDUSTRY actively participated in the setup of different project ideas: Produtech agenda for advanced production systems, CITEVE agenda for digitalisation of industrial processes and water consumption, CTCP agenda for shoe industry digitalisation, Galp agenda for lithium factory design, VW Autoeuropa agenda for drones and augmented reality implementation in automotive industry, BlueOcean agenda for the digitalisation of the Sonae fish factory, Port of Sines for the development of the logistics platform, and the Neuroplast agenda for sustainable plastics.

European Projects

At a European level, the TEC4INDUSTRY was also very active in Horizon Europe and EIT Manufacturing proposals setup and submission, in connection with different Centres. Related to the EIT-Manufacturing, the TEC4INDUSTRY supported not only education projects from EIT Manufacturing (e.g. Redvile), also submitted three proposals for innovation projects with one successful for 2022. In terms of European projects, the TEC4INDUSTRY supported and promoted participation in 7 proposals, where INESC TEC was leader in four. Moreover, supported the submission of different open calls, mainly related with Galactica and Change2Twin European projects.

National Projects

At a national level, TEC4INDUSTRY also provided an important contribution to promote R&D projects with national companies. In partnership with Farfetch, a strategic proposal was submitted in the logistics and artificial intelligence domain. Moreover, the SIAC and P2020 proposals submitted in 2021 in partnership with national companies and industrial associations, including VW Autoeuropa and industrial associations from Oliveira de Azeméis and Santa Maria da Feira were tracked and monitored to be successfully accepted during 2022. Also, three different service proposals were submitted to MOBIVOV for the development of the Observatory for the Automotive Sector, as well as to Herculano, Aquinos, Fraunhofer Portugal, Adega Cooperativa de Ponte Lima, Novarroz for digital maturity assessment.

Advanced Training in Industry

Following the advanced training strategy initiated in 2020 with the production and development of the COTEC e-learning course in Industry 4.0 and the Redvile project, during 2021 the TEC4INDUSTRY was active preparing the 2nd edition of the Industry 4.0 advanced training course with INEGI, and initiated the conversations with KAIZEN to deliver a special course in Industry 4.0, customised to their specific needs. Moreover, the TEC4INDUSTRY team has been working with the iiLab team to define and setup a strategy for hands-on training in the laboratory.

INESC TEC Promotion

In terms of INESC TEC services promotion, TEC4INDUSTRY was very active in the preparation and release of the 2nd INESC TEC journal dedicated to Industry, and actively supported the preparation of the 3rd edition with the writing of a section dedicated to 5G in Industry. Moreover, the TEC4INDUSTRY was also active in the preparation of the INESC TEC participation in EMAF 2021. Also, the TEC4INDUSTRY team participated in different events for INESC TEC promotion, such as the EU project Galactica webinar, 23rd Congress in logistics, organised by APLOG, as moderated and speaker, participation in bizFeira about the future of the economy after COVID pandemic, participation in event Industry 4.0 organised by Rotary Club from S. João da Madeira. Finally, the TEC4INDUSTRY team supported the development of promotional videos for the TECH3.

New Companies Leads

2021 was a fruitful year in terms of leads creation, with interaction with more than 55 companies, in several industrial sectors and related supplier and service sectors.

5.7 TEC4SEA

Coordinator: Eduardo Silva

Business Developer: Carlos Pinho

Communication, dissemination and continuous engagement: Ana Paula Lima

5.7.1 TEC4SEA Presentation

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

TEC4SEA is the INESC TEC initiative that brings together R&D&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, who 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; 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 customised 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.

5.7.2 Main achievements in 2021

Although in a lower level than last year, Covid-19 had a negative effect in the milestones and objectives proposed for 2021. These impacts were more significant in regard to “external” (stakeholders outside INESC TEC) ambition than “internal” (core teams of INESC TEC). Nevertheless, TEC4SEA managed to achieve most of the goals set for 2021, as listed below:

Internal:

- Continue the consolidation of a work team bridging and articulating the Centres and the TEC4SEA towards common objectives, actions, and initiatives.
- Creation of a Sea Economy awareness report with the landscape characterisation that impacts INESC TEC activities. INESC TEC’s positioning and strategy analysis.

- Internal alignment and engagement towards a 1st phase action plan on the Horizon Europe.

External:

- Conclusion of Due Diligence to the CEO – Companhia da Energia Oceânica. Considerable developments on the dynamization and valorisation of Aguçadoura's test zone, supported on a sustainability plan (economic and R&D+I initiatives). Manifestation of interest to the RNIE.
- The relation with core players was strengthened: Fórum Oceano, CIIMAR, Air Centre, INEGI, United Nations, Instituto Hidrográfico, Portuguese Navy, etc. Contacts with Galician entities were made to resume topics of common interest. Additional international relations were strengthened, specifically with partners in Europe, South Korea, USA and India.
- Several new contacts, with national research institutions and industries, to define synergies and identify possible collaborations were made: Aquiculture from Viana do Castelo, Aquazor, etc. New international contacts included: Oceanpowerparks, Mobifly, Symphony, Crestwing, Pôle Mer Bretagne Atlantique.
- Consolidation of the network of contacts, strengthening and revealing our initiatives and promoting INESC TEC name (5th REP(MUS)21 REA Warfare Group, Oceans'21 - Global, United Nations “A Brave New Ocean” & “Science & Technology capabilities (II) for the Satellite UN activity Remote Sensing and Smart Tech for Marine Litter”, Digital Workshop "Space for Cultural Heritage", World Ocean Summit (The Economist), Atlantic PDR (ESA), Vanguard Initiative Regional Conference - New growth of industrial regions through Smart Specialisation, Ocean Week 2021, “Addressing global challenges through collaboration in science, technology and innovation: The case for marine renewable energies.”, “Tech-Brokerage Norte de Portugal-Galiza”, Seminário da Associação Portuguesa de Aquacultores, Air Centre Networking Fridays, RAW MATERIALS SUMMIT 2021, “Offshore I&M: Towards Automation Through Advanced Perception and Heterogeneous Robots”, Marine Minerals (GCE Ocean Technology), 8th Atlantic Stakeholder Platform Conference, among others.
- The Participation in Business2Sea 2021 was once more very active, strengthening our relations with Forum Ocean and Galician stakeholders, through the co-organisation of the session “An offshore Atlantic test site to boost Blue Economy technologies” and oral participation.
- Tec4Sea participated with a booth in two events: “Explorers Club's Global Exploration Summit (GLEX) 2021 – Lisbon and Aquaculture Europe 2021 – Madeira.
- 2021 edition of the workshop “InTheBlack” was a hybrid event at Brussels with collaboration of INESC Brussels Hub. TEC4SEA organised and participated actively on the event focused on “Impact assessment for future exploitation of underwater minerals”. With 100+ registrations it was followed by a hybrid Portuguese Raw Materials Week at Porto, also organised by Tec4Sea.
- Identification opportunities, strategy definition, articulation with INESC TEC centres and external stakeholders and support for several project submissions: 1 Xkic (~137k€), 2 EEA Grants (~400k€); 1 KAVA call8 (~140k€), 1 Teaming (30M€), 1 Atlantic Area (~80k), 1 H.E. Wave Energy (~2,5M€), 7 PRR (~8,5M€) and one Blue Hub (~5,5M€).
- Submission of contributions to the “Navy Operational Experimentation Centre”.
- Formalisation of the association to +Atlantic CoLAB;
- Renovation of the Tec4Sea Infrastructure website to be prepared to offer services to the ecosystem, namely the research vessel “Mar Profundo”.

5.8 TECPARTNERSHIPS

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

5.8.1 TECPARTNERSHIPS Presentation

Our mission is 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. The viability and sustainability of the sectors being explored will allow for eventual transformation into a TEC4 specific to the respective sector or integration into one of the existing ones. The following markets were exploit:

Internet Market: Reviewing this sector of activity in terms of market positioning. Targeting the most interesting market segments and review institution's research lines. Focus on offer based in INESC TEC skills on IA and Computer Vision.

Financial: Currently in a restructuring period due to the entry of new players and the need to digitize by exploiting the data belonging to them. Activity in these sectors based on advisory on IT architectures, AI, Blockchain and Computer Vision technologies.

Construction: Sector in a digitalisation process, INESC TEC will offer process planning, digital automation, energetic efficiency evaluation and AI. Development of training environments in digital technologies using Augmented Reality and Virtual Reality.

Space: Promotion of INESC TEC's relevant competences among national and European partners, aiming at becoming a relevant partner in future initiatives, particularly PRR. Networking activities via EARTO's Space WG, AED Cluster Space Commission and sectorial events.

Defence: Internal promotion of new European Defence Fund R&D program and matchmaking with international relevant partners targeting consortia participation / supply chain entry. Networking activities via EARTO's SD WG, AED Cluster Defence Commission and sectorial events.

Public Administration: Under strong digital transformation process. First approaches to apply INESC TEC competences in municipalities.

Mobility: Diverse market, with several branches: aeronautical, rail, ports and road. Exploitation of national and EU opportunities via AED Cluster Aeronautical Commission, Rail Cluster, APDL and municipalities.

5.8.2 Main achievements in 2021

The COVID-19 pandemic continued to restrict all in person activities during 2021. Nevertheless, it was possible to participate in the QSP SUMMIT a conference/fair dedicated do enterprise management and marketing. Market strategic plans documents to Construction and Internet sectors were revised in order to incorporate the pandemic effects and the lessons learned.

The action plans define in the Market strategic documents were followed, limited by the pandemic situation. We expect to be able to implement all planned actions in 2022.

Strategic work of global analysis of companies with the capacity to be technology takers was fulfilled. In this context, a list was established (more 1000 companies analysed) by district/ranking turnover (limited to 300k€), of companies with the CAE 62 (Information services activities) and CAE 71120 (testing and technical analysis activities).

Companies with interest in the areas under analysis were classified, with a small description of the areas of intervention, identification of the contacts of most relevant CEOs and directors.

To promote INESC TEC activities related with these new sectors, exploring the list before described, 112 meetings were promoted with national enterprises and associations, of which 71 with new ones. Also were realised 40 meetings with international entities of which 37 were new ones.

In 2021, the most relevant achievements were:

Internet Market

Participation in QSP Summit 2021 with a stand and demonstrations of Augmented Reality and Computer Vision solutions as examples how INESC TEC can contribute to improve the consumer experience.

- Various proposals in preparation (direct contract).

Construction sector

Mobilizing project REV@CONSTRUCTION led by Teixeira Duarte began its activities.

- BUILT COLAB had first meetings with INESC TEC participating in the Board of Directors.
- DIGITALbuit: Approved the national Digital Innovation Hub for the Construction and railroad sectors, with the participation of sector clusters.
- Approved the idea proposal for the Innovation Agenda “Re-industrialisation of the construction sector”, led by Mota-Engil.

Financial Sector

Reinforcement of the partnership with Banco MONTEPIO, with new proposals and direct contract.

- First direct contract with Banco Carregosa, via the Cool Link (IT company that belong the bank).
- Proposals under discussion to various Fintech companies (direct contracts).

Space

- Reinforcement of INESC TEC’s role in NEWSAT project after withdrawal of one partner.
- Participation in one of PRR’s Space selected initiatives (Agenda New Space Portugal).

Public Administration and Mobility

- Two projects with Quadrilátero Urbano addressing mobility platforms and associated data interoperability.
- Membership of national Rail Cluster (PFP).

CRM

- Specification, development and trials (inside TEC4) of CRM solution.

WebSite TEC4s

- Benchmarking with relevant websites, content specification and validation of mockup.

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 working on scientific and technological challenges in telecommunications, computer vision, and multimedia. CTM is fully committed to 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 2021, CTM accomplished its mission, within the NIS scientific domain, by directing its activities towards 4 main areas of research: Optical and Electronic Technologies (OET); Wireless Networks (WiN); Multimedia and Communications Technologies (MCT); Visual Computing and Machine Intelligence (VCMI). CTM contributed to research in neuromorphic computing and planar antenna array design for sub-THz communications as well as in wireless communications for dynamic and extreme scenarios. The CTM's expertise in machine learning and audio-visual 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 and over the content.

6.1.2 Research Outcomes in 2021

The main broad research achievements obtained by **CTM in 2021** were:

- 40+ articles published in relevant scientific journals, more than 80% of them in journals classified by SCOPUS as "1st Quartile" and "2nd Quartile";
- 5 PhD theses and 50+ MSc theses successfully defended;
- Organisation of the 2021 Joint EuCNC and 6G Summit, a flagship conference sponsored by the European Commission;
- Editing of the 3rd Issue of Science & Society Magazine devoted to “Beyond 5G Communications”;
- CTM Open Day 2021, including international keynotes on Neuromorphic Photonic Computing and Edge Artificial Intelligence, and CTM Summer Internships with 39 students conducting a short-term R&D project.

The main achievements obtained by the **OET Area in 2021** were the following:

- **Method for modelling interface-type amorphous oxide semiconductor resistive switching** by using neural networks capable of simulating dynamic systems, a key step for neuromorphic computing.
- **Method for designing an efficient 300 GHz planar antenna on III-V substrates**, suitable for a true time delay microwave photonics based sub-THz transceiver with wide scanning angle.

The main research achievements obtained by the **WiN Area in 2021** were the following:

- **Traffic-aware placement algorithms for aerial networks** that enable significant performance gains (higher throughput, lower delay) when compared to state-of-the-art counterparts.
- **Simulation platform for underwater communications** enabling faster evaluation of underwater data muling oriented communications solutions and offline replication of real-world experiments.

The main research achievements obtained by the **MCT Area in 2021** were the following:

- **Activity and emotion recognition in shared vehicles** based on a strategy for efficient multimodal approach and the assessment of the impact of different types of visual noise in the obtained models.
- **High-level harmonic descriptors of semantic value for music information retrieval and musicological analysis** that can support many applications for musical analysis and retrieval (e.g., music recommendation and auto-tagging).

The main research achievements obtained by the **VCMI Area in 2021** were the following:

- **Achieving Cancelability and Non-Linkability in End-to-End Deep Biometrics**, based on the Secure Triplet Loss, focused on template cancelability, which was reformulated to address the problem of template linkability on biometric verification and face images.
- **Deep Signer-Invariant Representations for Sign Language Recognition**, a novel end-to-end deep neural network that explicitly models highly discriminative signer-independent latent representations from the input data.
- **Privacy-Preserving Generative Adversarial Network** for Case-Based Explainability in Medical Image Analysis**.**

6.1.3 Innovation Outcomes in 2021

The main broad innovation achievements obtained by **CTM in 2021** were the following:

- CTM researchers organised one advanced training course that took place in virtual format;
- Easy Ride final demonstration on activity and emotion recognition in shared vehicles;
- Ten direct contracts with national and multinational companies.

The innovation achievements obtained by the **OET Area in 2021** were the following:

- **Improved BLE indoor localisation solution for asset tracking in warehouses.** In partnership with a telecommunications company, a direction-finding Bluetooth Low Energy 5.1 based 8-antenna receiver was designed and implemented, and its operation was validated in an anechoic chamber.
- **Simulation framework for assessing antenna arrays with digital beamforming.** Tool developed in partnership with an antenna manufacturer company, which allows for the evaluation of an antenna array performance in the context of satellite communications systems.

The main innovation achievements obtained by the **WiN Area in 2021** were the following:

- **Communications Solution for Supporting the Digitalisation of a Farm**, in partnership with a national company for remote monitoring environmental and production-related parameters and controlling farming systems. This real-time monitoring and control leverage the implementation of precision agriculture techniques, lowering the production costs and the resulting carbon footprint.
- **5G-based Wireless Communications for Utilities**. A study was developed in partnership with an electric utility for assessing the suitability of 5G for supporting their operation, including smart metering and related applications within the use cases of an electric utility.

The main innovation achievements obtained by the **MCT Area in 2021** were the following:

- **A multimodal optimisation music mashup creation model for loop recombination at scale.** The solution enables tackling current scalability limitations in state-of-the-art models while enforcing the compatibility of audio loops and a pool of diverse solutions that can accommodate personal user preferences or promote different musical styles.

- **Framework for automatically detecting advertisements in television broadcasting content**. A flexible tool for processing TV broadcasting content, aiming at detecting channel logos and identifying advertising segments, without using prior data about the channel or content.

The main innovation achievements obtained by the **VCMI Area in 2021** were the following:

- **Advanced knowledge and technology for innovative intelligent mobility solutions.** We proposed using a wide array of sensors to characterise the emotional states of autonomous shared vehicle occupants, detecting and preventing unwanted behaviours (e.g. violence) while recognising in real-time the occupants' actions, emotions, and well-being.
- **Computer software to support the preoperative planning of patients proposed for breast reconstruction with a DIEP flap.** Tool used in the daily routine clinic that simplifies the work of health professionals and provides better outcomes to patients.
- **Software for manipulating 3D models of lower limb prosthesis.** Parametric model-based software for point clouds of prosthesis from lower limbs.

6.1.4 Activity Overview

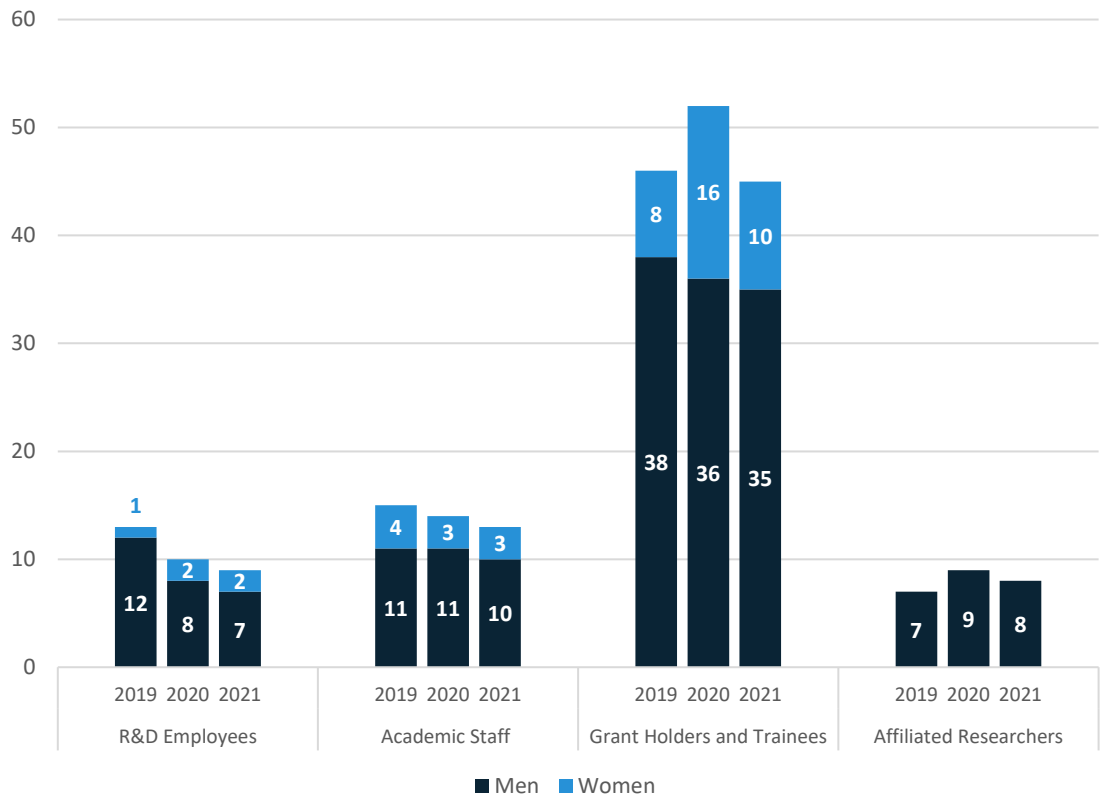


Figure 6.1.1 - CTM - Research team evolution

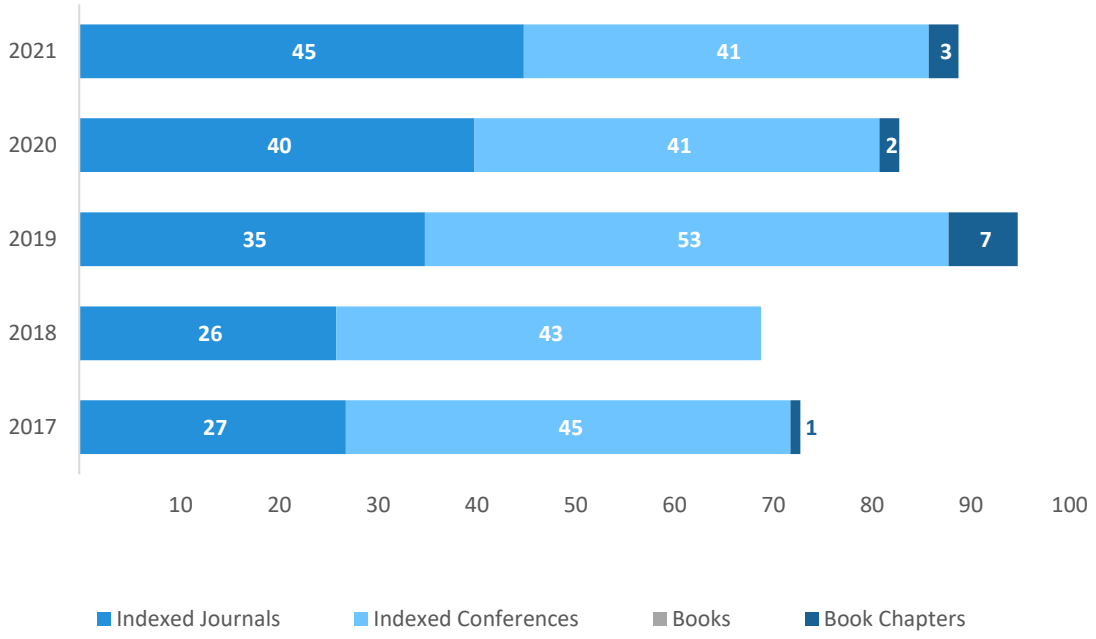


Figure 6.1.2 - CTM - Evolution of publications by members of the Centre

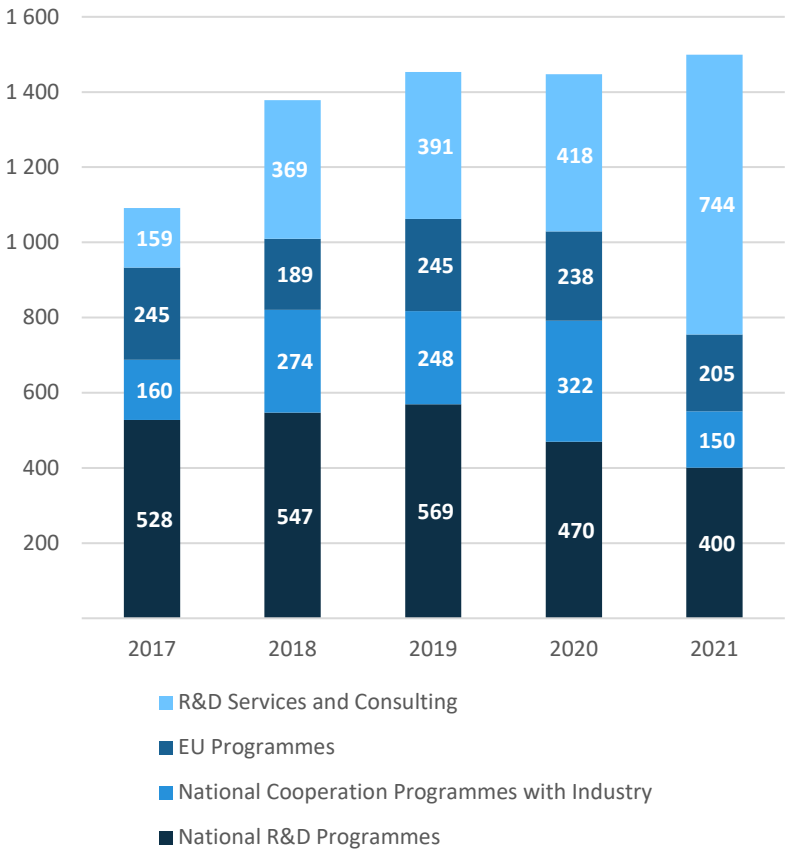


Figure 6.1.3 - CTM - Project funding evolution (k€)

6.2 CAP - CENTRE FOR APPLIED PHOTONICS

Coordinators: Paulo Marques and Ireneu Dias

6.2.1 Presentation of the Centre

CAP accomplishes its mission 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. CAP members (professors and invited professors) are involved in the experimental teaching on optics and microfabrication. They are also 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 2021

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 fibre tapers.

One important aspect on optofluidics is the fabrication of monolithic microfluidics channels, as opposed to glass channels with a PDMS cover layer. The achievement of monolithic fabrication is not easily achieved since multiple access holes have to be fabricated in order to allow the acid to penetrate through these multiple holes, therefore achieving uniform structures. Some of these multiple holes have to be blocked at a later stage. To have monolithic fabrication the recipes to glass-to-glass welding were determined. Suitable recipes for silica-silica or silica-soda lime welding were determined and the mechanical resistance of the welding substrates were determined.

Physical sensors

Raman Spectroscopy. The fibre Raman endoscope was characterised and is currently being tested in terms of performance. Several biological tissues with neoplasia, 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 fibre-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

A method for fast classification of cells and microparticles was developed using optical tweezers systems, equipped with position sensitive quadrant photodetectors and advanced signal processing applied in the frequency domain. Single particles and cells could be discriminated with high accuracy in less than 500 ms, paving the way for automated real time cell classification and handling.

Advanced signal processing and analysis were implemented enabling to unscramble spectral interference and matrix effects in Vitis vinifera Vis-NIR spectroscopy, paving the way to the quantification of non-dominant absorbance constituents (glucose, fructose, tartaric, and malic acids) with analytical precision 'in-vivo', opening the possibility of real-time and high-throughput metabolomics and plant physiology in precision agriculture.

Optimisation of a sputtering deposition system to the development of new optical sensing structures based on different types of surface waves (eg. SPR and Bloch) to achieve high sensitivity and resolution. These sensing structures are made from high quality thin films of special materials produced on steady planar substrates and around rotary optical fibres to be used in different applications.

Development and full characterisation of gold and silver nanoparticles with a wide range of sizes and shapes, with resonances at telecom wavelengths, to be used in optical fibres to the development of optical sensors for biological applications.

Development of new methodologies to measure optical properties of liquids and solids including the polymers curing process monitoring in real-time. This can be applied in a wide range of applications using a single optical fibre.

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 nanometres, 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:

- Design, simulation, fabrication and testing of metal-dielectric structures and new metamaterials for optical sensing based on nano-plasmonics and nano-structured optical material (development of Hydrogen sensors).
- Implementation of laboratory infrastructures and setup conducing toward the experimental implementation of optical analogues, quantum fluids of light and optical computing using the paradigm of reservoir computing.
- Develop of control toolbox to control the spatial light modulator (model) and light pattern acquisition. This toolbox is instrumental to control continuous-wave laser beams and an assisting incoherent pump field, it is shown how these media can provide an excellent framework to experimentally explore 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 2021

- Improved numerical models and codes for light-matter interaction in regimes out of equilibrium, with emphasis on solver of Generalised Nonlinear Schrödinger equation.
- Develop of control toolbox to control the spatial light modulator (model) and light pattern acquisition. This toolbox is instrumental to control continuous-wave laser beams and an assisting incoherent pump field, it is shown how these media can provide an excellent framework to experimentally explore 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.
- A software toolkit was developed to assist advanced LIBS system in demanding applications. A modular set of control and analysis software, including optimised adaptative mapping routines, were developed. These tools can be easily adapted to new systems, enabling fast prototyping of LIBS system for field applications, such a mineral analysis in mining, soil analysis and other.
- A modular sensing system was set up to evaluate the health of concrete structures by looking inside the structure using single optical fibres to monitor the levels of humidity, CO2 and the carbonatation processes due to the atmospheric CO2.
- An optimised multiplexing low-cost optical interrogation system was developed to read long period fibre gratings, Fabry-Perot cavities, SPR and LSPR based fibre sensing, relying in cost-effective tuneable lasers and advanced signal processing. Envisaged application includes in-situ environmental monitoring, and incorporation in critical infrastructures.
- A process for glass-to-glass welding were determined, either to join silica to silica or silica to a soda lime glass.

6.2.4 Activity Overview

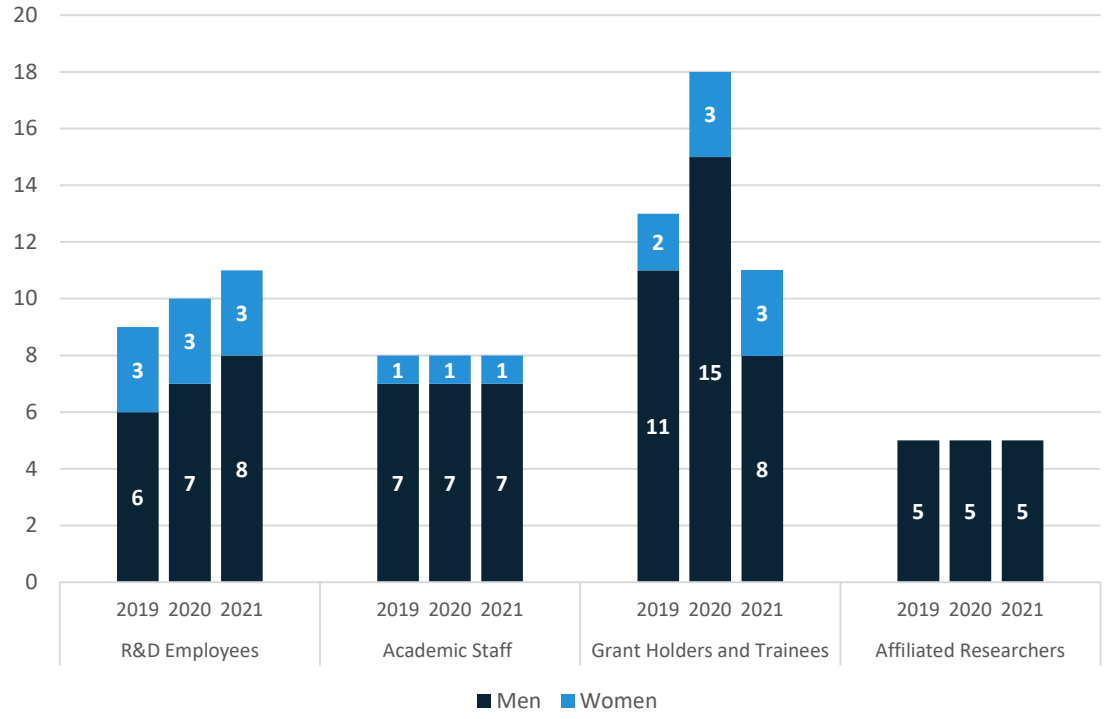


Figure 6.2.1 - CAP - Research team evolution

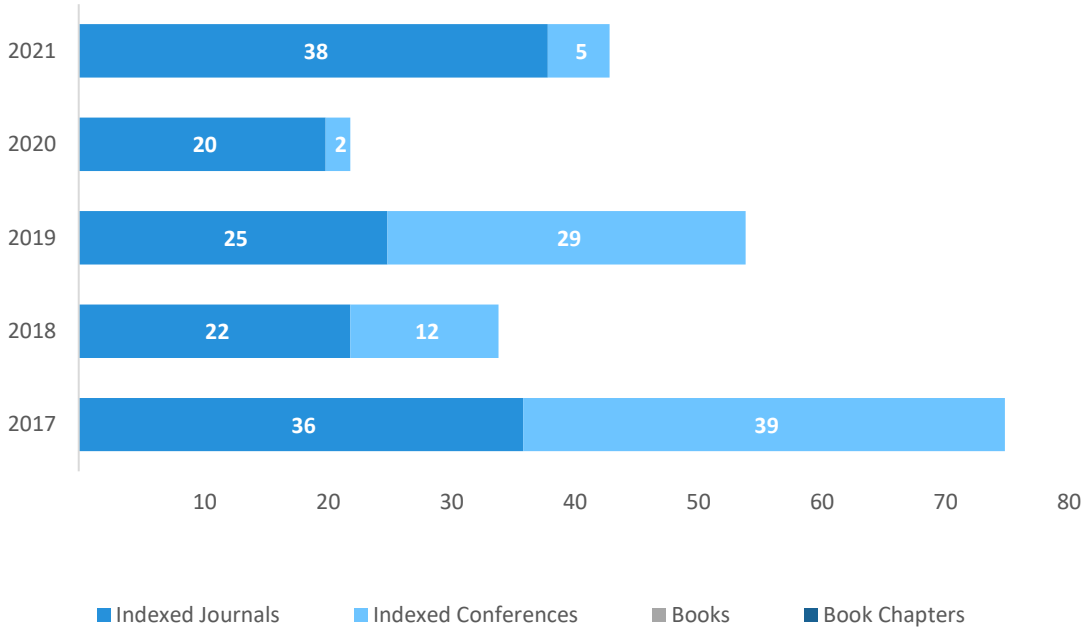


Figure 6.2.2 - CAP - Evolution of publications by members of the Centre

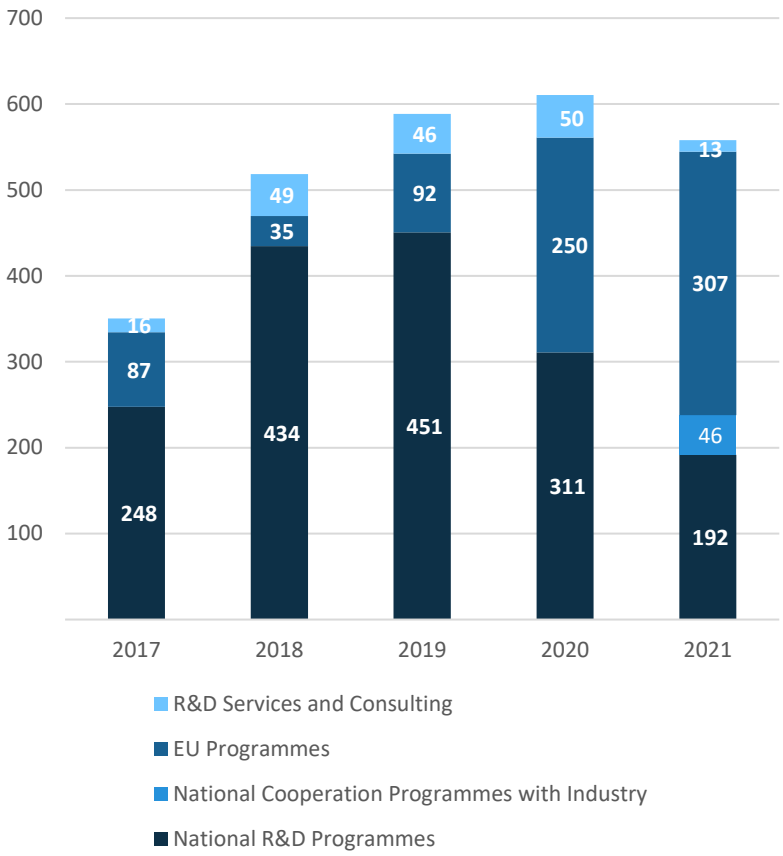


Figure 6.2.3 - CAP - Project funding evolution (k€)

6.3 CRAS - CENTRE FOR ROBOTICS AND AUTONOMOUS SYSTEMS

Coordinators: José Miguel Almeida and Nuno Cruz

6.3.1 Presentation of the Centre

The Centre for Robotics and Autonomous Systems (CRAS) aggregates 70 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. CRAS accomplishes its mission, by directing its activities towards 4 main areas of research: navigation and control (RL1), interaction with environment (RL2), perception and mapping (RL3), and platforms and operations (RL4).

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. These are organised in 4 innovation topics: robotic systems prototyping and upscaling (INOV1), navigation and mapping (INOV2), component development for robotic systems (INOV3), and Underwater acoustics for positioning, navigation and communications (INOV4).

6.3.2 Research Outcomes in 2021

In 2021, CRAS researchers published 16 papers in recognised scientific journals, most of them in 1st or 2nd quartile journals. This exceeds the planned number for the year (12) and approaches the pre-pandemic values of the centre. At the same time, there was a significant increase in the participation of CRAS members in Editorial Boards of major publishers, as well as active participation in the organisation of conferences.

A total of new 7 new PhD Scholarships were awarded: four Individual PhD Scholarships were awarded to CRAS researchers in the 2021 FCT Call for PhD Scholarships, two PhD scholarships in the Open International Call for AIR Centre PhD Scholarship Programme and one in the NIS PhD Scholarships.

The main Research Lines of CRAS benefited from major milestones in funded R&D projects, namely:

- FCT funded GROW project ended with a final workshop and demonstration with IPMA, with significant results in the use of AUVs for data mulling. There were important scientific contributions in algorithms for close range underwater navigation with the fusion of visual information with acoustic-based range and bearing (RL1, RL4).
- The Automon project was concluded, with significant results in the design and control of unconventional marine platforms, such as ASVs with aerial azimuth propulsion systems and combined systems with surface and underwater components (RL1, RL4).
- As a result of the QuALTOS and DORM projects, there were important advances in the application of feature extraction algorithms in underwater acoustic images (RL1, RL3).
- NetTag project, funded by EASME, was concluded, with significant advances in the design and deployment of custom robotic systems for localisation and retrieval of fishing nets (RL2 and RL4).
- ESAPlastics, an ESA research contract, was concluded addressing the test of the potential of using hyperspectral sensors for the remote detection of marine litter in coastal areas and shallow waters. Innovative methods in hyperspectral image processing for autonomous detection of microplastics were developed (RL3).

- EIT RM funded Mine-heritage Project ended with results in the 3D mapping of GNSS denied of underground environments integrating LiDAR and SFM data (RL3 and RL4).
- As result of the P2020 Feedfirst project, the resulting prototype was tested for monitoring of aquaculture tanks with visual system for estimation and characterisation of fish growth (RL2, RL3).

New advances in Research Lines are planned with new R&D Projects that started in 2021:

- EU-Scores (H2020) will focus on the use of robotic systems for Inspection and Maintenance of offshore energy production, with impact in RL1, RL3 and RL4.
- FIRELOGUE (H2020) Coordination and support actions on wildfire risk management that will provide knowledge, innovations and research findings to enhance the existing Wildfire Risk Management (RL3).
- Connect2Oceans (FCT) will focus on the development of an underwater autonomous eDNA sampler for in-situ operation (RL3).

6.3.3 Innovation Outcomes in 2021

Despite the continuing limitations of the pandemic during 2021, there was a slow return of events with physical presence, and CRAS had already the opportunity to resume field demonstrations. In the scope of ongoing R&D Projects and contracts, several important achievements were demonstrated:

- Automon, an autonomous platform for sampling the water column, combining a surface vessel and an underwater towfish, was demonstrated and shipped to Brazil (INOV3).
- Under a contract with a Brazilian hydroelectric power plant, a custom underwater inspection system was shipped to Brazil, in order to assess sedimentation in underwater shafts (INOV1, INOV2).
- In a subcontract with NIVA, a Norwegian R&D Institute, a water sampling device for DNA collection was developed and delivered (INOV3).
- As a result of the UNEXUP project the Up-scaling of the UX1 robot (UX1Neo) prototype was finished and deployed in several field trials (6 field trials in 3 countries: Portugal, Hungary and Ukraine) with huge improvements in operational and survey capabilities, exploring and 3d mapping underwater galleries with over 400m depth (INOV1, INOV2 and INOV3).

The return of events with physical presence also brought the opportunity to participate in various dissemination and outreach events, both at national and international levels. In particular, several technical workshops were organised by CRAS to disseminate achievements and competences. Some of these had strategic relevance due to the target audience or the importance of the topic, for example:

- Related with a contract with KRISO (Korea Research Institute of Ships and Ocean), several workshops related with underwater position, navigation and awareness.
- IN THE BLACK'21 “Impact Assessment for future exploitation of underwater minerals".

Under a partnership with the Portuguese Navy, the Slocum electric glider performed a continuous twelve-day operation in the western Atlantic coast, close to Tróia, during the NATO exercise REP(MUS)21.

In 2021 the establishment of spinoff UGR was concluded, an important result/milestone of the UNEXMIN project.

6.3.4 Activity Overview

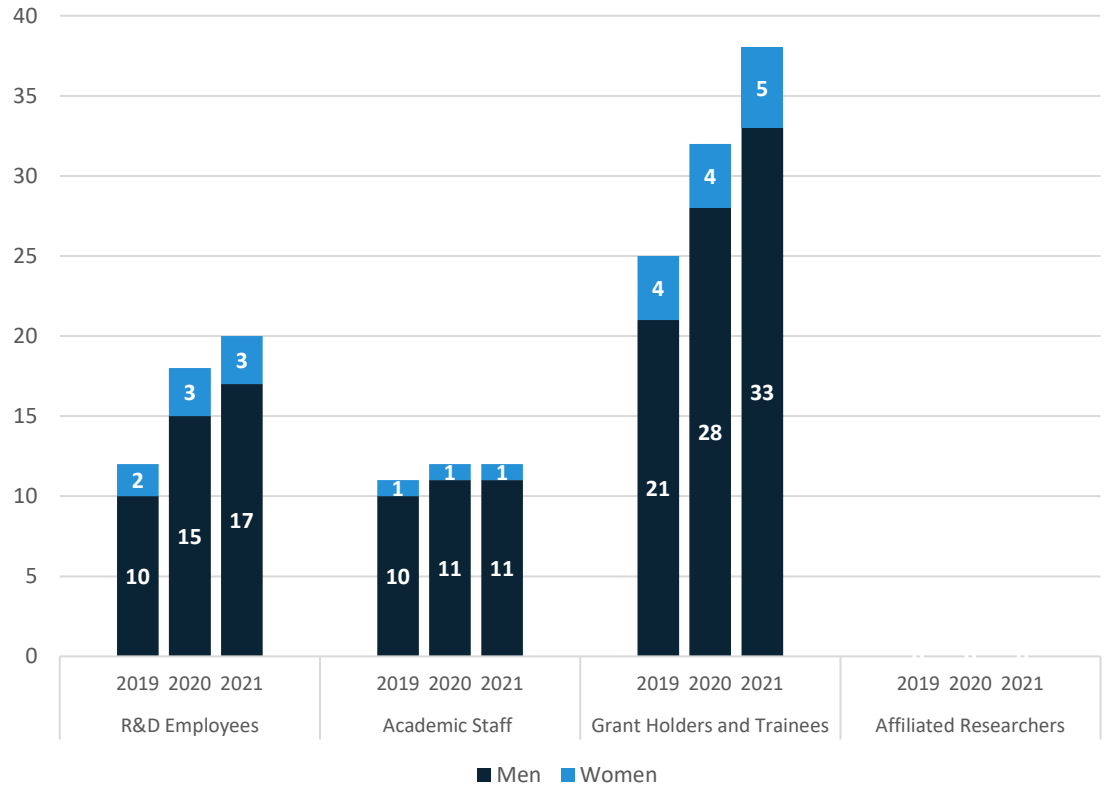


Figure 6.3.1 - CRAS - Research team evolution

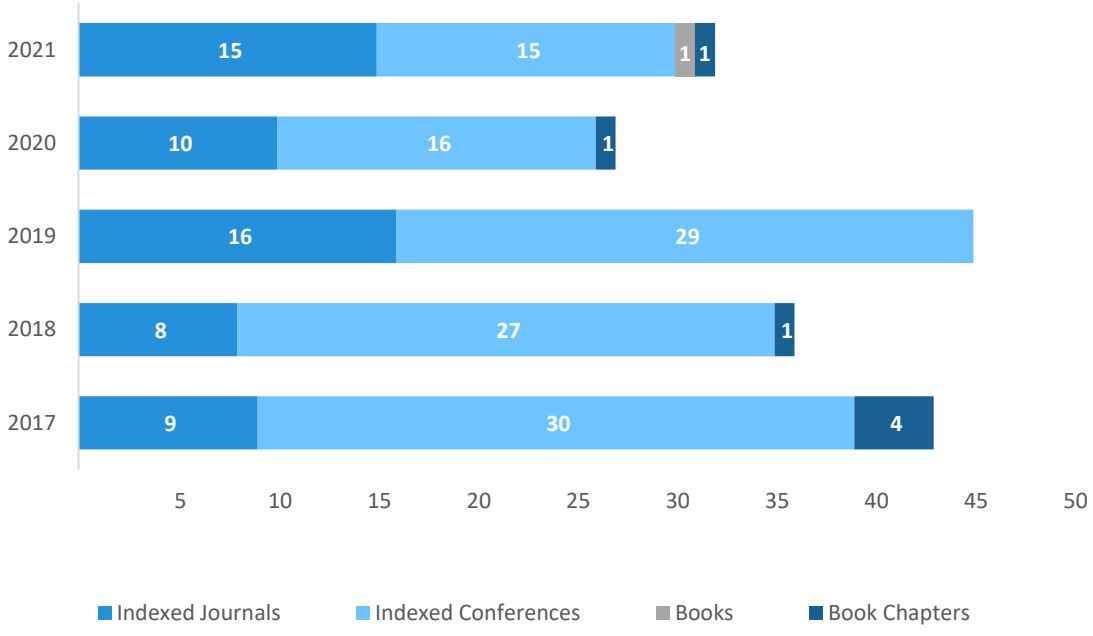


Figure 6.3.2 - CRAS - Evolution of publications by members of the Centre

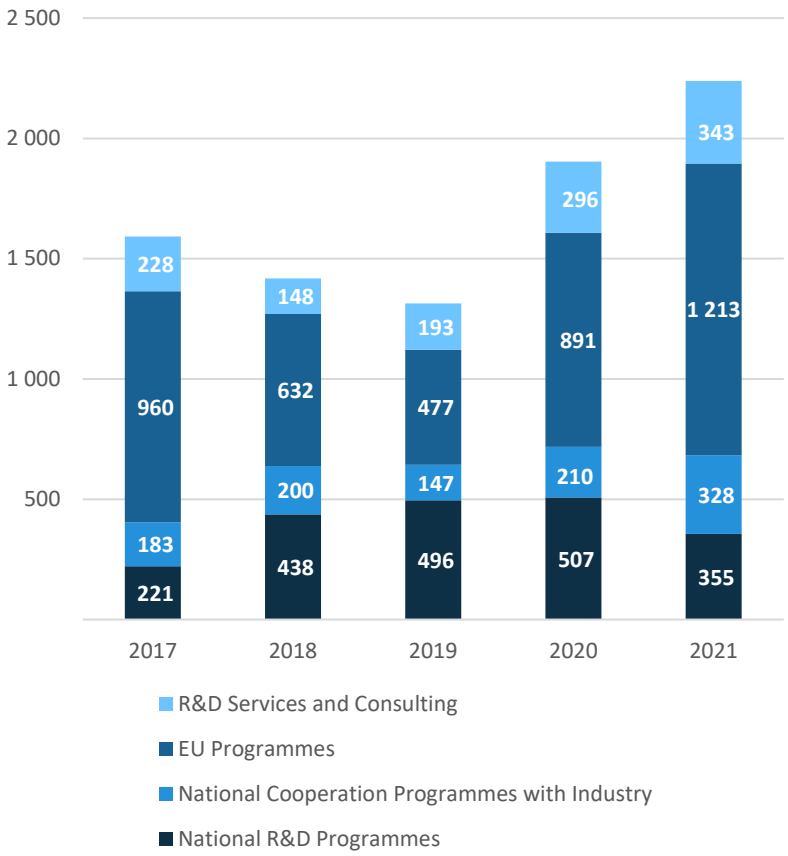


Figure 6.3.3 - Figure 6.3.3 - CRAS - Project funding evolution (k€)

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 mission of the Centre for Biomedical Engineering Research (C-BER) is "to promote scientific knowledge excellence through fundamental and applied research, advanced training and innovation in Biomedical Engineering". 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 & start-ups and foster international cooperation.

The year of 2021 was a landmark for C-BER with the integration and consolidation of new research lines, the approval of new national and European projects, new high impact scientific publications and the publication of a new open-source dataset. We believe that we were able to bring all the members together and push C-BER vision and objectives beyond the expected.

6.4.2 Research Outcomes in 2021

This second pandemic year was no easier than the first one due to the strong restrictions that were still in place, but we believe we were able to overcome and adapt to move forward current and new projects. One of the main blockers was the lack of response/interaction of our clinical partners leading to progress delays mainly on clinical data collection. This was one of our main constrains that influenced this year results, but we already see a change in their response, which will enable our research productivity to rise in 2022. Besides this major burden, C-BER was capable to slightly increase its scientific publication level in high-impact journals with a total of 26 indexed publications (21 in quartile Q1 and 5 in Q2).

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

- Retina CAD: Development of a new method for the segmentation of retinal layers in OCT images in the framework of a PhD thesis.
- Lung CAD: Further developments in the TAMI project and two ongoing PhD theses, with three new publications (one journal paper of Q1 and two proceeding papers)
- Multiscope: Francesco Renna and Miguel Coimbra are the organisation members of the 2022 George B. Moody PhysioNet Challenge, positioning C-BER in one of the most advanced research centre in this area with a large knowledge on the digital auscultation, also enabling the publication of an open-source dataset for the challenge. In this research area there were also more 3 main achievements: a prize of the best poster presentation on 2021 Computing in Cardiology; a prize of the best oral presentation on RECPAD2021 conference; and the approval of an INESC TEC internal project ("seed project") to further research this area.
- Two publications on "*Sensors*" journal had increased our visibility in one of our research lines of gait analysis, which lead to the invitation of the editor for the creation of a special issue in 2022 named "*Sensor Technologies for Gait Analysis*".

- One of our senior researchers was nominated as Editorial Board Member of *NATURE Scientific Reports*, the 6th most cited scientific journal in the World in 2020. This member was also nominated to the Editorial Review Board of *Frontiers in Signal Processing*.
- We have published our first publication (IEEE NER21) showing a synchronisation method for our innovative system that combines 3DVideo-EEG and Percept PC deep brain neurostimulator, showing that we are once again the pioneers in the creation of these neurotechnologies for neurological diseases monitoring and diagnosis support.

6.4.3 Innovation Outcomes in 2021

Intellectual Property

In 2021, C-BER was able to leverage the high standards in innovation reach until 2020 and also to keep a very well-organised intellectual property protection strategy. In 2020 we had 8 patent families and in 2021 these patents had 6 applications for internationalisation. Beside this, C-BER has filled one new patent and, with the support of INESC TEC Licensing Office (SAL), we were able, for the first time ever since our creation, 36 years ago, to sell a patent directly to an industry player, which was a landmark institutional achievement for 2021.

Internally we have filed 6 invention disclosures that are being analysed and study to understand it best strategy. From these 6, two of them were software copyrights registrations that are being licensed to companies. We were also able to close 3 license agreements with companies, which 1 was concerning a software, and two were concerning the two patent families of our two start-ups iLoF and InSignals Neurotech. This was only possible due to the high interaction with SAL and the continuous support from them, juridical service and other members and services of INESC TEC.

Start-Ups

To complement our strong intellectual property awareness and strategy definition, we have been very active in the creation and launch of spin-offs, and in 2021 we were able to secure funding for C-BER second spin-off - inSignals Neurotech. As expected, this year we have signed a contract with this start-up in order to support them in the creation of their minimum valuable product for their clinical trials in several European countries. Our support to inSignals Neurotech will continue in 2022 where we aim to further evolve their system, support their clinical trials and also to development new features for the system.

We have also supported iLoF, the first C-BER spin-off, with our services and a plan to sign a second contract in 2022 for further support in the development and guidance in their system. We also supported iLoF in a new European Horizon Europe project proposal that aims to expand their technology to poverty countries if approved by the European Commission.

Our third start-up under development, WeSENSS (Wearable SENSors for Safety), changed slightly its strategy and we are now focused on a B2B approach, which has been very fruitful and have lead already to the licensing of a software, an approved H2020 project in the area of firefighters monitoring, an approved national project in the area of farm workers monitoring and a mutual interest contract with EQS company for the development of a joint pilot application for the oil&gas market. We believe that this strategy will lead us to share our technological capabilities with different markets and industrial players that will enable us to take the next step and show the potential of WeSENSS technology and reach funding opportunities.

6.4.4 Activity Overview

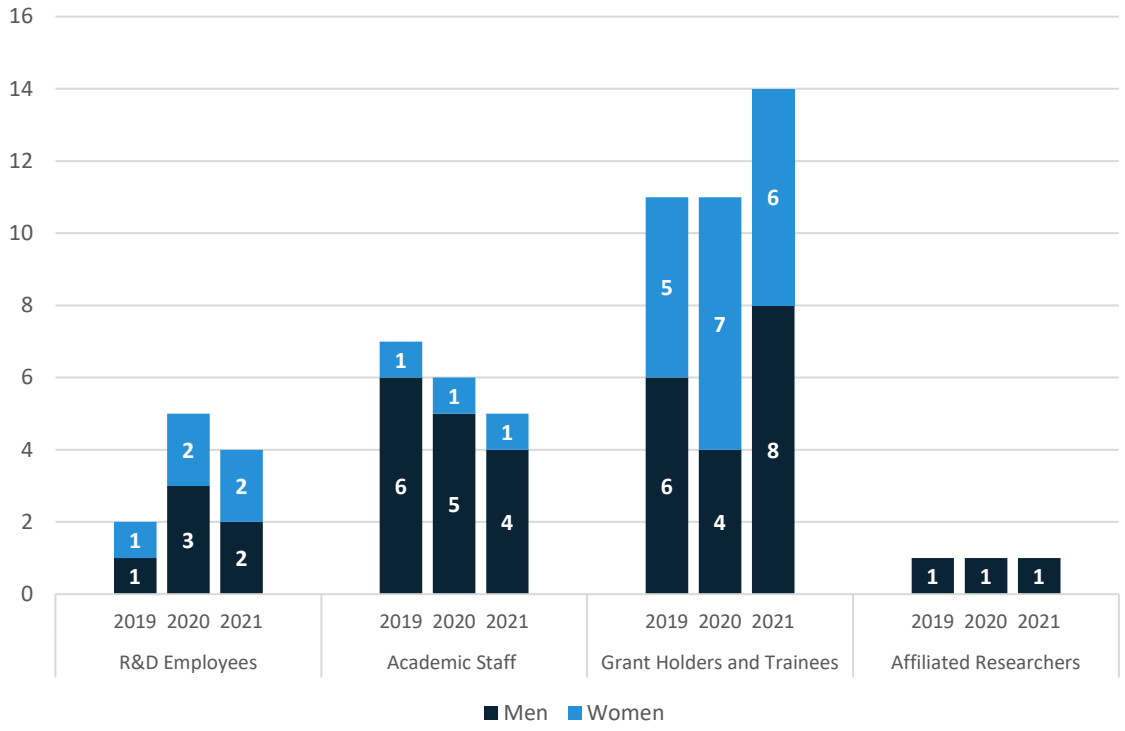


Figure 6.4.1 - C-BER - Research team evolution

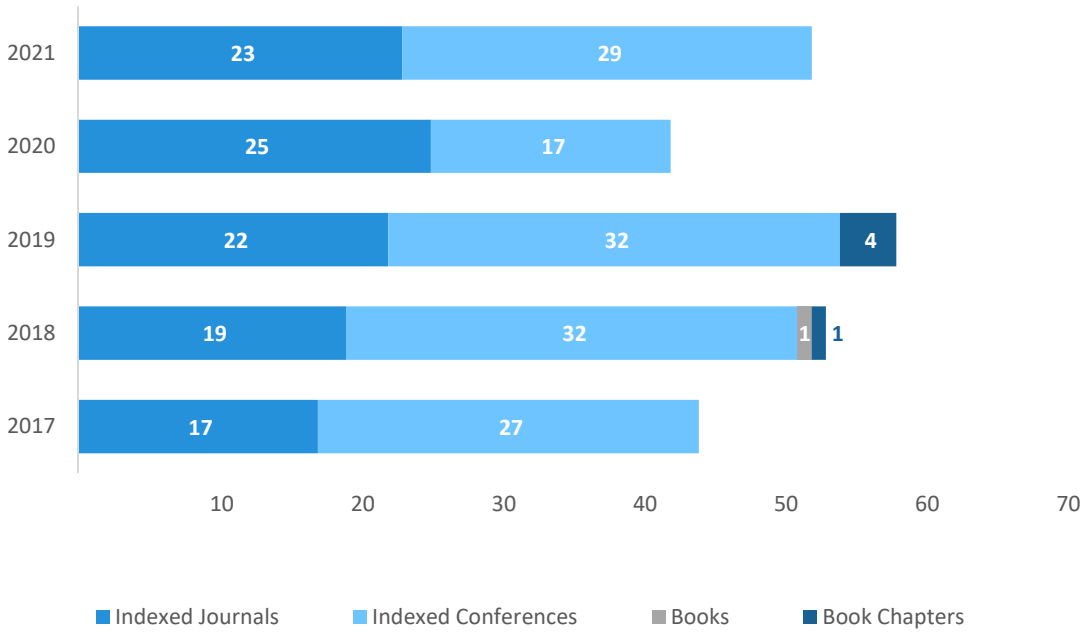


Figure 6.4.2 - C-BER - Evolution of publications by members of the Centre

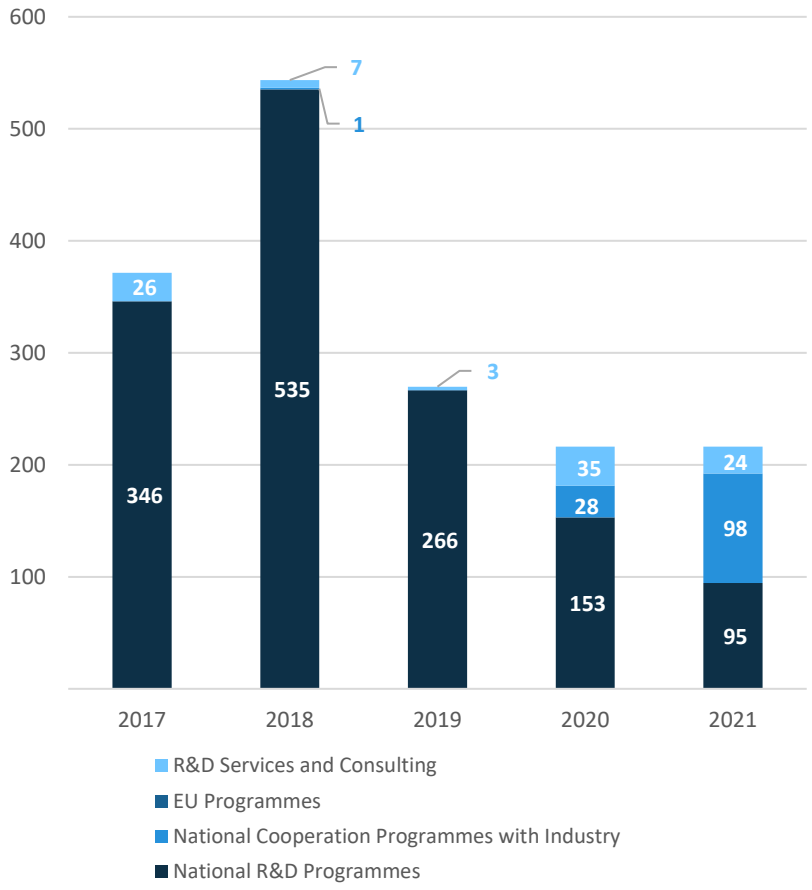


Figure 6.4.3 - C-BER - Project funding evolution (k€)

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 a world reference in large scale integration of RES. CPES has three IEEE Fellows, is a strong player in European Commission Competitive funding and regularly grants 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 2021, the Centre coordinated three EU H2020/Green Deal projects.

6.5.2 Research Outcomes in 2021

Novel two-stage Constructive Heuristic Algorithm (CHA) to handle integer investment variables in transmission network expansion planning, published in the *Electric Power Systems Research* journal.

Development and testing of a conceptual model to detect and mitigate extreme losses in electrical distribution networks, namely as a consequence of the connection of large amounts of small generation units at this voltage level.

Development of a functional model for quantifying consumption elasticity of the demand response (DR) contracted consumers. The model aims to determine the load adjustment the DR consumers can provide to the retailers or utilities for different price levels. This work was published in the *Energy and Buildings* journal.

Development of novel federated learning and data markets algorithms for renewable energy time series forecasting, co-funded by H2020 Smart4RES project and VALOREM (seed project). The algorithms were published in two IEEE Trans. on Sustainable Energy papers and a mathematical analysis of the state-of-the-art methods published in the International Journal of Forecasting. A PhD thesis (Carla Gonçalves) about this topic was concluded in 2021, and an international patent application PCT/EP2021/080427 was made in November 2021. Moreover, the federated learning protocol was applied to distributed learning of sensitivity indices in low voltage electrical networks and the work accepted in PSCC 2022 conference.

Participation in a peer-reviewed encyclopaedic journal paper titled “Forecasting: theory and practice” with more than 70 co-authors, 167 pages, covering all the topics in time series forecasting, published in *International Journal of Forecasting*.

Development of an approach for improving the dynamic security in islanded power systems based on the quantification of minimum synchronous inertia considering fault-induced frequency deviations – H2020 Smart4RES project.

Advanced control strategies for improving fault ride through performance of smart power transformers feeding hybrid (AC/DC) microgrids. Published in *MDPI Energies* journal.

Development of a methodology to define the best model and experiment design for battery parameter estimation. These models were tested as a state of charge estimator on a battery applied on an electric forklift. Published in *MDPI Energies*.

Development of two data-driven functions for smart alarm processing with two main goals: (i) identify the complexity of an occurrence in the distribution grid, (ii) provide fast advice to the human operator on how to solve it, which takes a sequence of alarm information from the occurrence and shows the operator which switch or OCR (Remote Cutting Organ) he needs to close or open, in order to locate the problem on the power line.

Bid optimisation algorithms for multi-energy aggregators participation in electricity and gas markets were developed – published in *Applied Energy* journal. Methodologies to increase the observability over the gas network were developed, together with algorithms to optimise the injection of green hydrogen in the public network.

6.5.3 Innovation Outcomes in 2021

A simulation environment and models of dynamic behaviour were created to evaluate electrolysers potential to provide frequency support services – to be used later in research (in H2020 GREENH2ATLANTIC) and consultancy work.

Leveraging from past research in energy time series forecasting, a consultancy study was conducted for Austria Power Grid (APG) to design highly accurate nodal load forecasting models for transmission networks, leveraging from feature engineering, machine learning, and deep learning techniques.

Development of a decision support system to the Portuguese DSO for long-term reinforcement planning of distribution networks.

Demonstration in Portugal (E-REDES in the framework of H2020 EU-SysFlex) of a prototype tool for managing active and reactive power flexibilities existing in distribution grids to cope with TSO requests (TSO-DSO cooperation).

Leveraging from past research work about RES integration in isolated and interconnected power systems, grid-code compliance studies were conducted for 5 renewable power plants.

New improvements in CEVESA MIBEL market simulator software (hydrogen integrated model, integration of financial indexes) and conceptual design and first implementation steps of the optimal allocation of the cross-border interconnection capacity. Presented in IEEE Madrid Power Tech 2021.

Local market platform for energy trading based on Ethereum blockchain technology (Seed project). Governance models and tools for peer-to-peer energy markets and DSO operation coordination. Definition of a general framework for the energy allocation and settlement of renewable energy communities. Used in a consultancy contract with Elergone.

Design and implementation of the third generation of a home energy management system (HEMS) within the H2020 InterConnect project. The new version implements a full cloud-based system with central and modular computational capability whilst ensuring compliance with the interoperability framework.

Development and transfer to EFACEC of software module for the predictive optimisation of medium-size battery energy storage.

Development and laboratorial validation of software modules for voltage regulation and self-healing for MV/LV smart substations – Portugal 2020 NextStep project.

Monte Carlo based tool for simulating the multi-year operation of interconnected power systems including storage.

Data-driven software prototype (contract with E-REDES) for assessing the health of circuit breakers and automatic reclosers in distribution grids.

Improvement in terms of computational performance via parallel computing of the Model for Operational Reserve Adequacy (MORA) software.

6.5.4 Activity Overview

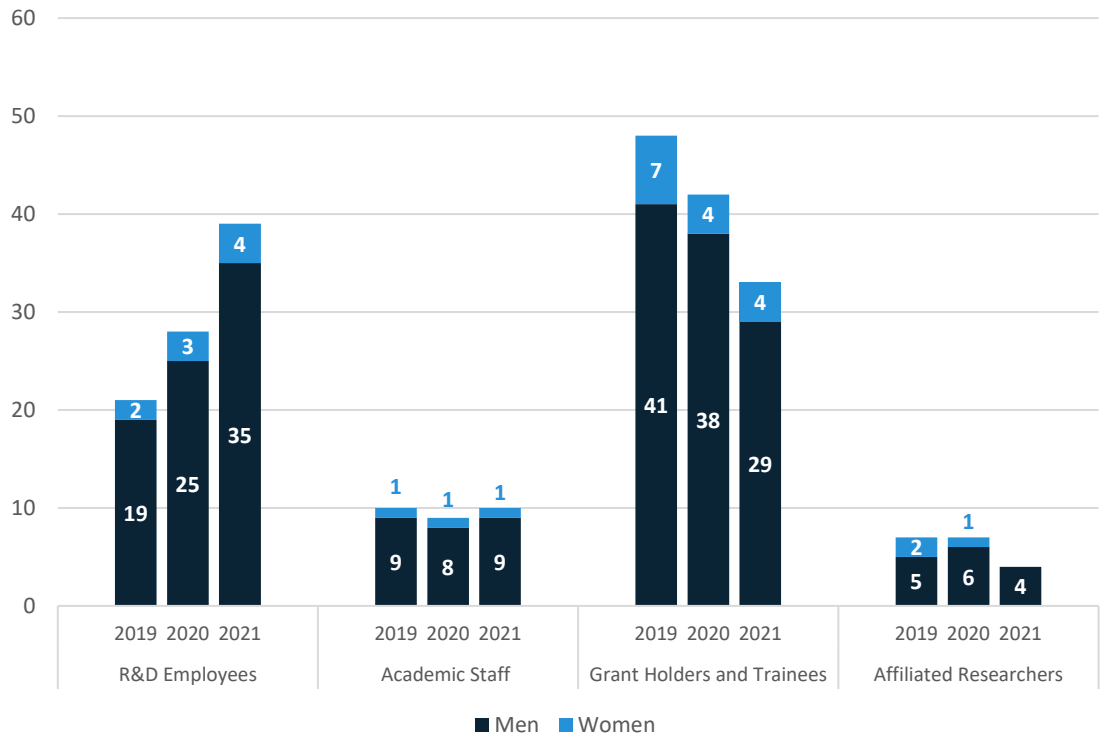


Figure 6.5.1 - CPES - Research team evolution

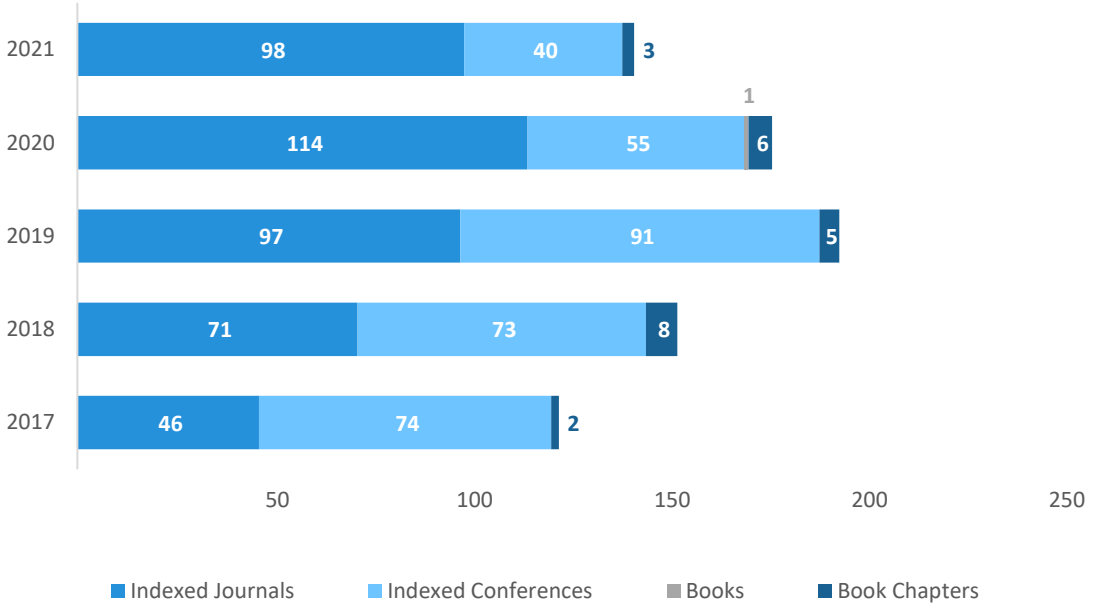


Figure 6.5.2 - CPES - Evolution of publications by members of the Centre

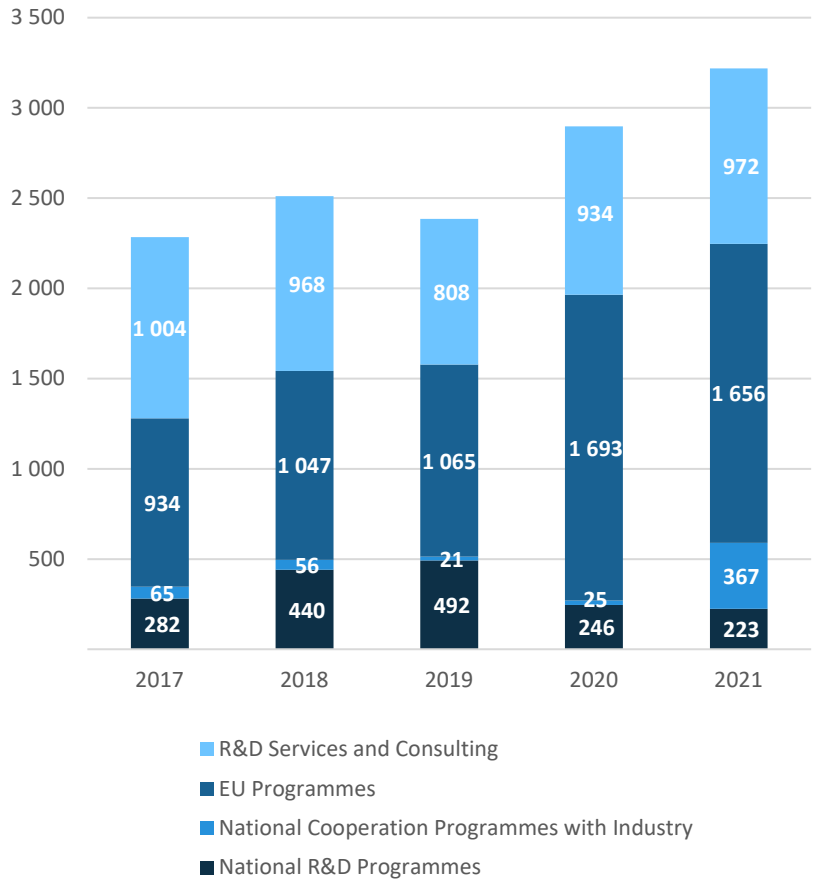


Figure 6.5.3 - CPES - Project funding evolution (k€)

6.6 CESE - CENTRE FOR ENTERPRISE SYSTEMS ENGINEERING

Coordinators: António Lucas Soares and Rui Rebelo

6.6.1 Presentation of the Centre

CESE's mission is to advance scientific knowledge in enterprise systems engineering, resulting in unique expertise in developing innovative systems and services for the management of industrial organisations. CESE produces high-quality research that results in a set of competencies recognised by industrial partners as improving competitiveness, sustainability, and resilience of their business processes and supply chains. To fulfil its mission, CESE pursues five research lines: Manufacturing Systems Design and Management, Supply Chain and Collaborative Networks Management, Industrial Information Systems, Technology Management in Industry, and Transportation and Logistics.

6.6.2 Research Outcomes in 2021

RL1. Manufacturing Systems Design and Management. During this period, the two main objectives defined in the plan of RL1 where explored, namely concerning: a) integrating Data Science and Artificial Intelligence approaches into decision support systems to address complex manufacturing challenges; b) how optimisation algorithms can be combined with simulation models to manage the operations of manufacturing systems when facing unexpected events. The usage of reinforcement learning (RL) for decision support in manufacturing systems continued to be studied. An outcome of this study was a new approach to WIP management in Assembly Manufacturing Systems. In line with the defined objectives several research papers have been published, namely: "A new simulation-based approach in the design of manufacturing systems and real-time decision"; "Using variable neighbourhood descent and genetic algorithms for sequencing mixed-model assembly systems in the footwear industry"; "Scheduling footwear moulding injection machines for a long time horizon"; A Monte Carlo simulation-based approach to solve dynamic sectorisation problem"; and "PREFAB Framework - PRoduct quality towards zEro deFects for melAmine surface Boards industry".

RL2. Supply Chain Management. In RL2, CESE has contributed to literature and practice by exploring contemporary challenges faced by supply chains and addressing strategies to increase their resilience and sustainability. The book Next Generation Supply Chains, published by Springer, provides an in-depth analysis of current supply chains and presents a roadmap for the next years. The book, a result of the collaboration carried out in project NEXT-NET, was edited with the collaboration of CESE and counted with the contribution of recognised authors from multiple European Countries. Papers published in journals such as the International Journal of Logistics Management also addressed relevant strategies to face supply chains' contemporary issues.

RL3. Industrial Information Systems. In the research topic of Digital Enterprise Architectures, the research work in the Transformer4.0 project led to preliminary results on the exploration of the product digital-twin concept, both in the architectural and the data/information management dimensions. The results obtained were published in several international conferences, and include: "A Vision for a Platform-based Digital-Twin Ecosystem"; "Digital Platforms as Enablers of Smart Product-Service Systems"; and "The Digital Twin as a Knowledge-Based Engineering Enabler for Product Development". Still in the context of the Transformer4.0 project, but on the topic of Design and Impact of IIS, a first step was achieved in creating a design theory for the development of digital-twin based architectures, presented in a conference under the title "The digital twin as an enabler of digital transformation: a sociotechnical perspective". Also on this topic, the results of the study "From Digital Platforms to Ecosystems: A Review of Horizon 2020 Platform Projects" provided relevant insights for architecture design. Finally, regarding the Data and Information Management topic, results were achieved in the study of the informational dimension of immersive systems and knowledge management for street lighting management.

RL4. Technology Management in Industry. One of the challenges embraced by CESE is to support industrial companies in the digital transformation. One of the important ways to achieve this support is through training courses for professionals. The M NEST II project, in the education pillar, resulted in the creation of training courses for professionals in companies. The participation in this project inspired the following publications: "Innovative Learning Scheme to Up-skilling and Re-skilling – Designing a Collaborative Training Program Between Industry and Academia Towards Digital Transformation"; and "Adoption of digital technologies during the COVID-

19 pandemic: Lessons learned from collaborative Academia-Industry R&D case studies". The participation of CESE in Large-Scale Collaborative R&D Projects ("Mobilizadores" projects) in recent years not only supported industrial companies in upgrading industrial processes to the digital era, but also improved CESE's experience in managing these large projects. Therefore, besides technological contributions and results based on CESE developments, it was also possible to publish in 2021 on the "Challenges in Managing Large-Scale Collaborative R&D Projects" based on that experience. Finally, the RedVile project, funded by EIT, delivered results in the development of an immersive training platform. This platform aims to be the European reference marketplace for Augmented and Virtual Reality (AR/VR), stimulating the use of these modern technologies in education. Some publications are planned within this project.

RL5. Transportation and Logistics. The OPTI-MOVES project (funded by FCT, concluded in December 2021) developed a framework using open access technologies for big data, capable of collecting and storing urban mobility data in an automated way and allowing the implementation of new mobility services and knowledge extraction in different dimensions of analysis. The project's main outcomes were: (i) visualisation and data mining to efficiently identify patterns that affect the quality of urban mobility services; (ii) optimisation techniques (meta-heuristics) to improve the quality levels of these services; and (iii) development of an information system to support decision making. Preliminary work on the e-LOG project (funded by FCT, starting in January 2022) has been addressing the new business models and operations strategy for urban logistics (with the huge expansion of e-commerce), with particular focus on the "last mile" and the environmental impacts of parcel distribution. In the recently started Horizon 2020 funded project MAGPIE – sMArt Green Ports as Integrated Efficient multimodal hubs (2021/2024), port logistics processes and their relationships with the hinterland are explored, and interoperability issues raised by the multiplicity of information systems are addressed. Focus is given to sustainability and efficiency aspects.

6.6.3 Innovation Outcomes in 2021

Within the scope of digital transformation, the Digital Maturity Assessment and i4.0 Roadmap services have assumed high importance, not only because of the number of international and national projects executed, but mainly because of the impact achieved in the interventions in companies. Advanced production systems and internal logistics continue to be strategic areas, in this sense, with CESE and CRIIS developing innovative services for industry to evaluate and quantify logistics systems with AGVs. For this purpose, the use of simulation was considered, a technique that allows the creation of a digital model of the production system, for dimensioning logistics systems (route definition and AGVs dimensioning). This methodology considers an innovative architecture composed by a simulation tool and a path planning algorithm that communicate with each other, in each scenario evaluation run.

CESE is responsible for developing a public portal with national and international strategic information on the Automotive Industry – the Automobile Observatory – to be provided to the actors in the sector as well as to the general public. To this end, the platform collects, organises and processes data from different sources, producing a set of indicators. This information is made available through state-of-the-art information visualisation tools.

6.6.4 Activity Overview

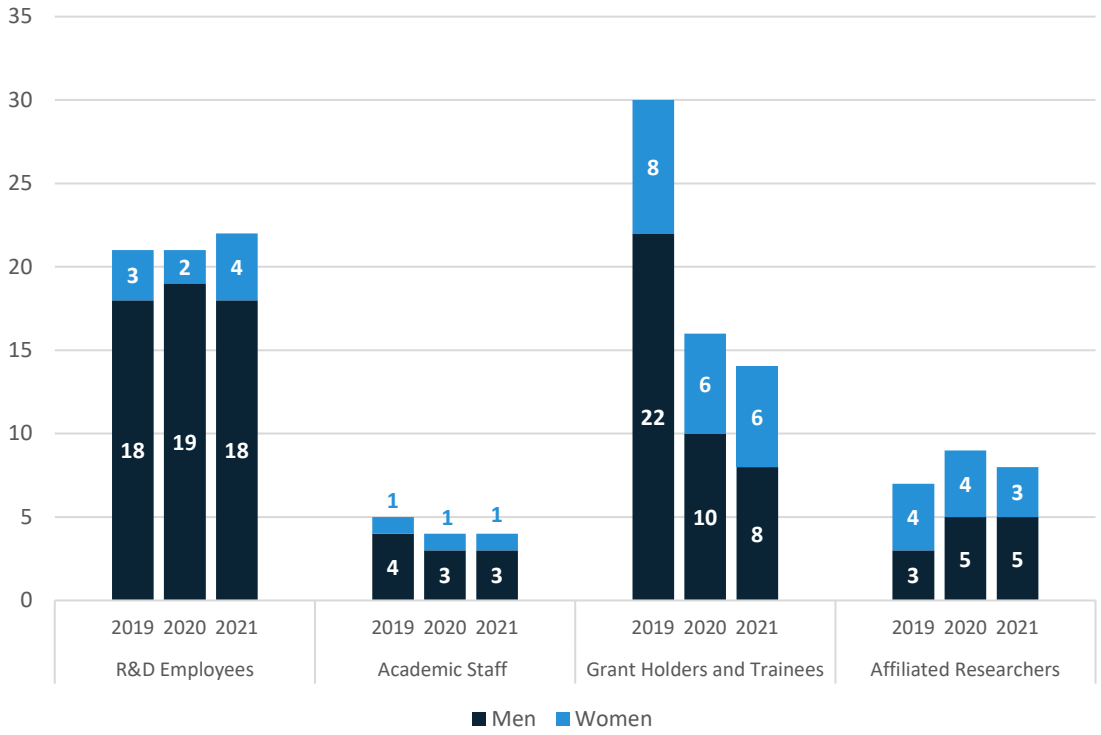


Figure 6.6.1 - CESE - Research team evolution

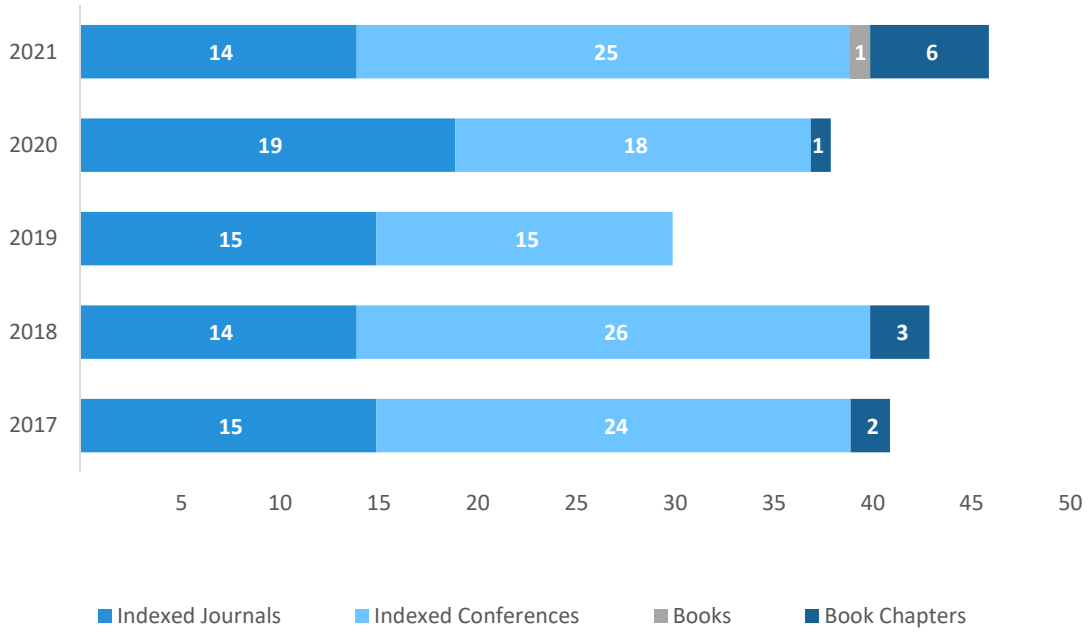


Figure 6.6.2 - CESE - Evolution of publications by members of the Centre

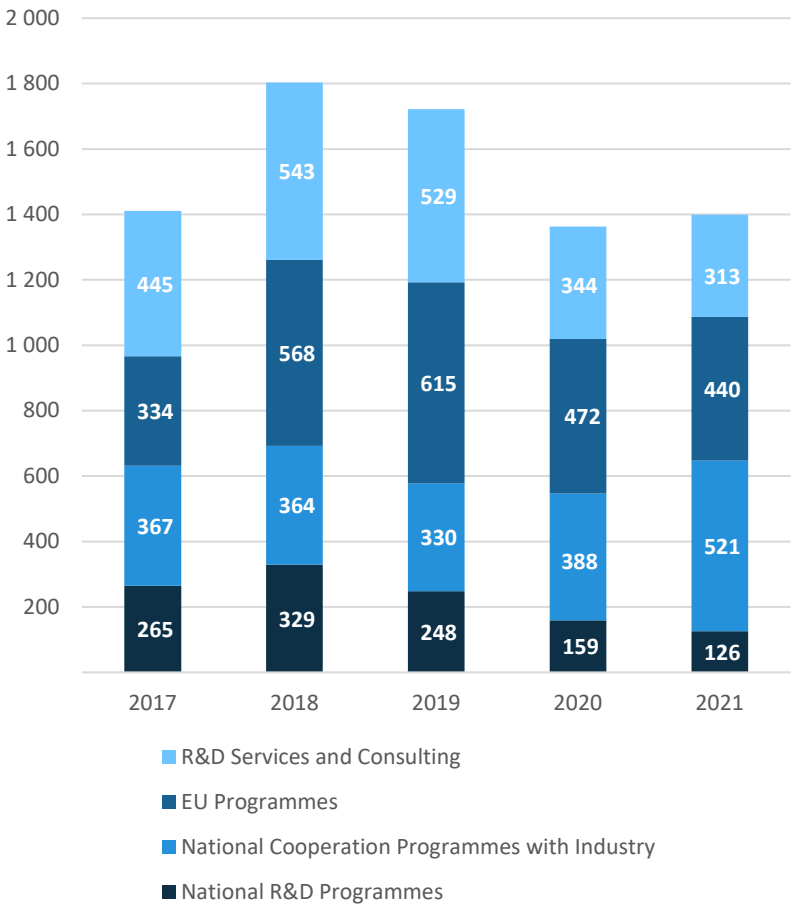


Figure 6.6.3 - CESE - Project funding evolution (k€)

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 Robotics and Intelligent Systems Centre designs and implements innovative solutions within the areas of robotics and intelligent systems. The Centre works in close cooperation with Companies, other INESC TEC Centres and other Institutes and Higher Education Institutions, following the lemma from Research and Development to Innovation, passing through Design, Prototyping and Implementation.

6.7.2 Research Outcomes in 2021

The main research outcomes are provided along the Centre's main research lines.

RL1. Navigation, Localisation and Coordination of Mobile Robots. In this line, a multi-robot coordination system, considering communication failures, is under development, with useful outputs for different projects (PRODUTECH 4S&C, Continental FoF, …). Two PhD students are also working in this subject. AgRobPP (https://gitlab.inesctec.pt/agrob/agrob_pp) and VineSlam (https://gitlab.inesctec.pt/agrob/vineslam_stack/vineslam) were upgraded with new features relevant for agricultural contexts. These modules were tested in the PRYSM and SCORPION projects.

RL2/3. 2D/3D Industrial Vision, Advanced/Intelligent Sensing and Control. A modular and highly reconfigurable 3D Robot Perception Framework to allow robotic systems to pick up objects in complex scenarios was developed, with a software module to deal with entangled objects. An inspection and quality control system tailored to support human operators during the inspection of metallic parts, resorting to different machine vision and deep learning approaches, was also completed. In addition, three robotic perception modules for agricultural monitoring, spraying and harvesting tasks have been developed, and more than six datasets relevant for deep learning training were built, most of them available at https://zenodo.org/communities/criis-inesctec/?page=1&size=20

RL4. Human Robot Interfacing and Augmented Reality. Several developments contributed to improving the Centre's projected spatial augmented reality system. These developments aimed to increase the maturity level of the technology and improve its user interfaces, increase its range of industrial applications, namely to support human operators both in the construction of silos for the food industry, and in the construction and maintenance of ships for the shipbuilding industry.

RL5. Future Industrial Robotics and Collaborative Robots. CRIIS has developed a cognitive system aiming to increase the natural collaboration level of a robotic system with its human partner, considering a realistic engine assembly station. This system is powered by computer vision and deep learning to interpret implicit communication cues from the operator, allowing the robotic system to automatically respond in accordance. At this level, CRIIS has also developed a module called FollowMe, that can be used for robots to follow individuals performing agricultural tasks, in operations support logistics.

RL6. Vertical Integration, IoT, Industry 4.0. An AI-based methodology was developed to keep digital representations of manufacturing environments updated, relying on sensor data collected by robotic systems and processed at local, edge, and cloud levels. Also, the vertical integration layer of the OSPS framework was enhanced with support for cloud-based capabilities to complement the operation of robotic systems. In addition, parts of the OSPS framework are being integrated with the Robotics and Automation MarketPlace (RAMP), targeting the uptake of technology by European SMEs. The AgIoT module features were expanded and have reached V2.0 for SmartTrap (based on the AgIoT solution). SmartTrap will enable the detection of agricultural disease vectors in a faster and more cost-effective way.

6.7.3 Innovation Outcomes in 2021

Flexible Production using Robotics

The main innovation activities were: (1) the 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 industrialisation and technology transfer of the results of the CoopWeld project, targeting the development of a projection mapping solution to aid human operators in a collaborative robotic cell for the fabrication of steel structures; and (3) the industrial deployment of a machine vision system designed with segmentation of flat sheet metal waste in a robotised plasma cutting cell.

Agricultural Robotics

The main innovation activities were: (1) moving a spraying robot's Manufacturing Readiness Level from level 4 to level 7, in project PRYSM (with Pulverizadores Rocha); (2) the testing and validation of the CRIIS navigation stack on greenhouse logistics robots, in project ROBOTCARE.

6.7.4 Activity Overview

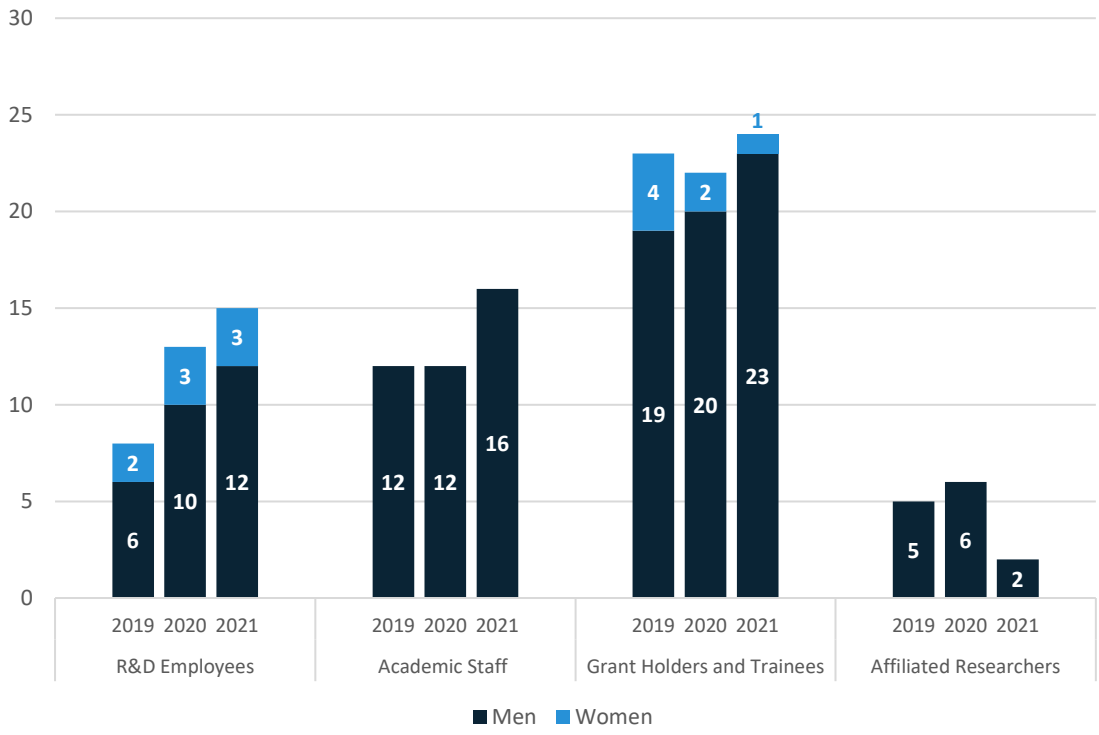


Figure 6.7.1 - CRIIS - Research team evolution

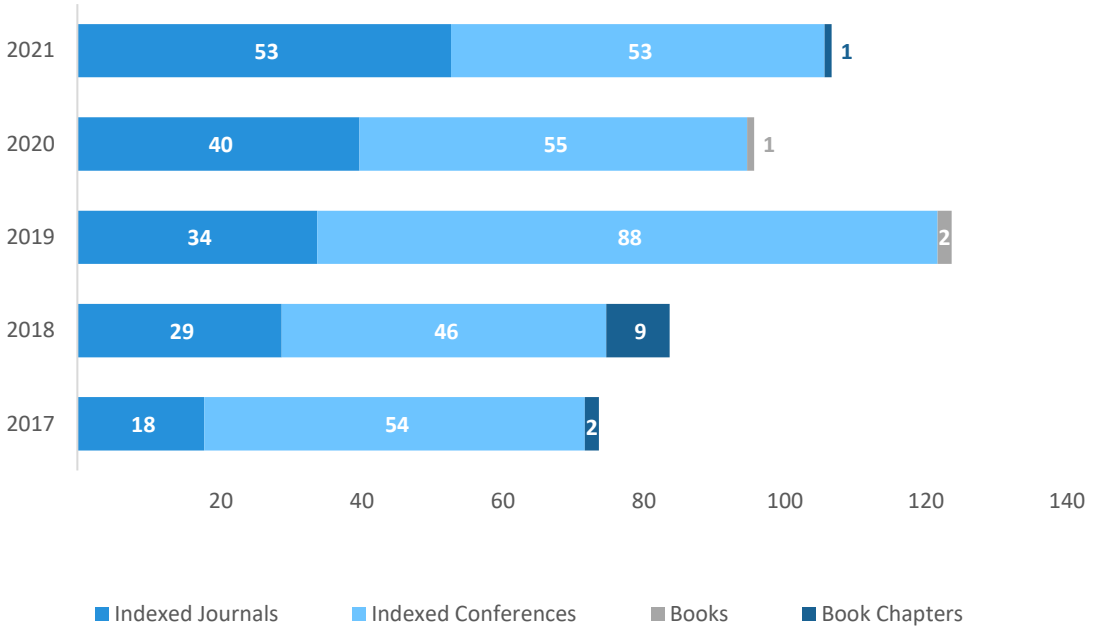


Figure 6.7.2 - CRIIS - Evolution of publications by members of the Centre

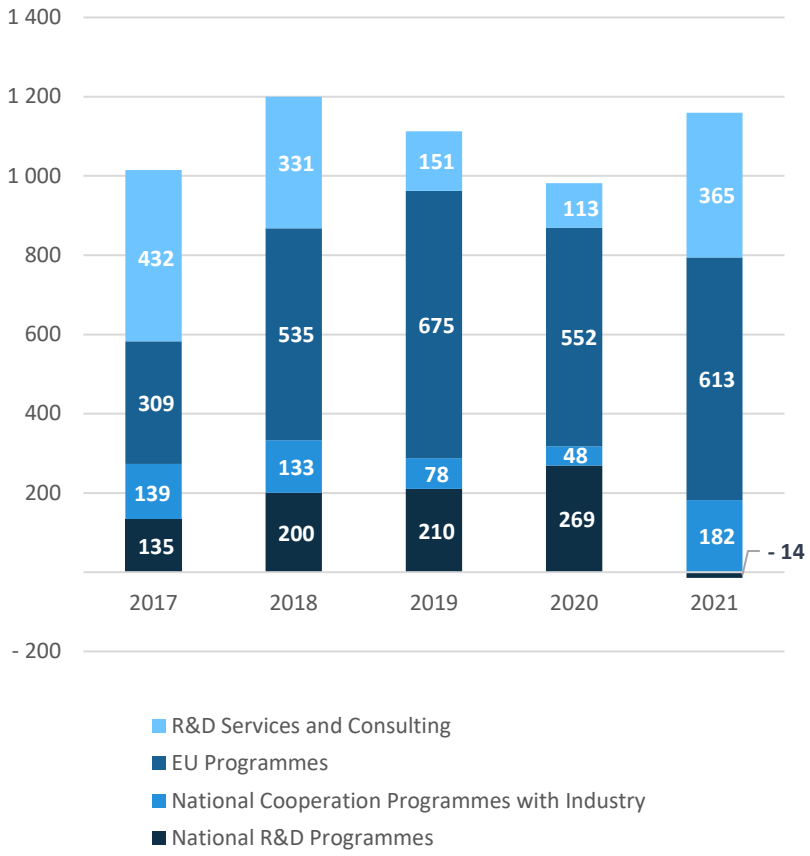


Figure 6.7.3 - CRIIS - Project funding evolution (k€)

6.8 CEGI – CENTRE FOR INDUSTRIAL ENGINEERING AND MANAGEMENT

Coordinators: Ana Viana and Pedro Amorim

6.8.1 Presentation of the Centre

CEGI 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., asset management). The Centre has a vision focused on an ever-integrated and flexible value chain across different industries (e.g., manufacturing, retail, health and mobility). To fully address the challenges raised by this vision, the competences of the Centre in Operations Research and Operations Management, as well as in Service Engineering, will be crucial. Such vision will be materialised with the involvement, in particular, of research in new effective and efficient quantitative methods, which adequately handle the readily available data from a system perspective and provide robust solutions. The contribution to society through knowledge transfer is also a central point of the activity of the Centre. Building up on its past experience, CEGI continues to provide the Energy Sector with updated asset management expertise. Aligned with the European agenda, it is also contributing to the dematerialisation of processes and improvement of insights in the health sector, and to the sustainable operations of the supply chain in Retail.

6.8.2 Research Outcomes in 2021

In 2021, CEGI's activity led to several research outcomes, in different domains, that are worthy of highlight.

One of the Centre's goals in recent years has been to publish research outcomes in FT50 journals. This was achieved in 2021 with the article Amorim, P., & Dehoratius, N. (2021). Online Shoppers Don't Always Care About Faster Delivery. MIT Sloan Management Review, 63(1), 12-14. By analysing online customer data, the authors revealed that other delivery attributes matter more than how quickly an order is received. Within the same research project – Tec-FEL – three additional papers were also published and four papers submitted for publication in international journals. The developed knowledge on online commerce has also been disseminated through 10 communications in conference.

Still within the e-commerce sector, CEGI researchers published an important paper, which targets a service for the future: Santini, A., Viana, A., Klimentova, X., & Pedroso, J. P. (2022). The probabilistic travelling salesman problem with crowdsourcing. Computers & Operations Research, 142, 105722. In the paper, the authors study a variant of the Probabilistic Travelling Salesman Problem arising when retailers crowdsource last-mile deliveries to their own customers, who can refuse or accept in exchange for a reward. To address this problem, they propose Machine Learning and Monte Carlo simulation methods to approximate the objective function, and both a branch-and-bound algorithm and heuristics to reduce the number of evaluations. They show that these approaches work well on small size instances and derive managerial insights on the economic and environmental benefits of crowdsourcing to customers.

In 2021, there were also important intermediate outcomes achieved, that will soon lead to final results. In the TRUST-AI project, symbolic learning algorithms, based on genetic programming (GP) were studied in depth, and different grammar-based variants were compared, such as context-free grammar (CFG-GP) and grammatical evolution (GE). These algorithms were also compared to an enumerator, which generates all the possible, non-redundant, dimensionally-aware expressions. This work has resulted in a MSc thesis and a working paper, which will be submitted to a Q1 international journal (such as Computers and Operations Research). These GP algorithms were applied to flexible job shop scheduling, with current results already outperforming the state of the art. This is still going to be further iterated and possibly combined with a Reinforcement Learning algorithm to select on the fly the dispatching rules generated by GP. This will be submitted to a special issue of the Informs Journal on Computing. The application to online retail is also being explored, with the algorithms being used to predict the customers' willingness to pay. A literature review on online fulfilment is also being prepared and should result in a paper to be submitted to an international journal (e.g., Omega). The application of GP to this problem is going to be explored in a consultancy project with Farfetch, which was prepared in 2021 and is starting in 2022.

6.8.3 Innovation Outcomes in 2021

During 2021, CEGI continued to collaborate with industry and services, providing specialised consultancy and developing state-of-the-art solutions to support their daily activity.

Project MINE4HEALTH (now IPO Gentil) resulted in the development of a system capable of extracting and synthesizing dozens of pages of clinical diaries in a simple dashboard, which allows a quick analysis by health professionals. In addition to the clear benefit for clinical practice, the system also facilitates the extraction of indicators for research purposes, as well as management indicators for the monitoring of hospital management. A pre-production pilot will now start its operation in the Instituto Português de Oncologia's (IPO) emergency department. The project won Portugal Digital Awards 2021 in the “Best Future of Work Project” category.

Project BEST ORDER, which started with a small proof of concept in 2019, with only four pharmacies, is now in large-scale production, ensuring daily inventory management for more than 30 community pharmacies. Community pharmacies delegate to BEST ORDER the responsibility for forecasting the sales of their products (between three and six thousand products), as well as defining when and how much to order. Pharmacies can thus focus their efforts on better serving customers.

Within the area of Power Systems, in 2021 project HEAD concluded the endeavour of creating failure probability and remaining useful life models for all major asset types of E-Redes. The final asset type was the OCR, for which the historical records regarding failures and replacements was very limited and with significant technology modifications in the most recent units. As such, the project team had to combine the available information with expert knowledge from company technical staff to develop robust reliability indicators, which are now adopted to manage the OCR pool.

Within the same area of intervention, European project XFLEX achieved important breakthroughs in the methodology to define a holistic health index (HI) for the complete hydro power system. The methodology uses Data Envelopment Analysis to create a composite indicator that aggregates the information of the several performance measures. The resulting HI is embedded into a mathematical programming model to optimize the operating points of the hydroelectric unit. Preliminary results show several advantages over the current HI definitions.

European project POCITYF also achieved several goals in 2021. Within Service Engineering, the organisation of cocreation sessions, workshops, and interviews to develop Citizen Engagement Strategies, are worthy of highlight. The Centre researchers also created a Citizen Engagement Plan to guide the implementation of engagement initiatives in the cities involved in POCITYF (Lighthouses & Fellow Cities). A Social Engagement Monitoring Framework was also developed, based on the Social Key Performance Indicators (KPIs) of POCITYF. The framework sets the monitoring approach for all the cities involved in POCITYF in terms of timeline, data collection, and data reporting, focusing on the operationalisation of the Social KPIs.

Results from project "Transformer 4.0 – Digital Revolution of Power Transformers" included a mathematical model for determining optimal maintenance policies, using important variables on power transformer operation. Such model was materialised in a MSc dissertation that, in particular, analysed the impact of maximum load on the optimal maintenance schedule along a transformer’s lifetime, including support of independent maintenance of various components. Some partial simulation models for power transformers have been included in the model, using hybrid physics- and predictive-maintenance techniques. More detailed models are awaiting development of a digital-twin.

6.8.4 Activity Overview

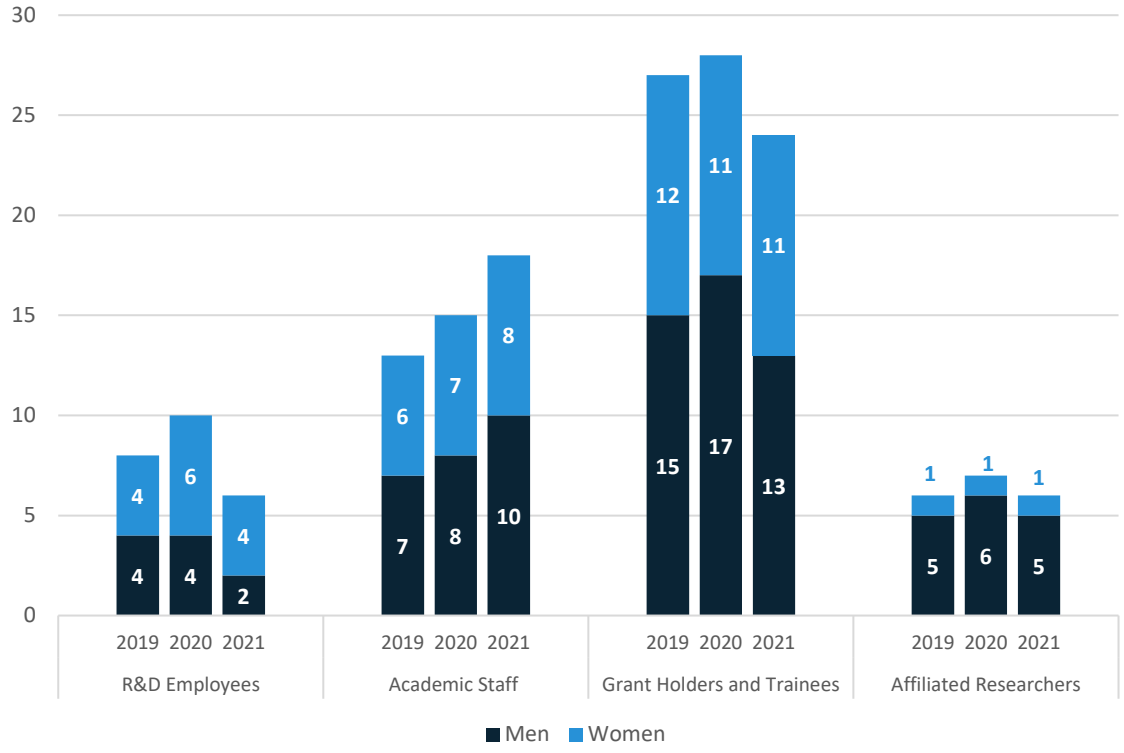


Figure 6.8.1 - CEGI - Research team evolution

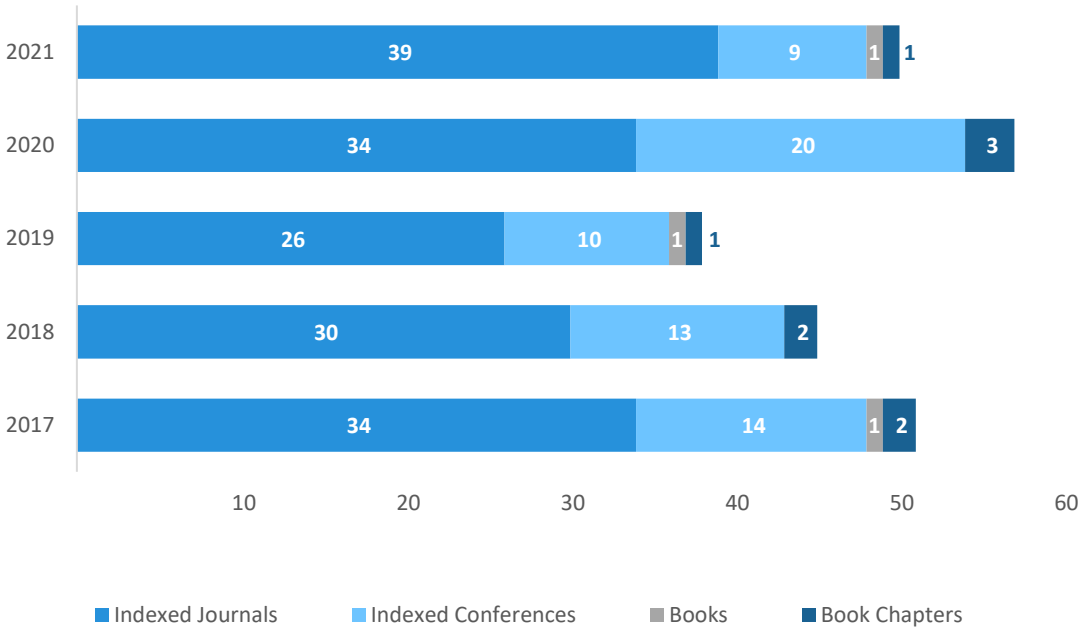


Figure 6.8.2 - CEGI - Evolution of publications by members of the Centre

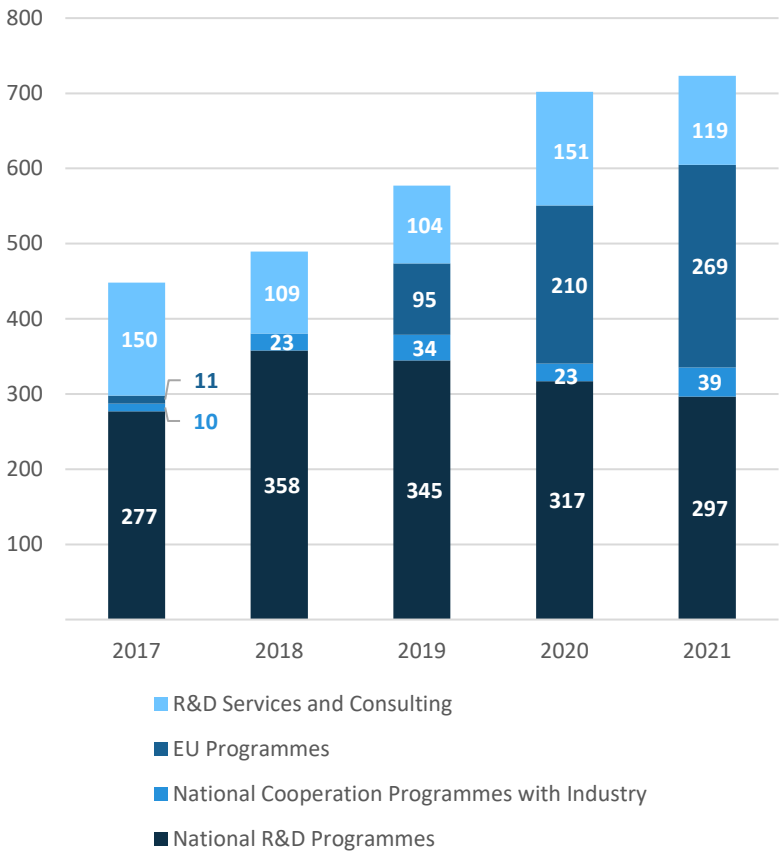


Figure 6.8.3 - CEGI - Project funding evolution (k€)

6.9 CITE – CENTRE FOR INNOVATION, TECHNOLOGY AND ENTREPRENEURSHIP

Coordinator: Alexandra Lobo Xavier

6.9.1 Presentation of the Centre

CITE aims to contribute to maximising the value and impact of R&DI outputs, empowering researchers, public and private organisations, entrepreneurs and citizens in the Process of Innovation. The overarching objectives of the Centre are: to leverage research outputs for market uptake and society benefit by empowering researchers and organisations in the process of innovation, technology management and technology valorisation; to foster an entrepreneurial mindset in research communities, business and society in order to generate new technological concepts and new business models to address socio-economic challenges; to act as a cross-cutting Centre across Scientific Domains and TEC4s at INESC TEC, contributing with the development of methodologies, frameworks and tools to support R&D management and technology exploitation.

CITE pursues the following Research Lines (RL): RL1 – Innovation Management (IM) and the Fuzzy Front End of Innovation (FEI); RL2 – Technology Management and Policy; RL3 – Business Model Innovation; and RL4 – Co-creation Methodologies for Customer Centric Innovation to Support Entrepreneurship.

The scope of the Centre's activities encompasses: developing theories, concepts, models and tools, to support Innovation and Technology Management, the Front End of Innovation, and Technology Exploitation strategies, with a focus on technology driven innovation; addressing current and future challenges of Responsible and Sustainable innovation; applying the above to SMEs, entrepreneurial projects and start ups; exploring diverse research methods – quantitative and qualitative, with a focus on action research and design science research; applying the outputs of R&D activities in consulting and executive training programs.

To foster an entrepreneurial mindset in research communities and society, CITE operates the Laboratory for Technological Entrepreneurship of INESC TEC (LET-In), which offers accelerator programs, training, mentoring, and 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 2021

In the topic of new frameworks for the FEI (RL1), three new developments have been proposed: (i) "The Entrepreneur and the Investor Perspective on the Investment"; (ii) "Using a Research Domain Ontology as a Driver for Technology Commercialisation"; and (iii) "Modelling Technology Innovation Commercialisation (TICO) Activity in Academia and Industry – An Ontology."

CITE submitted three proposals to FCT's call: (i) Measuring Innovation Performance in Food Vegetable Value Chains: A Responsible Research and Innovation & Ethics perspective (proposal led by a CITE member); (ii) Digital technologies and transformation of the teaching-learning-assessment processes: Pre and post COVID-19 (led by a CITE member); (iii) Enhancing the benefits and societal impact of university-industry R&D collaborations. Although not approved, the proposals contributed to strengthening important partnerships and will be improved and resubmitted in the next call. (RL1,2,3)

The Centre submitted five proposals to European Programs in Knowledge Management, Responsible Innovation Assessment, Open Innovation Methodologies and Business Model Innovation. Three projects have been approved for funding starting in 2022 (FIRE_RES, SoTecIn Factory, VR2Care). (RL1,3,4).

CITE is present in Active and Healthy Ageing partnerships (as result of EIP_AHA) namely in the SAFE consortium (28 countries) and in international and national thematic networks for "Smart Healthy Age-Friendly Environments", and also in the Food-Waste national task force. (RL1,2,3). A CITE senior researcher also supervised a summer trainee resulting in a State-of-the-art Review on Medical Devices Technology Assessment. (RL1)

CITE's research team had a participation in the Scientific Committee of the VII Conference on Entrepreneurship Education – CEE2021 held at the Federal University of São Carlos (UFSCar), SP – Brasil.

One of CITE's researchers is co-editor-in-chief of the Journal of Innovation Management, an open-access, multidisciplinary peer-reviewed journal hosting a cutting-edge debate on innovation and its management,

whatever form and facet it takes and embracing the technological features, managerial processes, and impacts of innovation. The journal is indexed in Scopus since January 2021.

6.9.3 Innovation Outcomes in 2021

LET in, the Laboratory for Technology Entrepreneurship

In 2021 CITE submitted three proposals to EIT Manufacturing| Business Creation. Three accelerator programmes have been accepted for funding starting in 2022 (Teck2market, GreenManufacturing, Demo4 Green). All the programmes aim at contributing to the development of Sustainable Manufacturing and Ecoinnovations. During 2021, the Centre coordinated one international accelerator programme – EIT Jumpstarter 2021 – and also organised two dissemination events, coached 10 international teams, provided expert training and coaching to five national teams, and evaluated 10 business plans. Three of the five teams trained by CITE won 2nd prize on their KIC category.

CITE followed the investment process of Insignals Neurotec, acting as Ignition Partner and within the scope of the investment relationship with Portugal Ventures.

Innovation Management Consulting Activities and Standards

Two advanced consulting contracts for implementation of Innovation Management Systems have been executed during 2021, with the companies Bondalti and Agroinsider.

Under the research contract with the company EurA, CITE is developing a study to identify and analyse practices leading to successful matching of organisations seeking to develop joint innovation projects.

CITE kept its active contribution to the International and National Technical Committees for Innovation Management (ISO TC 279 and CT169), as a national expert in Working Group ISO56008 – Guidance standard on innovation operation measurements and metrics – and as a participant in the review of NP4457:2007 according to ISO 56002:2019 – Innovation Management Systems – Guidance.

EEN Portugal and EEN Innovation Journey

The active role in the Enterprise Europe Network (EEN) builds on INESC TEC's reputation as an interface organisation, working closely with companies, including start-ups and scale up companies, and on former successful enterprise-based network / enterprise-oriented projects. Under the umbrella of EEN projects, in 2021 CITE completed the programme cycle by delivering a total of 112 expert services – 58 advisory and partnering support services, and 54 innovation advisory services.

Executive Training

CITE submitted a proposal to EIT Manufacturing (project Turing) to design and implement a personalised and flexible digital enhancement training program for SMEs, aiming to re-skill and up-skill employees in Digital Transformation. The proposal has been accepted for funding starting in 2022.

During 2021, INESC TEC organised and delivered several advanced training activities, exploring Innovation topics: the masterclass "From Innovation to Operations: The Management of new technology implementations", UT Austin Portugal Annual Conference, October 21, Porto, Portugal; the online course "Responsible Innovation", UT Austin Portugal, 27th, 28th, 30th of September, and the 1st of October, Porto, Portugal; the workshop "Challenges in adoption implementation and use of technologies in health sector", Biomedical Engineering Summit, 2021, 3-5 September; and an innovation-training course in Nigeria, promoted by Dr. Deseye (Oye) Umurhohwo, Founder of Innovate4Africa with the topic "Innovation Awareness: the value of Network and Stakeholders".

6.9.4 Activity Overview

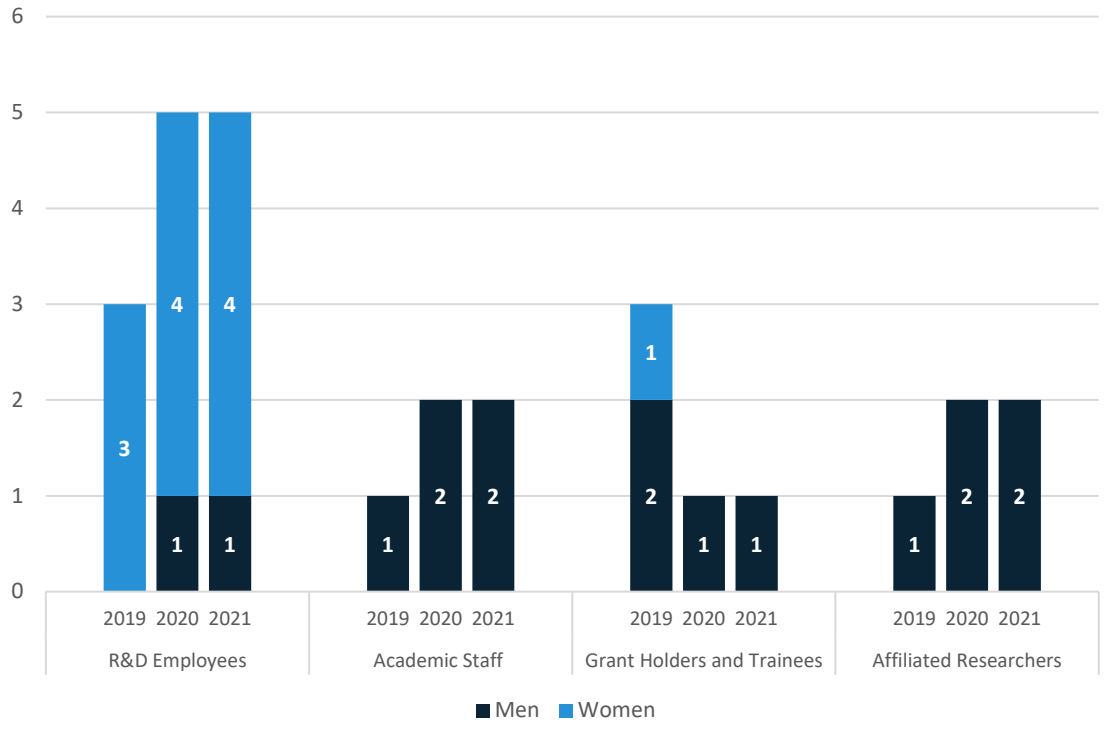


Figure 6.9.1 - CITE - Research team evolution

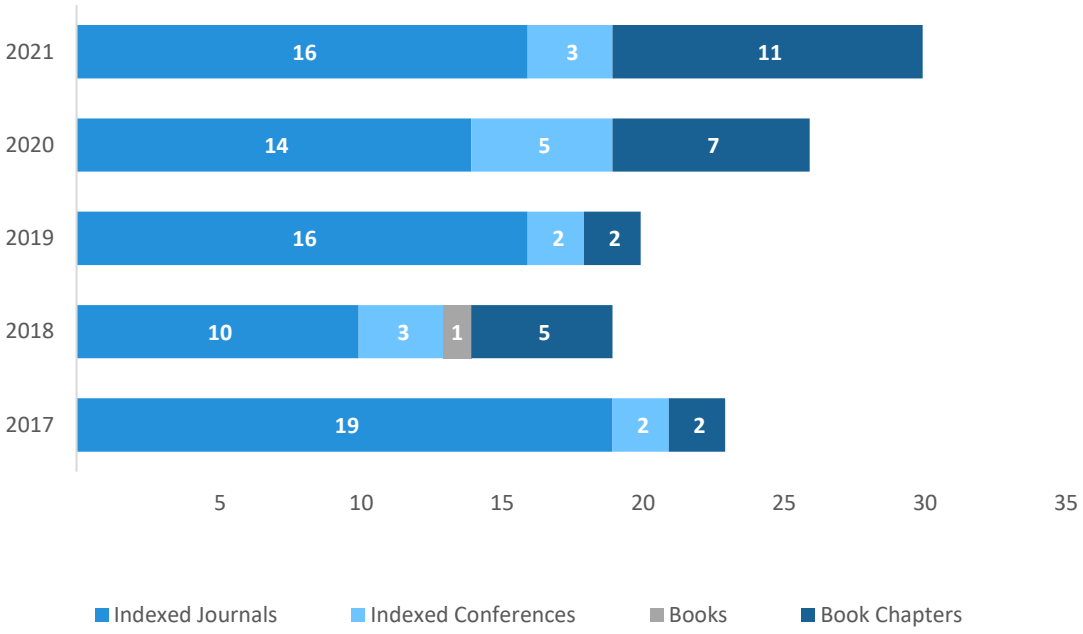


Figure 6.9.2 - CITE - Evolution of publications by members of the Centre

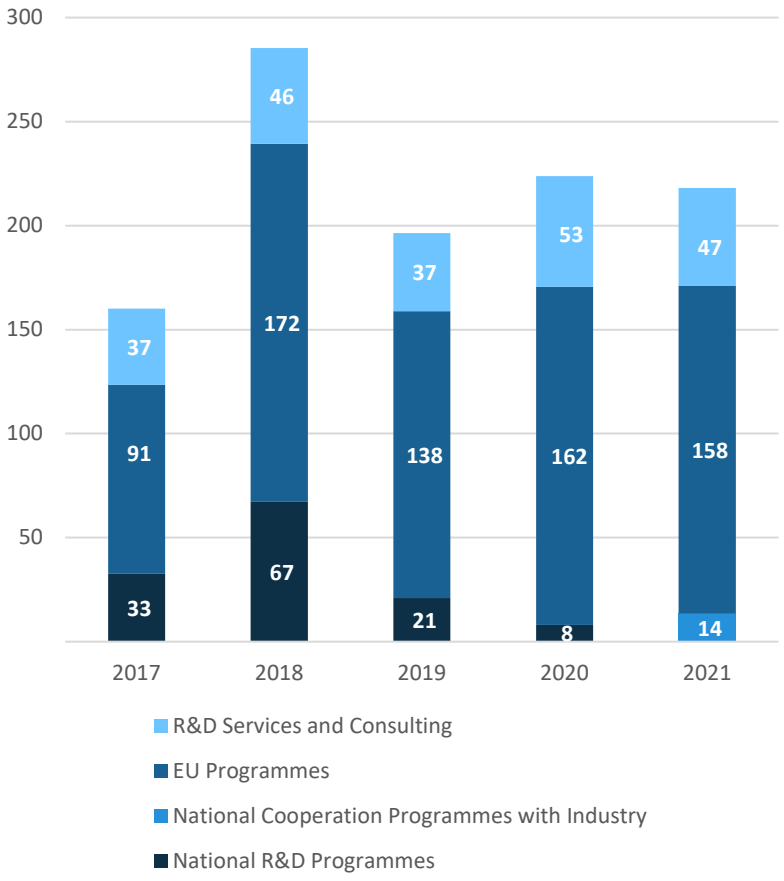


Figure 6.9.3 - CITE - Project funding evolution (k€)

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

In 2021, CSIG moved firmly towards the vision of an interdisciplinary centre focused on research at the forefront of human-centered computing (HCC) with broad and deep expertise in computer science (CS) and information science (IS). At the Centre, engineers, scientists, and designers focus on research and development of software systems, methods, and tools, capable of leveraging human abilities and practices within their communities and environments. Our mission is to pursue high-quality research, innovation, consultancy, and technology transfer, in close cooperation with academic and industrial partners. We focus on five main research areas and four innovation areas, detailed below.

Furthermore, we are also strongly committed to training young researchers and professionals, with a significant track record in the supervision of master and PhD students. Presently, our researchers originate from the University of Porto (UP), Polytechnic of Porto (IPP), University of Trás-os-Montes e Alto Douro (UTAD), Universidade Aberta (UAb), and University of Minho (UM).

6.10.2 Research Outcomes in 2021

Computer Human Interaction (CHI). The CHI group (formerly Accessibility and Assistive Technologies group) worked on several research activities and projects, leading to multiple indexed scientific publications. namely In the PAFSE H2020 project, the team has been contributing with the communication and dissemination strategy, having just started to plan specific case studies of Portuguese Northern schools. In the Walking PAD project (granted by NORTE2020, EU, FCT), the development of a proposed virtual assistant is currently a work in progress. Furthermore, the team also organised the International Conference of Innovative Technologies and Learning – ICITL 2021 (https://icitl.org/).

Computer Graphics and Interactive Digital Media (CGDM). The group has concluded a series of projects in R&D on Immersive Training for Industry 4.0. An authoring tool was developed to allow easy and intuitive training activities. This authoring tool is able to integrate multisensory immersive environments that are perceptually certified for training certification. With EIT Manufacturing, a recommendation engine has been developed to assist companies in deciding the best approach to immersive training. European project Feedback has been concluded and a gamification framework has been concluded that helps companies reduce energy costs by promoting behaviour change in their collaborators.

Information Management and Information Systems (IMIS). In the EPISA project (FCT) (http://episa.inesctec.pt), the team continued developing an ontology for archival records. The first version of the prototype for record navigation in linked data was deployed. A very successful international workshop (over 100 participants) was organised in the context of the TPDL'21 conference – Linked Archives'21 (http://linkedarchives.inesctec.pt).

Software Engineering (ES). Software engineering contributions are spread among several research topics and projects. In the iReceptor Plus (H2020) and Inno4Vac (IMI2/EU), the key contributions focused on the software development process, design and implementation of novel architectures using federated repositories, privacy-preserving mechanisms to support federated machine learning, and blockchain-based mechanisms for tracing data transformations. The researchers of the area were involved in the organisation of several international conferences, namely: 21st IEEE International Conference on Software Quality, Security, and Reliability, 13th Symposium on Search-Based Software Engineering (SSBSE 2021), Agility with Microservices Programming (AMP 2021), 14th International Conference on the Quality of Information and Communications Technology (QUATIC 2021), 28th International Conference on Pattern Languages of Programs (PLoP 2021), and 22nd International Conference on Agile Software Development (XP 2021).

Special Purpose Computing Systems/Embedded Systems (SPeCS). In the PEPCC project (FCT), the team continued exploring the generation of accelerator circuits from binary instruction traces for several instruction set architectures, including ARM, RISC-V and MicroBlaze, as well as analysis of memory access patterns based on dependency graphs. The team continued researching source-to-source compilation for several languages. It was proposed a new approach for robust multi-language analysis, validated with a use case based on code metrics.

On the C/C++ front, there was an exploration of advanced techniques for the application of memorisation, detection of code vulnerabilities and restructuring of source code to a streaming paradigm. The team contributed to the area of reconfigurable computing, by organising the event REC2021 and continuing the research on the approach for automatic code restructuring of C code for HLS and targeting FPGAs. This included analysis of the viability of using HLS for graph algorithms, in an HPC context, and automated hardware/software co-design, in an embedded context.

6.10.3 Innovation Outcomes in 2021

Geospatial Information Systems Engineering

Application of the OGC standard (SensorThings API) for IoT and decision support in climate change adaptations for viticulture (INFRAVINI P2020 project). Implementation of a catalogue of location-oriented information, compatible with the OGC standards and the INSPIRE Directive, for the implementation of search services (discovery services) and, with that, to provide HF Radar (High-Frequency Radar) data in open access (RADARONRAIA POCTEP project). Under TRIMAPSTRACK (P2020 project) the key contribution was creating a Digital Twin engine based on the 3D Tiles OGC (Open Geospatial Consortium) standard, designed for streaming and rendering massive 3D geospatial content. In SIGIPRO (P2020 project) we started to exploit the Geospatial Temporal Enablement applied to a document and process management system, allowing us to add the capacity of geolocation and spatial-temporal geoprocessing in a business process, in an integrated way.

Personalised Health Research (PHR)

PM4PHR had 4 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. iReceptor Plus implemented and tested a repository-agnostic security middleware on different ADC-compliant repositories for immunogenetics. Furthermore, it developed a proof-of-concept implementation of a block-chain based approach for the traceability of transformations used in the processing of human RNA data. ImmuneML, a DSL for Machine Learning on the Immunology application domain, was published on Nature Machine Intelligence in collaboration with our partners from the University of Oslo. 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, with the goal of implementing an in-silico platform to accelerate vaccines development, was started in 2021.

Earth, Ocean, and Space Science (EOSS)

Under H2020 MELOA, a software ecosystem for the real-time processing of geospatial data streams was prototyped and tested, along with tools and methods for the assisted curation and exploratory analysis and publishing of large scientific datasets. In the MarRISK project, a platform incorporating the semantic interoperability of data from IoT platforms was extended and the extraction of climate change indicators prototyped. Project FCT MOST prototyped and tested a platform that incorporates libraries for efficient spatiotemporal data-access for handling data input to visualisation pipelines, the automatic representation and quantification of change on spatiotemporal phenomena, and its summarisation through static visual narratives. From this work, a new Improved Interval B+ Tree (I2B+Tree) was proposed. The group is engaged with activities in Collaboratory for Geosciences (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.

Information Systems and Applied Computing (ISAC)

ISAC had 6 active specialised consultancy projects, of which we highlight the following aspects:

- DigCore project produced a transformation plan for a SME to implement in the next two years, composed of a set of projects that will enable the migration from the current architecture to the future information systems architecture aligned with the company's business strategy.
- In the PGDados project, the maturity of the Master Data Management process of a Portuguese Bank was assessed in terms of Data Governance, Data Strategy, Data Quality, Data Operations, Architecture & Platform, and Support Processes. This provided the basis for an Action Plan at strategic, tactical and operational levels, to improve the maturity of these processes.

- mobData4Urb and Data4CiMob projects supported collaborations with Quadrilatero Urbano association, which includes the municipalities of Barcelos, Braga, Famalicão and Guimarães. Inspired by the C-Streets European program, they defined an architecture for data integration in Minho Access Point (MAP) and its interoperability with the municipal, intercity, and national Access Points, concerning various mobility services.

6.10.4 Activity Overview

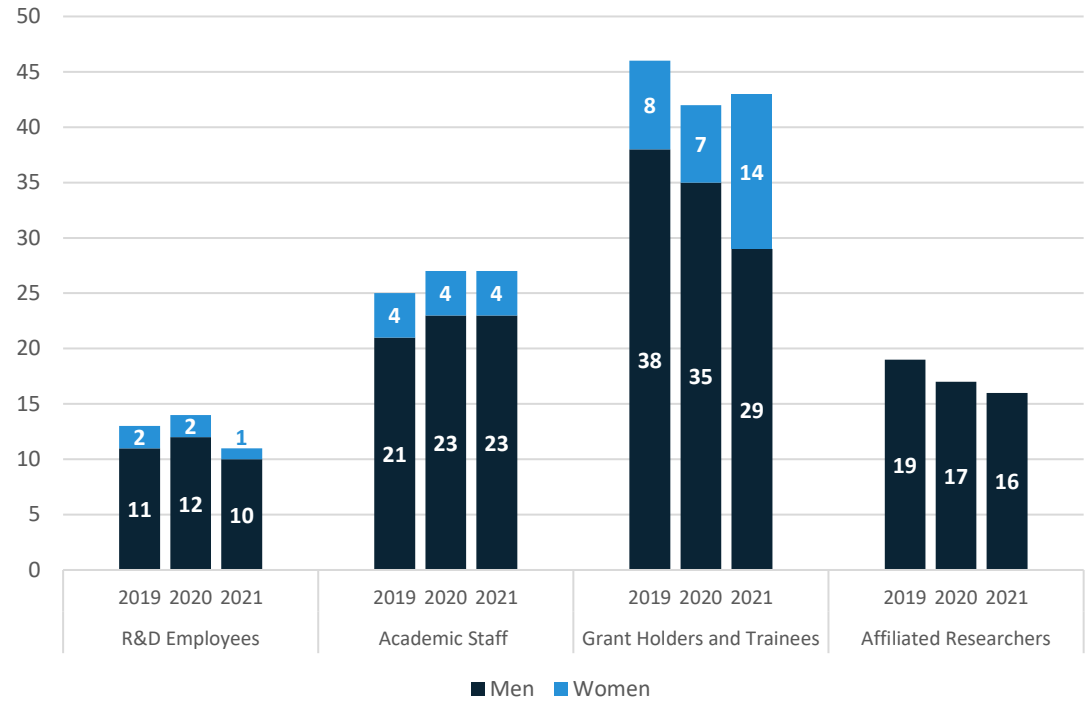


Figure 6.10.1 - CSIG - Research team evolution

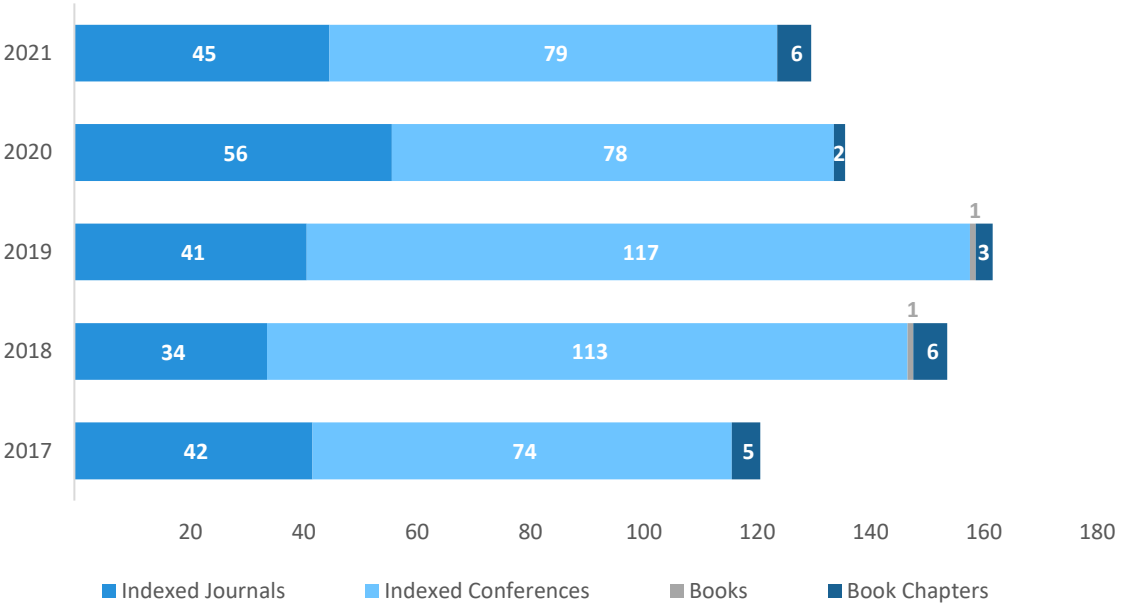


Figure 6.10.2 - CSIG - Evolution of publications by members of the Centre

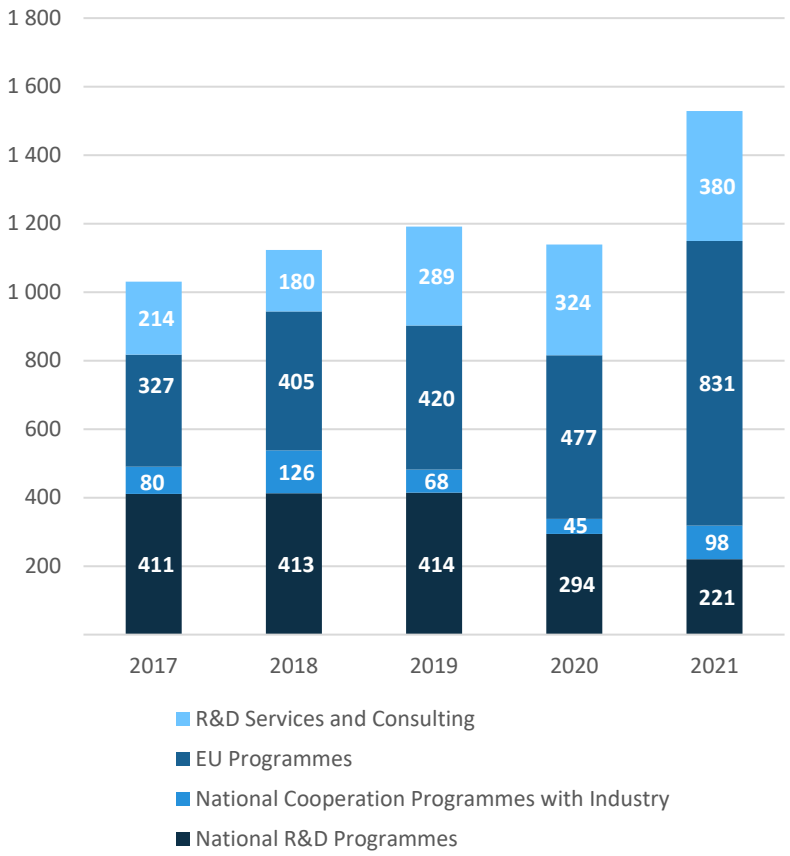


Figure 6.10.3 - CSIG - Project funding evolution (k€)

6.11 LIAAD – ARTIFICIAL INTELLIGENCE AND DECISION SUPPORT LABORATORY

Coordinator: Alípio Jorge

Assistant to the Centre Coordination: Ricardo Sousa

6.11.1 Presentation of the Centre

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

LIAAD aims at producing 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 2021 LIAAD had a total of 122 members, with 29 core researchers and 19 grant holders and trainees. 22 of the researchers were Academic staff mostly from the University of Porto.

6.11.2 Research Outcomes in 2021

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 26 of the 39 published journal papers. Other strong areas are **Modeling and Optimisation** (7 papers) and **Mathematical Modeling** (5 papers).

In the European **Network of Excellence on Artificial Intelligence,** which started in 2020, LIAAD has been involved in a few 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, SIGIR Forum, DSAA and the Computational Linguistics Journal. We organised Text2Story2021, 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). Ricardo Campos received the Vannevar Bush Best Paper Award at JCDL 2021.

In **Large Scale ML** LIAAD organised new editions of the Data Streams track at ACM SAC 2021, the IoT Stream for Predictive Maintenance workshop at ECMLPKDD 2021 and the SoGood workshop (data mining for **social good**), also at ECML/PKDD. We successfully organised DSAA 2021, the core A conference on Data Science and Advanced Analytics. European project XPM (Chist-Era) was officially launched. Bruno Veloso and Pedro Campos received best paper awards in two different events.

6.11.3 Innovation Outcomes in 2021

- Our work in NLP, in collaboration with CEGI, for IPO Porto was indirectly awarded as IPO Porto received a **Portugal Digital Award** mainly for featuring our information extraction and summarisation pipeline.
- We finished our collaboration with **Outsystems** on an AutoML pipeline.
- We participated in project **Port XXI**, funded by ESA - the **European Space Agency**, to prospect the use of data science in port management.
- We started **7 national projects** with companies and organisations.
- We participated in the European EIT project AI-Sov in collaboration with **Sonae Arauco**.
- We finished project FailStopper with **Metro do Porto**.

6.11.4 Activity Overview

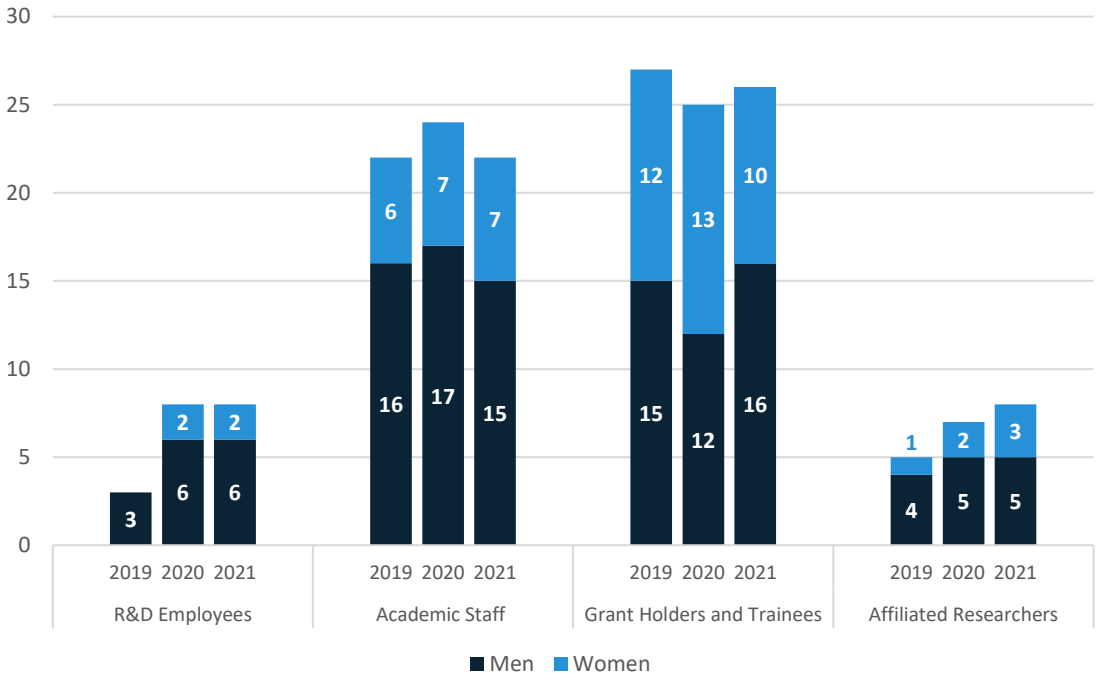


Figure 6.11.1 - LIAAD - Research team evolution

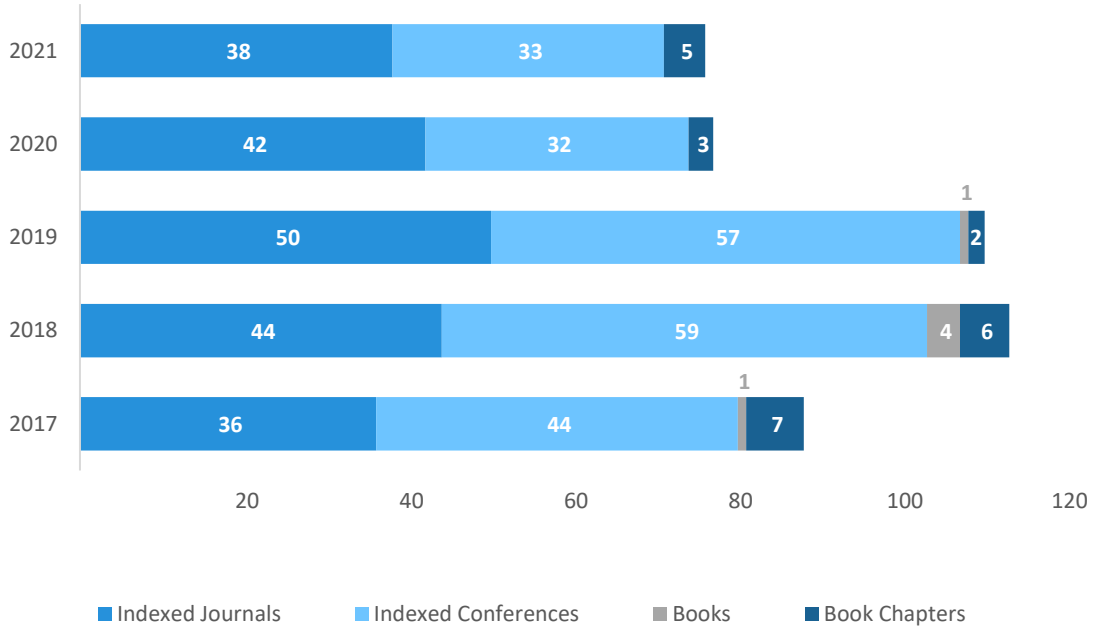


Figure 6.11.2 - LIAAD - Evolution of publications by members of the Centre

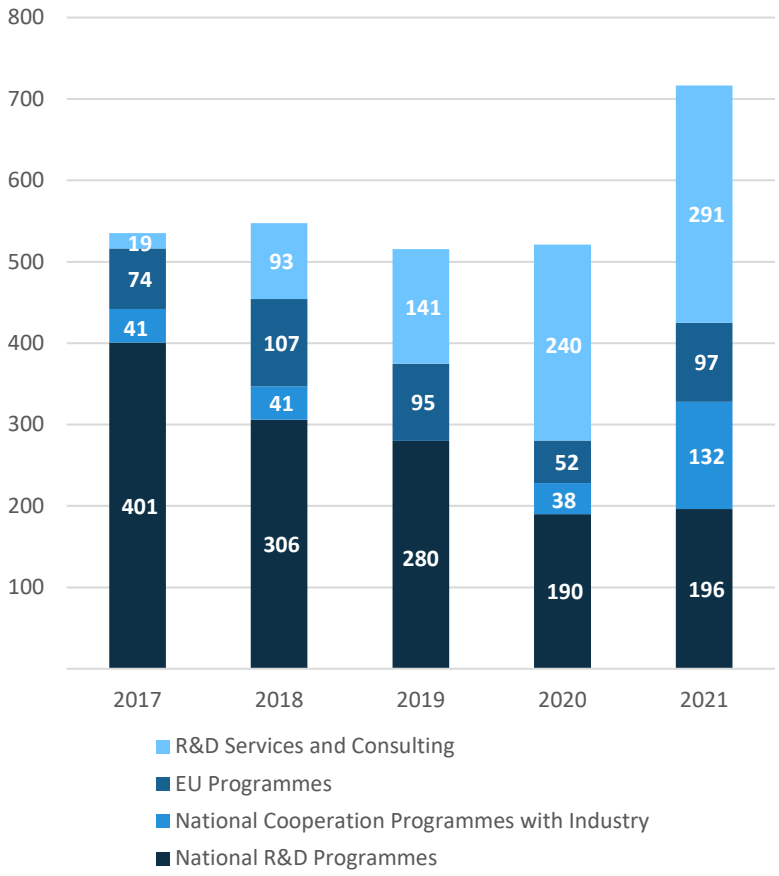


Figure 6.11.3 - LIAAD - Project funding evolution (k€)

6.12 CRACS – CENTRE FOR RESEARCH IN ADVANCED COMPUTING SYSTEMS

Coordinator: Ricardo Rocha

6.12.1 Presentation of the Centre

CRACS pursues 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 research team stabilised in the last years, from 37 researchers in 2019 and 34 in 2020 to 37 researchers in total in 2021. The core research team includes mostly faculty members at the CS department at FCUP for a total of 18 PhD researchers in 2021 (one less than in 2020).

6.12.2 Research Outcomes in 2021

A key goal for 2021 was to maintain CRACS's international visibility, notoriety and publication output, after the significant improvement observed in 2020. In fact, in 2021, there was an increase in the number of participations as editor in journals, from 5 in 2020 to 18 in 2021, and in the total number of publications in indexed journals and conferences, from 51 in 2020 to 54 in 2021, and we achieved similar outputs for the number of participations in program committees of international events, from 43 in 2020 to 41 in 2021, and for the number of international events organised by CRACS members, from 7 in 2020 to 6 in 2021. In particular, CRACS's members were involved in the organisation, as General and Local Chairs, of the 37th International Conference on Logic Programming (ICLP 2021), the best known and recognised international conference in Logic Programming (online event with 200 worldwide participants). We would like to emphasise also our participation in project Theia, a new P2020 project with Bosch Braga, and our award in the 2021 Autopsy Module Development Contest. In what follows, we enumerate in more detail CRACS's main research achievements in 2021.

- Logic programming: (i) stabilisation work on the Yap Prolog system and improved documentation; (ii) development of semantics and implementation for a type system; (iii) integration with docker.
- Lock-freedom: novel lock-free elastic design for a trie-based hash map that automatically resizes the internal data structures that support the hash map operations in order to meet varying workloads. Experiments show that elasticity effectively improves the search operation.
- Quantum complexity: for various computational problems, the best-known quantum algorithm performs quadratically better than the best-known classical algorithm. We have shown that, under a certain complexity-theoretic assumption, the best possible quantum speed-up for all these problems is quadratic, so, for the various problems we studied, the current known quantum algorithms are the best possible.
- Type theory: our previous work on type languages based on records for event processing led to the development of a polymorphic record calculus with extensible records, which is a very useful structure when dealing with event processing operations. We have developed a static type of system for this calculus and a sound and complete type inference algorithm. Most ML-style polymorphic record calculi that support extensible records are based on row variables. We presented an alternative construction based on extensible types.
- Mobile edge clouds: we developed Jay, a system that allows mobile offloading application developers to seamlessly test their creations under different hybrid cloud topologies, task type and distribution and offloading algorithms. This research takes place in the scope of the Safe Cities project, following up on previous work from the Hyrax project (CMU/Portugal).
- Machine learning: (i) novel language for the generation of neural networks, and corresponding parameter and structure learning algorithms; (ii) development of sampling techniques for the evaluation of rare events (highly skewed data sets).
- Graph mining: (i) development of an open-source semantic web crawler capable of traversing the linked data cloud starting from a set of seed resources; (ii) a thorough and systematic survey of the extensive state of the art in subgraph counting and network motif discovery; (iii) thorough and systematic survey

of time series analysis via Network Science; (iv) a novel methodology for computing football players' similarities using the topology of the network of passes.

- Microsatellite screening: novel pipeline, named Micro-Primers, designed to identify, and design Polymerase Chain Reaction primers for amplification of Microsatellites loci from a multi-individual Microsatellite library. Micro-Primers significantly reduces the processing time, in comparison to manual analysis, while keeping the same quality of the results.
- Automated assessment: new tools to support gamification of programming exercises, such as an authoring tool, programming exercise converters, and an API to exercise repositories. Definition and prototyping of an algorithm to assess web interfaces based on visual properties.
- Fake news detection: development of a novel process to identify bots and creation of a model to automatically balance the need for information regarding volume and time.
- Trust, privacy and security: (i) controlled, policy-based and confidential searching/sharing of Indicators of Compromise (IoC) available in a group of Malware Information Sharing Platform (MISP), which makes use of encrypted search mechanisms and of a shared encrypted reverse-index of IoCs; (ii) an efficient and secure distributed K-Means algorithm, that is robust to non-IID data; (iii) a novel controller-based architecture to deploy adaptive causal network coding in heterogeneous and highly-meshed communication networks; (iv) integration of secure enclaves for hardening cryptographic secrets, keys and certificates; (v) better authentication for Fiware devices; (vi) hardening of apache webserver through the use of secure enclaves; (vii) development of a fault injector for distributed protocols (best paper at NSS 2021).
- Digital forensics: development of an autopsy module, named MF_Detector, for the Autopsy digital forensics tool to detect manipulated photos, namely deep fakes, splicing and copy-move manipulation types. The module processes photos using a Support Vector Machine based method to evaluate the features previously extracted and to assign it a probability of the photo being manipulated. The module can be valuable to automate and speed up the detection of tampered digital photos, and to assertively search the most relevant artefacts. This work won the second place in the 2021 Autopsy Module Development Contest and is available at https://github.com/saraferreirascf/Photo-and-video-manipulations-detector.

6.12.3 Innovation Outcomes in 2021

In what follows, we enumerate CRACS's main innovation achievements in 2021:

- Biolens: a citizen science tool for evaluating ecosystem health. We use artificial intelligence techniques to develop models that allow the automatic identification of biological taxa that are sensitive proxies for ecosystem health (https://rubisco.dcc.fc.up.pt/biolens/). Currently we have models for odonata (dragonflies and damselflies), lepidoptera (butterflies and moths) and for the Portuguese flora. The models are available online and via mobile apps so that users can photograph a species, submit the information to a server and get an automatic suggestion for the identification of the living being in the photo. The project is a collaboration with Parque Biológico de Gaia, the Portuguese Botanical Society and the Museum of Natural History and Science at UPorto.
- Indoor location of mobile devices: we use multiple techniques to tackle the problem of seamless indoor location, namely dead reckoning, trilateration and computer vision. The goal is to create non-intrusive, energy efficient, algorithms to locate mobile devices inside a building. We have a complete prototype of such an infrastructure based on two technologies: Bluetooth beacons and computer vision (that uses the camera of the devices). Ongoing developments with Bosch Ovar also employ WiFi-RTT and UWB beacons. This research takes place in the scope of the Augmanity and Safe Cities project in collaboration with Instituto de Telecomunicações (IT), FEUP, Bosch Ovar, Bosch Aveiro and the Museum of Natural History and Science at UPorto/Galeria da Biodiversidade.
- Automated assessment (FGPE+ and JuezLTI Erasmus+ projects): integration of computer programming ecosystems in learning management systems in order to allow programming instructors and students in the teaching-learning process of computer programming education.

- Wireless networks: prototype implementation in software-defined radios (SDR) of physical-layer security mechanisms for wireless networks.

6.12.4 Activity Overview

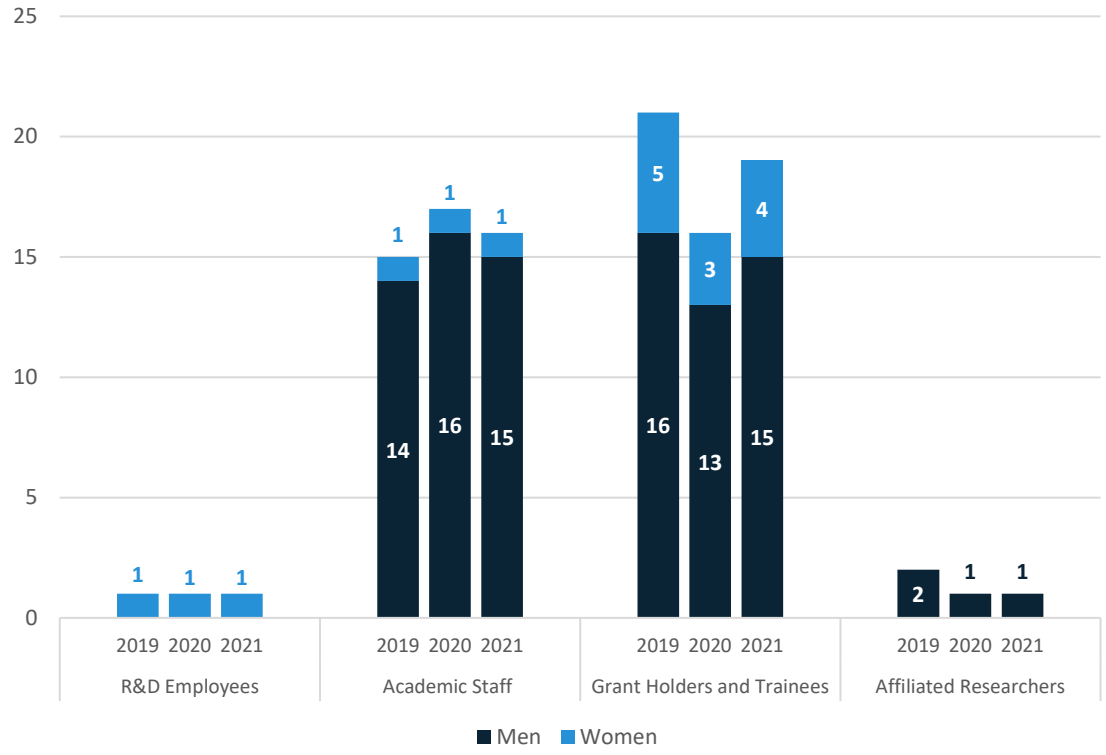


Figure 6.12.1 - CRACS - Research team evolution

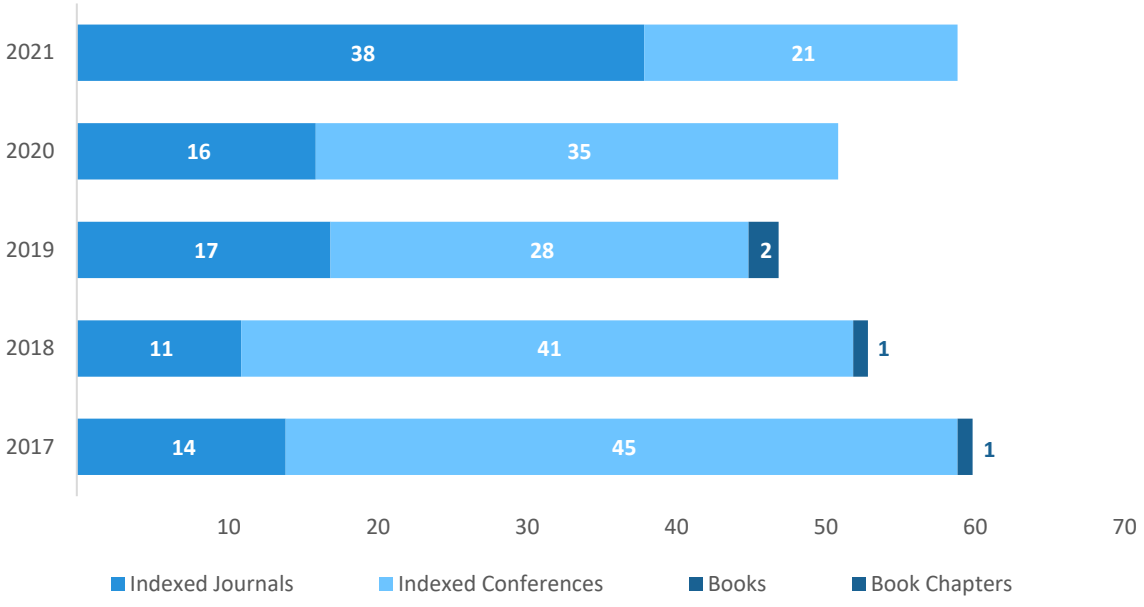


Figure 6.12.2 - CRACS - Evolution of publications by members of the Centre

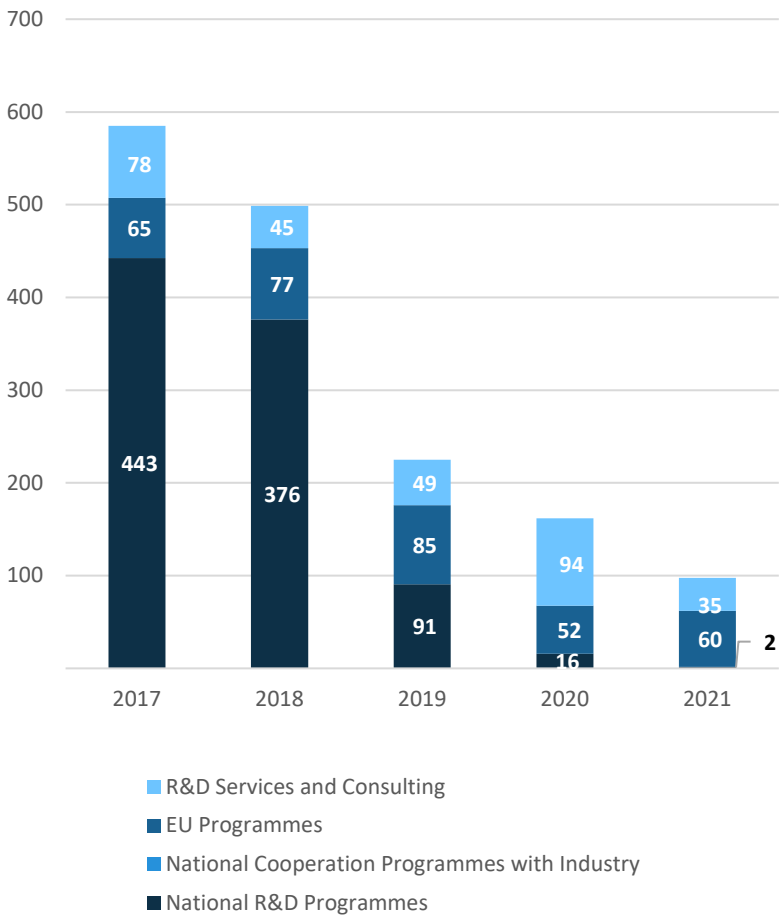


Figure 6.12.3 - CRACS - Project funding evolution (k€)

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. To accomplish this mission, HASLab covers three main competences within INESC TEC Computer Science domain — Software Engineering, Distributed Systems, and Information Security — complemented by other competences such as Human-Computer Interaction, Programming Languages, or the Theory of Computation. In particular, HASLab research focus on:

- Software Engineering – methods, techniques, and tools for rigorous software development, that can be applied to the internal functionality of a component, its composition with other components, as well as the interaction with the user;
- Distributed Systems – improving the reliability and scalability of software, by exploring properties inherent to the distribution and replication of computer systems;
- Information Security – minimise the vulnerability of software components to hostile attacks, by deploying structures and cryptographic protocols whose security properties are formally proven.

Concerning innovation, HASLab aims to provide solutions — combining theory, methods, languages, and tools — for the development of complete ICT systems that provide strong high-assurance guarantees to their owners and users.

6.13.2 Research Outcomes in 2021

In 2021 HASLab continued to produce high-quality research together with renowned international partners. In particular, we would like to highlight three achievements:

- The information security group continued to make progress on its long-term goal of deploying structures and cryptographic protocols whose security properties are formally proven and published three CORE A* papers on this topic at the ACM Conference on Computer and Communications Security (CCS), one of the most important conferences in this area. These papers were also joint work with key international partners in this area, namely SRI International (USA) and the Max Planck Institute for Security and Privacy (Germany).
- The distributed systems group researched novel storage solutions, namely in the context of the PASTor and BigHPC projects, in collaboration with UT Austin, TACC, Hood College (USA), and AIST (Japan). This research already led to several papers co-authored by AIST researchers, including one CORE A.
- The software engineering group saw its long-term research on formal methods, namely related to the popular Alloy formal specification language (first developed at MIT), be internationally recognised with the release of Alloy 6, a new version of the language that incorporates major contributions developed by HASLab in collaboration with ONERA, the French aerospace lab.

In terms of research projects, we highlight the acceptance of three new FCT funded projects, two in the area of formal methods and one in the area of energy efficient networking, which will focus on fundamental research at low level TRLs.

Regarding internationalisation, in 2021 HASLab was involved in the organising committee of eight international events (conferences and workshops). Moreover, HASLab organised four webinars as part of the BigHPC and AIDA projects (focusing on topics such as Big Data, HPC, and 5G, edge computing and privacy), one tutorial at a top international conference. Jácome Cunha was also elected as chair of the IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC) Steering Committee, a premier international forum for research on this topic.

Concerning young researchers, as planned, we established a tutoring programme for PhD students, where they will meet annually with the centre's coordination council to discuss the progress on the work plan. This

programme was very well received by the students and hopefully will contribute to decrease the mean time for PhD completion in the centre. We also continued with the HASLab internship programme to attract young researchers, namely MSc students, funded by BII grants. In 2021 this initiative involved 12 MSc students, one of which will pursue a PhD in the centre. MSc students were also involved in research that led to several publications at international venues, including one paper at SYSTOR, one of the key international conferences on the storage field. One MSc student also received a grant from the New Talents in Quantum Technologies programme, an initiative promoted by the Calouste Gulbenkian Foundation in 2021.

6.13.3 Innovation Outcomes in 2021

In terms of innovation, the main highlight of 2021 was the IDINA project - Inclusive Non-Authoritative Digital Identity – that won the IN3+ Award, promoted by the Portuguese Mint and Official Printing Office (INCM). This project aims to create an effective and inclusive identification platform open to all citizens, particularly, in countries with no encompassing central civil registration infrastructures. Related to the same topic, HASLab successfully concluded the MobileID project, also with the INCM, where a proof of concept was developed for the Mobile Driver's License (mDL).

Key ongoing projects in terms of innovation outcomes are the Interconnect and Sustainable HPC, European projects, both collaborations between HASLab and CPES. The Sustainable HPC is developing an innovative energy management solution that will make the operation of supercomputers more sustainable. In InterConnect, HASLab was partially responsible for establishing the interoperable reference architecture for cross-domain services, which is endorsed and used in Interconnect. Moreover, HASLab led the development of all software prototypes of the interoperability framework (a Key Exploitable Result of the project), and also focused on the communication and dissemination activities of the project, including engagement with EC initiatives that will shape the European interoperability roadmap.

Related to innovation in education, it is relevant to mention the ongoing ENSICO project, where HASLab researchers are collaborating in the goal of establishing / improving the teaching of Computer Science in Portuguese schools, namely by supporting the creation of innovative practices in the digital age, through new teaching tools, materials, and learning software.

Another relevant European project that initiated in 2021 is CircThread, that aims to make appliances truly sustainable - and where HASLab collaborates with CESE.

Key project proposals where HASLab was involved in 2021 include the AURORA project, where HASLab aims to work with BOSCH (in collaboration with CTM) to improve the data cycle and the development and processing of models to characterise the activity and emotions of passengers in autonomous vehicles, and the ATTRACT Digital Innovation Hub, which is a collaborative network comprehending specific digital competence centres, focusing on the dissemination and adoption of advanced digital technologies among companies – namely SMEs – by promoting their development and testing.

Finally, it is important to highlight that, in 2021, HASLab registered three invention disclosures, all related to novel storage solutions.

6.13.4 Activity Overview

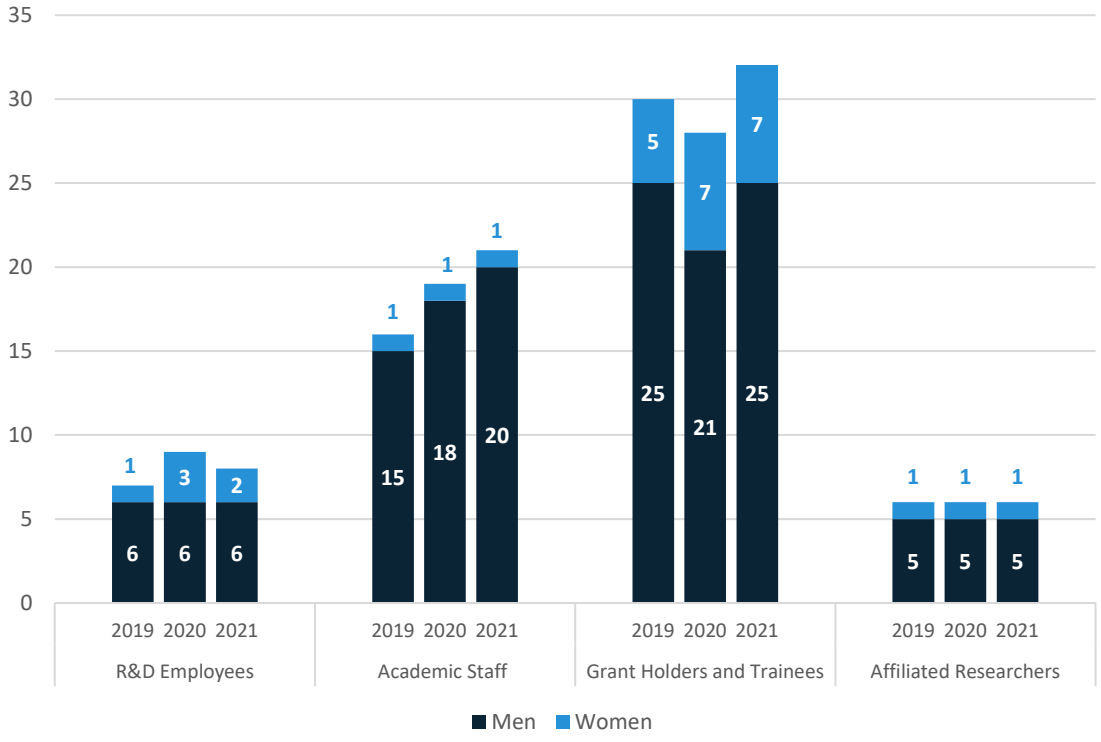


Figure 6.13.1 - HASLab - Research team evolution

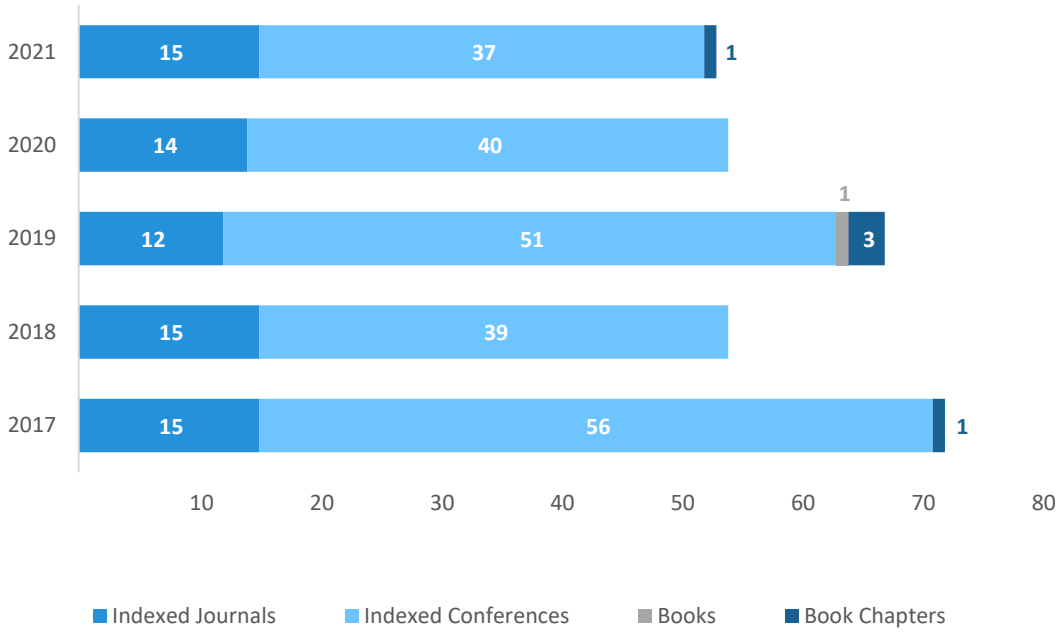


Figure 6.13.2 - HASLab - Evolution of publications by members of the Centre

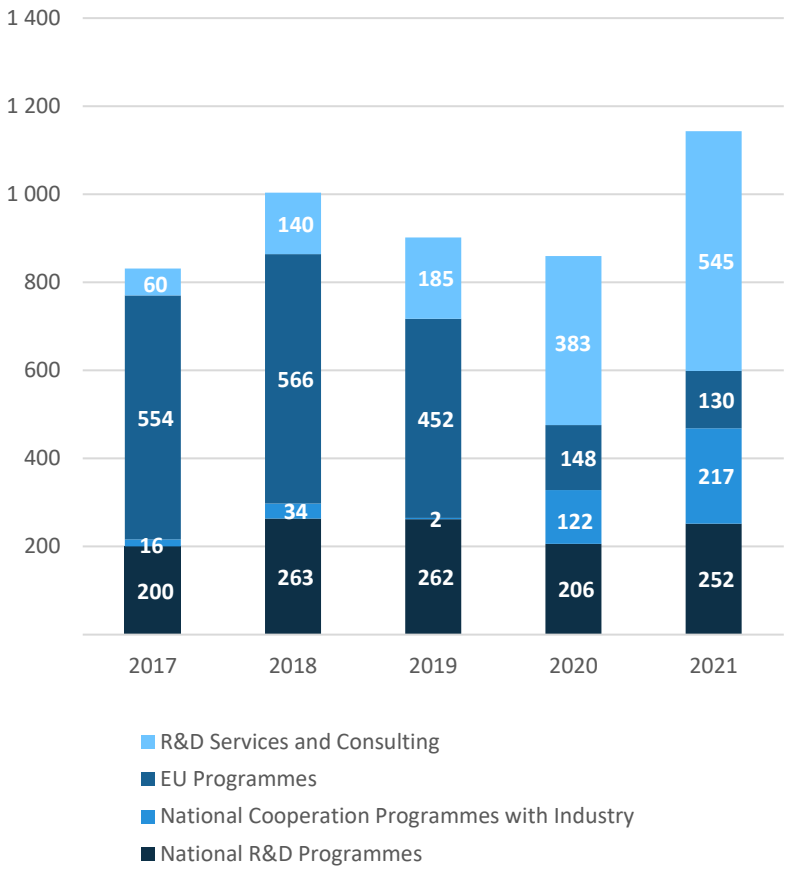


Figure 6.13.3 - HASLab - Project funding evolution (k€)

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 2021

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 that lead to extend the project for more four months until April 2022.

In 2021, the research vessel Mar Profundo was finally finished and tested during the REP(MUS)21 naval exercise in September 2021. In that exercise, Mar Profundo was used to test and deploy several underwater systems (Turtle Lander, EGIM, EVA and IRIS AUVs) during two weeks of the exercise. Showing its potential as a mobile laboratory at sea, hosting a team of researchers on board, and providing good working areas and infrastructure conditions for field research.

During 2021, the project and tenders for the support facilities in the Leixões harbor were done and started its implementation phase. 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 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 lead by IPMA (Instituto Português do Mar e da Atmosfera) and involving 15 other research institutions working on ocean science or technology, including INESC TEC.

The ultimate goal of EMSO-PT is to organise the Portuguese contribution to the EMSO-ERIC network, a large-scale European Research Infrastructure, networking fixed point, deep sea multidisciplinary observatories, with the scientific objective of real-time, long-term monitoring of environmental processes related to the interaction between the geosphere, biosphere, and hydrosphere. It is a geographically distributed infrastructure at key sites in European waters, spanning the Arctic, the Atlantic, and the Mediterranean, up to the Black Sea. It will be in place by the end of the decade.

EMSO identifies eight main scientific questions where advances are foreseen: 1) Dynamics of tectonic plates and magmatic systems; 2) Climate and greenhouse gas cycling; 3) Ocean productivity and ocean dynamics; 4) Marine mammal and fish stocks; 5) Non-renewable marine resources; 6) Episodes, events and catastrophes; 7) Origins and limits of life; 8) marine ecosystems dynamics. All these topics are dependent on long-term, continuous observations, able to capture significant episodes as they occur.

So far, the Portuguese participation in EMSO has been focused on the Azores and Cadiz nodes, in cooperation with France (Azores) and Italy (Cadiz) using two of the few available technological solutions for long term seafloor monitoring (ASSEM and GEOSTAR). Within the scope of EMSO-PT two sites will be considered close to the mainland: a deep water one, 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 2021

The main achievements of EMSO-PT during 2021 were:

- Participation in an oceanographic cruise organised by IPMA between Lisbon and Sagres, aboard the R/V Mario Ruivo, in May 2021. One the activities of the cruise was the deployment of the Slocum glider, to acquire oceanographic data: dissolved oxygen, conductivity, temperature, depth, fluorescence and chlorophyll;
- Operation of a Slocum glider for 12 consecutive days off the Atlantic coast of Portugal in September 2021. During the mission, the glider was surfacing every 2 hours to send information to the control station using a satellite communications link;
- Assembly and test 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;
- The developed EGIM system was deployed on Unicorn Seamount - Madeira Tore at 865m depth, between 24th November and 2nd December 2021, from IPMA Mario Ruivo Research Vessel;
- Launch of the public tender for the acquisition of two autonomous underwater 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 operationally and have been fundamental for the establishment of partnerships.

7.3.2 Main Achievements in 2021

The main achievement of the Robotics and Autonomous Systems Laboratory in 2021 were the following:

- Reorganisation of the physical space at the FEUP campus, with the separation into 5 dedicated areas: Electronics and instrumentation, System integration, Mission Control, Test tank, and PhD student area. Apart from these exclusive areas, the Laboratory also manages a shared space of the department of EEC at FEUP, including a machine shop and a testing area.
- Upgrade of physical space at the ISEP campus, adding a new entrance and road access for heavy and large vehicles access, improving the work area around the water test tank, and Upgrade of the workshop facilities (added new large-scale CNC, added new large volume 3D printer).
- Upgrade of robotic platforms taking advantage of ongoing projects:
    - Integration of Doppler Velocity Logs in the MARES AUV and DART deep water AUV, increasing the accuracy of the dead-reckoning navigation systems.
    - Development of a multipurpose ROV to support R&D activities in sonar mapping, underwater localisation, image processing, and fusion of sonar and image information.
- Development of a reconfigurable acoustic beacon to transmit arbitrary waveforms and to record underwater sounds.
- Development of a synchronised 4 channel underwater acoustic receiver to estimate time differences of arrival and provide localisation of acoustic sources.
- Acquisition of a set of underwater acoustic modems for testing real time communications with networking capabilities.
- Upgrade of the scientific instruments available with new sensors such as Hyper spectral cameras, navigation systems, LiDARS, Multibeam sonars, thermal cameras, and several underwater sensors.
- Training of technicians to operate workshop 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 INESC TEC. 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 (Centre 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;
- Laser welding of transparent glasses.

7.4.2 Main achievements in 2021

During 2021 the main achievement was the demonstration of the optimal parameters for laser welding of two glasses, either silica-to-silica or silica-to multicomponent glass. The process was calibrated in terms of several parameters such as energy, velocity, polarization, scanning trajectories, etc.

The glass micromachining allows the fabrication of 3D embedded hollow structures that were filled with a low softening point metal alloy; this process allowed the construction of microelectrodes placed strategically near a microfluidic channel to form a miniaturised electrorehometer, resulting in a patent application.

The fabrication of monolithic devices in silica was a work in progress and the structures fabricated locally continue to set 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.

– Multiline welding seam between a soda-lime glass plate and a silica substrate. Pulse energy of 0.95µJ, scanning speed of 2 mm/s and spacing of 20µm.

7.5 Smart Grids and Electric Vehicles Laboratory (SGEVL)

7.5.1 Mission and positioning

The Smart Grids and Electric Vehicle Laboratory (SGEVL) has a unique integrated capacity to simulate, prototype and test solutions for the energy 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 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.

7.5.2 Main Achievements in 2021

The main achievements of the RI for 2021 were:

- Finished the installation and commissioning of the 100kVA PHIL amplifier and first successful experiments integrated with laboratory installation.
- Finished the implementation of ISO15118 and final validation with a certified electric vehicle (EV) emulator. Charger-side OCPP 2.0 and OCPP 1.6 successfully implemented and validated with commercial equipment. Development and validation of the server-side (CSMS) OCPP, compliant with both versions.
- Validated the upgraded hardware version of the electric vehicle supply equipment (EVSE), with improved energy meter and protection circuits. Development of MQTT and REST API for third-party integration.
- Commissioning of a synchronous generator emulator targeting realistic emulation of static and dynamic behaviour of electricity grids.
- Finished the setup of a MV/HV grid protections test bed with 12 current channels and 12 voltage channels. Integration with OPAL real-time simulator.
- Conclusion of the design of a simplified home energy management system (HEMS) (hardware solution). First steps of the user interface to use in the POCITYF/InterConnect project demonstration activities.
- Start of the development (modeling and simulation) of power electronics converters for green hydrogen application (GreenH2Atlantic EU project).
- Conclusion of the design, procurement and contract of the laboratory microgrid expansion, considering additional cable simulators and loads.
- Design, execution and reporting of the laboratory tests for the conclusion of Portugal 2020 NextStep project.
- Conclusion of the field-validation of load desegregation techniques specifically focused on electric vehicles charging (project Grid2C). Start of project FaultPredict, were real-time modeling and simulation is supporting the development of novel fault prediction methods. (Direct contracts with Eneida.io)
- R&D team have been reinforced with two PhD and two MSc with competences in power electronics, user interfaces, mobile applications, artificial intelligence in power converters and software/firmware development.
- First step in the preparation of the upcoming call regarding Portuguese research infrastructures roadmap (RNIE – Roteiro Nacional das Infraestruturas de Interesse Estratégico).

7.6 Biomedical Imaging Lab

7.6.1 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, machine leaning and deep learning 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. This year was of great importance for the Biomedical Imaging Lab due to a strategic internal re-organisation of the research lines that will allow to increase visibility and foster new projects, new partnerships, define research objectives and achieve innovative technologies:

- Research Line 1: Ophtalmology CAD - Research for CAD systems for retinal image analysis (Coordinator: Ana Maria Mendonça; Key Partner: CHUSJ);
- Research Line 2: Lung CAD - Research for CAD systems for lung image analysis (Coordinator: Ana Maria Mendonça; Key Partner: CHVNGaia; Projects: TAMI, CMUPortugal project);
- Research Line 3: CAGE - Research for gastric cancer endoscopy exams (Coordinator: Miguel Coimbra; Key Partner: IPO-Porto; Projects: CAGED, FCT project);
- Research Line 4: Cardiovascular Imaging - Research for cardiovascular imaging exams (Coordinator: João Pedrosa; Key Partner: CHVNGaia; Projects: THOR, FCT project);
- Research Line 5: Multiscope - Research for multimodal, point-of-care, cardiology signal analysis (Coordinator: Francesco Renna; Key Partner: CHVNGaia, RHP; Projects: Multiscope INESC TEC internal project);
- Research Line 6: Capsule Endoscopy - Research for capsule endoscopy exams (Coordinator: António Cunha; Key Partners: HSA, IPO-Porto);

The Lab has 5 university professors, 2 post-docs, 7 PhD students and during 2021 had 7 MSc students.

7.6.2 Main Achievements in 2021

Several of the research lines of the Biomedical Imaging Lab were very active during 2021 and were responsible for several relevant achievements during this year. Some of these highlights include:

- Lung CAD: Novel algorithms were developed in this research line, associated with the TAMI CMU|Portugal project and two ongoing PhD theses, with three new publications (one journal and two conference papers);
- Multiscope: 1) Launching of the CirCor DigiScope Dataset, with the full support of Physionet, making it the best pediatric auscultation dataset for machine learning research available today; 2) Internal INESC TEC project approved. 3) Best poster presentation award at Computing in Cardiology 2021; 4) Best oral presentation award at RECPAD 2021;
- CAGE: Official launch of the CAGED FCT project in March 2021;
- Cardiovascular Imaging: Official launch of the THOR FCT project in March 2021;
- 17 papers were published in high impact international journals;
- 2 PhD grants were approved by FCT in 2021 and 10 other PhD students have been developing their theses in the Lab;
- 4 Conferences organised by INESC TEC members (in the organising committee or chairing technical committees) - Centreis 2021, ProjMan 2021, HCist 2021, CAPSI 2021;
- 8 international events in which INESC TEC members participate in the program committees - AIME 2021, IWAIPR 2021, MedPRAI 2021, Biostec 2021, Icpram 2021, HCist 2021, ICCS 2021, VISAPP 2021.

7.7 iiLab – Industry and innovation

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 2021

Finalisation of the architectural project and specialities (electricity, HVAC, etc). Launching the public procurement procedure to select the company to carry out the works on the facilities.

Execution 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".

Procurement, installation and testing of various equipment foreseen in the project. Definition of a governance structure to develop iiLAB's activity plan, according to its mission and the above-mentioned project. Beginning of the preparation of a document with the iiLab internal regulations.

Training courses and sessions:

- EIT Manufacturing @ INESC TEC iiLab, October 13th, 2021
- EIT Manufacturing Doctoral Winter School, November 22th, 2021
- Estágio de Verão Ciência Viva
- Advanced Program in Industry 4.0, June 2nd and 30th, 2021
- CENTRA 5 Meeting
- TV reportage Mentes que Brilham

Project Demonstrators

- FAMEST - Demonstration of a Smart Intralogistic solution showing the horizontal integration between a LEAN AGV and Smart Warehouse;
- PRODUTECH SIF - Demonstration of an Augmented Reality Solution to aid human operator during the marking and cutting processes of silos;
- DM4MANUFACTURING - Demonstration of the multi-robot coordination solution;
- PRODUTECH SIF - Industrial Robot Programming By Demonstration using 6DMIMIC and an IMU sensing device to deal with marker occlusion;

- 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 customised 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 Computer Graphics and Virtual Environment Laboratory

7.8.1 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

7.8.2 Main Achievements in 2021

- Design and development of an authoring tool for training in VR;
- 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;
- Development of a Framework for immersive learning recommendation for the Industry 4.0;
- Start of projects:
    - Frontown (FCT)
    - VR2Care (Horizon 2020 - ICT)
    - LifeSkillsVR (Strategic Partnerships for vocational education and training)
    - REDVILE (Horizon 2020 - EIT-Manufacturing)
    - Bprepared (P2020 com subcontratação explícita do INESC TEC - I&D Empresas)
- Conclusion of projects:
    - VRTrainingIndustry (P2020 com subcontratação explícita do INESC TEC - Projetos Individuais I&DT)
    - FEEdBACk (Horizon 2020 – ENERGY)
- Concluded PhD theses:
    - Fernando José Cassola Marques, A mobile gamification app to promote behaviour change on energy consumption of office buildings, Doutoramento em Informática, UTAD.
    - Roberto Ivo Fernandes Vaz, Blind and visually impaired visitors in museums: enhancing the visitors' experience through assistive technologies, Programa Doutoral em Media Digitais, UP.
    - António Alberto Castro Baía Reis, Immersive media, social change, and creativity: a framework for designing collaborative 360° video productions, Programa Doutoral em Media Digitais, UP, 2021.

7.9 Cloudinha Laboratory

7.9.1 Mission and positioning

The laboratory provides computational support to research and development activities of INESC TEC and University of Minho, providing bare metal, virtualisation capabilities, containers and security features such as trusted hardware.

The cluster is composed of 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, 16 GB of memory, and heterogeneous storage hardware including HDDs, SSDs, and NVMe devices. The servers are connected through either a 1 Gb or 10 Gb network.

The heterogenous hardware nature of the cluster is important for supporting different research projects that may require specific hardware features (e.g., different storage or network technologies, access to trusted hardware capabilities).

7.9.2 Main Achievements in 2021

In 2021, the laboratory provided the computational infrastructure to develop, optimize and test the software prototypes being developed by HASLab researchers. These software prototypes were developed under the scope of HASLab's research and innovation projects, as well as PhD and MSC theses.

Briefly, the laboratory supported research on key topics, such as:

- Distributed systems and data management
- Storage systems and databases
- Privacy and security
- Blockchain and Internet of Things
- Software engineering

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

7.10.1 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 Aguiar (PhD candidate), 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), Renato Caldas (MSc).

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

7.10.2 Main Achievements in 2021

In 2021, this laboratory has participated in five H2020 projects, namely NOVATERRA, SCORPION, PRYSM, AgRoboFood (DIH). The SCORPION project is a 2.5M€ project with 11 European partners and it is coordinated by INESC TEC.

During 2021, laboratory has maintained and developed 28 Software and Hardware prototypes. Two robots (Weta and Modular-E) were built from scratch and taking in consideration high TRL and MRL levels. These robots were developed to simplify the process of technology transference and answer end-users needs. On the project PRYSM (with Pulverizadores Rocha), the PRYSM spraying robot has upgraded its Manufacturing Readiness Level from level 4 to level 7. On the project ROBOTCARE, the CRIIS navigation stack has been tested and validated greenhouse logistic robots (TRL7). This laboratory team has increased the AgIoT module features (TRL7) and has reached V2.0 for SmartTrap (based in AgIoT solution). The SmartTrap will enable to detect agricultural diseases vector in a faster and cost-effective way.

12 scientific publications were published in international and indexed peer review journals, 5 master theses were realised in this laboratory, and hosted 8 PhD works. More than 40 references were made in mass media and in technical magazines. This laboratory was participated on the 2021 FIRA World Agricultural Robotics Forum, with Scorpion project and WETA robot.

8 SPECIAL PROJECTS

8.1 UT AUSTIN

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 part of the University of Texas System: the MD Anderson Cancer Center, based in Houston.

8.1.1 Main Achievements in 2021

When 2021 started, there was some optimism about the regression of the pandemic as the first vaccines against Covid-19 rolled out. Nevertheless, the emergence of new variants, either more aggressive or fast-spreading and with different evolution paces across the globe, meant another year of uncertainty and the continuation of several restrictions upon society and the economy. To some extent, this context affected the Program's activity plan as we had envisioned it and explains why we only half of the budget for which funding was requested. For instance, we could not organise research exchanges as we did in previous years; we could not take any delegation to UT Austin, and most of our training was forced into an online setting.

At the same time, such hurdles forced us to challenge ourselves and find alternative ways to keep our community connected and not lose momentum. Redesigning part of the Program's activity plan to best suit the context in which we had to play entailed redistributing funds among cost categories that either had not been considered or had been underestimated when the budget for 2021 was first drawn up.

Education

In 2021, we launched a pilot action. Through a competitive call, we invited our transatlantic community to come together and submit proposals for short-term advanced training covering topics aligned with the Program's Areas. Accepted proposals addressed themes as relevant as responsible innovation; principles, applications, and nanotechnology innovation in pharmaceutical sciences; biological engineering and medicine; the challenges and the opportunities of proton therapy; the potential of 2D Materials in biomedical applications and the role of nanotechnologies in advanced energy generation, conversion, and storage towards net-zero climate emissions. Additionally, we collaborated with one of our Strategic Research Projects to launch a webinar series on High-Performance Computing.

Through these training activities, we have succeeded in mobilising registrants and world-class speakers across academia and industry from the Partnership's geographical scope and beyond, with the Program's brand reaching countries in Europe, Asia, and America.

In the frame of the Program's largest knowledge-sharing and networking event - the Annual Conference - we hosted five Masterclasses with leading minds from organisations in Portugal, the USA, Germany, New Zealand and Spain. The main problem we were faced while implementing the training plan - which was entirely composed of online or hybrid activities in 2021 - was ensuring that registered participants were actually in attendance. Generating commitment from registrants seems to be more challenging with online events, and it is aggravated by the fact that registrations for the Program's training activities are free of charge. At a certain point, we decided to include in some of our communication materials messages to make registrants aware of the costs and the number of people allocated to the planning and setting-up of our courses. Additionally, when Covid-19 restrictive measures were eased, and the Program returned to organising hybrid events (e.g., the Annual Conference and Advanced Computing Masterclass), with physical sessions being broadcast live on YouTube, a large majority of registrants opted for the online participation mode. As for the research exchanges scheme, we had to put it again on hold due to ongoing travel restrictions and limited access to UT Austin campus and facilities for most of the year.

Research

We have secured another round of approximately € 800.000 to support a new set of exploratory research projects through a competitive solicitation that attracted over 40 PT-UT consortia. Submitted applications indicate increasing focus on R&D for health- and energy-related projects, with Nanotechnology consolidating its status as a cross-cutting area. The funded projects show that cancer detection diagnosis and treatment channels most of the funds devoted to this Call.

We also kept close to our ongoing Strategic and Exploratory Research Projects to understand how they were getting on with their research activities. This was possible through regular reporting, science storytelling and networking activities, such as the National Science Summit or the Thematic Roundtables at our Annual Conference, even if the in-person component of these events ended up falling short of expectations. As the Program moves towards the end of the current funding cycle, its project portfolio shows evidence of:

- science-based knowledge clusters feeding into specific application markets/domains and initiatives of national strategic interest;
- the Program's ongoing contribution to human capital development through advanced hands-on training of students and researchers both in Portugal and at UT Austin and even globally;
- the formation and strengthening of individual networks between Portugal and UT Austin-based researchers, linked to efforts to leverage previous results and pursue collaborations using the Program's instruments and others;
- the consolidation of Nanotechnology as a cross-cutting area, where the Program has been most contributing with projects; and the
- growing internationalisation of Portuguese application-driven science and exposure of Portuguese companies to US partners.

Innovation

The Program's success in the 2019 Strategic Research Projects competition came at the expense of readjusting the Partnership's budget to accommodate the support to more projects than it had been anticipated, especially at UT Austin. This reallocation tipped the Program's investment balance to research and away from the Program's Technology Innovation and Entrepreneurship (TIE) activities, most notably the PT Corps pilot. Nevertheless, in 2021, three training activities with TIE's seal were organised: the Responsible Innovation workshop, the From Innovations to Operations – the Management of New Technology Implementations Masterclass and the Commercializing University Research Innovations Warm-up Session.

Communication and Monitoring

We were highly committed to diversifying how we communicated with our community and stakeholders by embracing science storytelling, moving beyond simply reporting facts to write stories people could relate to and feel empathy for. We adventured ourselves for the first time in new narrative formats, most notably podcasts to cover our strategic research projects. We went on producing animated videos to promote our thematic sessions at the Annual Conference and devoted time to browse through the Program's archives initiatives whose impact can be measured only now and is worthy of visibility.

Lastly, we used our meetings with the Governing Board and the External Review Committee as an opportunity to reflect on how well we've been delivering on our mission and how we can improve ourselves to stay up to our community and sponsor's best expectations

9 SUPPORT SERVICES

9.1 LEGAL SUPPORT SERVICE

Manager: Rita Barros

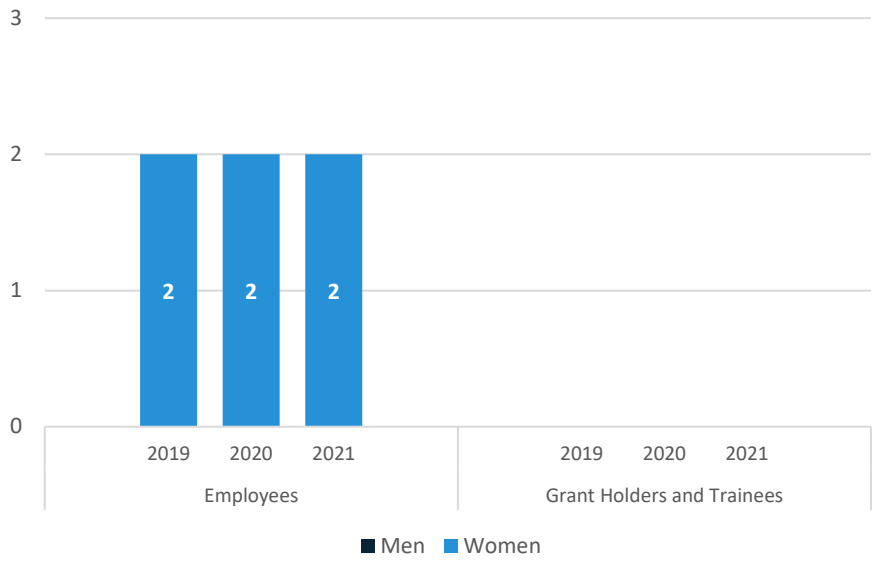


Figure 9.1.1 - AJ - Team composition and evolution

9.1.1 Presentation of the Service

The Legal Support is a vital service in the pursuit of INESC TEC's objectives of achieving advancement in science and technology development and transfer. The service is committed to always defend the institution's best interests, ensuring compliance with International, European and National applicable legal frameworks, safeguarding the best practices in all relevant matters, such as human resources, institutional relations, contracts, public procurement and personal data protection, seeking, at all times, to give the most appropriate response to each problem raised, or advice requested.

9.1.2 Highlights in 2021

The year 2021 continued to be marked by the impact of the pandemic, but with a more rapid adaptation and, consequently, a more effective capacity to respond to the new situation. The service maintained its support to activities strongly linked to the pandemic context, whether in terms of research and development, or in labour matters, with compliance with the rules applicable to teleworking, sometimes mandatory, sometimes recommended, depending on the evolution of the pandemic. In this sense, the Legal Support Service maintained a demanding pace of work, diversifying its activities. The main highlights are as follows:

- Permanent need to adapt the Contingency Plan prepared and adapt the reorganisation measures according to the evolution of the pandemic, as a result of the permanent change of restrictive measures imposed by the Government, such as the end of the State of Emergency, on the 30 April 2021. INESC TEC maintained the possibility to its employees to adopt the telework regime, when this did not result from legal imposition, which required the preparation of specific plans and updating of the Telework Agreement;
- Increase in contractual activity, both within the scope of financed projects and in direct contracting with companies and institutions, national and foreign;

- There was also an increase in the signing of Confidentiality Agreements with national and international companies in order to allow exploratory meetings for future collaboration and/or to evaluate the possibility of services being provided to those entities;
- Similarly, INESC TEC signed several Memorandum of Understanding and Collaboration Agreements with national and international entities, in order to create vehicles for future collaborations;
- Start of the European project VR2Care, being INESC TEC the coordinator, which involved the management of the entire process related to the preparation of the Consortium Agreement. Similarly, INESC TEC was also a partner in several European projects, with intense contractual negotiation, namely in the FIRE-RES, Green2Atlantic and MAGPIE projects;
- Digital Innovation Hubs - INESC TEC was the coordinator of the ATTRACT project, having also taken the lead in drafting the consortium agreement for the PRODUTECH project;
- EIT Manufacturing - involvement in the negotiation of the Digital Content Agreement for the Mirrorlabs, Mirrorlabs2, CPPS101 and AM-HLP projects;
- Negotiation of consortium contracts with Portuguese corporate and non-corporate entities, namely the OceanACT project and the CityAnalizer project;
- Negotiation of consortium contracts with Portuguese corporate and non-corporate entities, namely the OceanACT project and the CityAnalizer project;
- Legal support to the formalisation of operations related to INESC TEC's participation in associations and companies: APVE - Associação Portuguesa do Veículo Eléctrico; BATPOWER - Associação Portuguesa Para o Cluster das Baterias (CLUSTER); HyLAB - Green Hydrogen Collaborative Laboratory; PFP - Associação da Plataforma Ferroviária Portuguesa; AIOTI - Alliance For Internet of things Innovation; ETSI - European Telecommunications Standards Institute; UGR - Unexmin Georobotics Ltd.

Other Highlights

- 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);
- Legal support to the negotiation and drafting of licensing deals in close collaboration with SAL and participation in the Task Force formed by the two services, in order to make the follow up of the most critical projects in IP matters;
- Participation in one of the Working Groups on Human Resources, namely on the Careers subject;
- Study of the legal implications and monitoring of the application of the legal framework for the Recovery and Resilience Plan. Legal support to the drafting and negotiation of applications and other contractual instruments;
- Intense activity in public procurement, both as contracting authority, especially in the implementation of large infrastructure projects, and as contracting entity. Clarification sessions on the application of the various legal diplomas applicable to INESC TEC as contracting entity.

9.2 ACCOUNTING AND FINANCE SERVICE

Manager: Paula Faria

Assistant Manager: Libânia Caetano

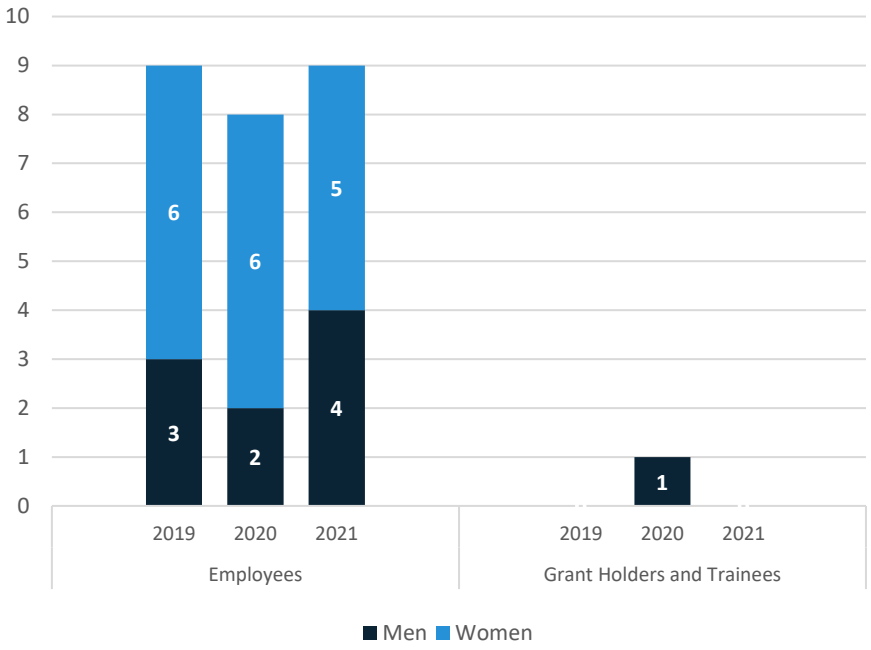


Figure 9.2.1 - CF - Team composition and evolution

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 2021

The pandemic led the Finance and Accounting Service to evolve through a set of challenges. Working in a remote or hybrid environment became regular forms of work. Ensuring a digital-ready service became a key requirement to guarantee the service's future operation.

The main highlights for 2021 are:

- QR Code set-up in the invoice form;
- Brexit's impact in the relationships with clients and suppliers, analysis, implementation and training;
- Implementation of an Invoice Entry Platform in the corporate Intranet, in cooperation with SIG;
- Improvement of the accounts and receivable process;
- Implementation of a VAT reimbursement request;
- Draw guidelines towards an increase efficiency on Fixed Assets management;
- Reinforce continuous improvement activities and practices through internal training sessions on different subjects.

9.3 MANAGEMENT CONTROL SERVICE

Manager: Vanda Ferreira

Assistant Manager: Bárbara Maia

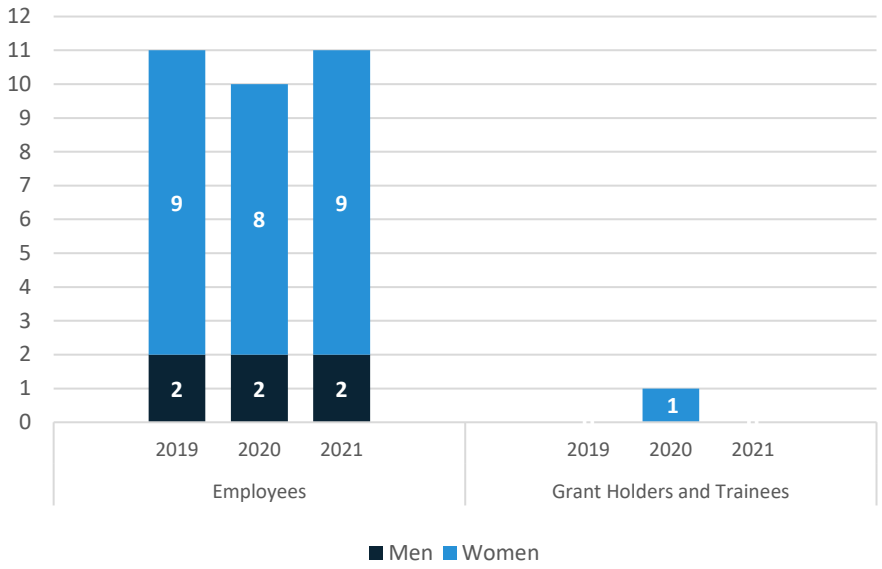


Figure 9.3.1 - CG - Team composition and evolution

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 2021

During 2021 the service prepared the financial reporting of 208 projects for the respective funding entities, representing more than 16 million euros of expenses.

Among these, 67 projects were funded by H2020 European Union framework programme, 8 of which were coordinated by INESC TEC, all with multiple partners, and one of them with almost 50 partners. The service also reported 15 projects funded by other European programs, such as INTERREG and others. The expenses reported throughout the year amounted to 6,5 million euros.

Regarding national projects, the service managed 61 projects funded by FCT (Fundação para a Ciência e a Tecnologia), reporting more than 5,8 million euros of expenses, and 46 projects in cooperation with companies, funded by Agência Nacional de Inovação (ANI), reporting 1.7 million euros of expenses.

There were also a set of large-scale strategic projects such as FCT's Multiannual funding, or regional (CCDRN) funding for highly qualified human resources that required a large effort from the service, representing more than 2 million euros of reported expense.

As to internal control matters, we would like to highlight the implementation on a new budget control model that allowed to close the accounts earlier, and also provided a better management tool for the board of directors and Centre managers. The service also proceeded with its work on the continuous improvement of information systems, in collaboration with other services.

9.4 HUMAN RESOURCES SERVICE

Manager: Luís Seca

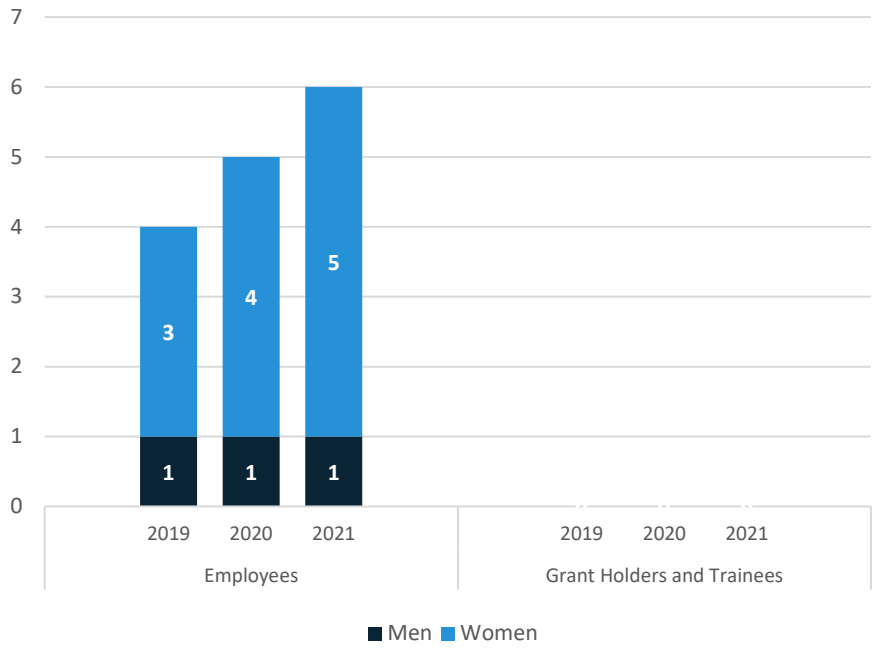


Figure 9.4.1 - HR - Team composition and evolution

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 2021

For 2021, the main highlights in the 2 dimensions of the service were:

STRATEGY AND DEVELOPMENT

Performance appraisal (PA):

- Dynamization of the working group that was created to review the current PA model of the institution and discuss the design and implementation of a new PA policy. Hence:
    - Meetings were attended in order to discuss the guidelines for INESC TEC PA policy (n=19);
    - Elaboration of a final deliverable developed by the group: a document regarding the "Guideline for INESC TEC's new PA Policy" delivered and presented to INESC TEC Executive Board (CE).

Training:

- Redefinition of the scope of the working group that will be responsible to redefine INESC TEC guidelines for this process;
- Identification of the working group members;
- Evaluation of the impact of the advanced training in project management (external training session that started on the previous year).

Careers:

- Dynamization of the working group to discuss the design and implementation of a new career policy for INESC TEC. Hence:
    - Meetings were attended in order to discuss the guidelines for INESC TEC new career policy (n=10);
    - Elaboration of a final deliverable developed by the group: a document regarding the "Guidelines for INESC TEC's new Career Policy" delivered to CE.

Onboarding:

- Redefinition of the scope of the working group that will be responsible to redefine INESC TEC guidelines for this process;
- Identification of the working group members;

Job descriptions and competencies:

- Elaboration of job descriptions for INESC TEC services:
    - Preparation of job structure, job content and specific competencies (based internal documentation and benchmarks);
    - Meetings with the services coordinators (n=13) in order to discuss the information produced;
    - Validation of the job structure, job content and specific competencies.

- Elaboration of job descriptions for INESC TEC centres:
    - Preparation of job structure, job content and specific competencies (based internal documentation and benchmarks);
    - Meetings with INESC TEC Domains coordinations (n=3) and some executive committee members (n=2) in order to gather information;
    - Meetings with the centre coordinators (n=6) in order to present the job structure, content and specific competencies;
    - Elaboration of a status document delivered to CE in order to have a validation of the job structure, content and specific competencies of the centres.

OPERATIONAL

- In the sequence of the new Research Grant Holder Statute (EBI), that established new conditions for grant holders, namely the decision to support tuition fees by our institution, the following actions have been taken:
    - Creation of a new module of scholarships and tuition fees was made available on IRIS, developed to collect and update information regarding the academic situation of each grant holder in each academic year;
    - Preparation of an internal document on the payment of tuition fees was drawn up;
    - Requests for payment of tuition fees from educational institutions;
    - Creation of various mandatory declarations under the new grant holder statute;
    - A new template of the minutes and evaluation form was created to support the grant announcements;
    - Automatic generation of research grant contracts that have been done manually until now;
    - Automatic e-mail informing about the renewal of grant / project;
    - Automatic loading of our calls onto the Euraxess platform;

- Creation of a Working Group responsible for elaboration of grant contracts and sending of documentation to financial entities.

- Call for applications for PhD research grants under the cooperation agreement between FCT and INESC TEC;
- Admission of employees working in foreign countries (IBH);
- Creation of a new module to make requests for teaching posts and automatic generation of authorisation declarations;
- A review of the email lists and tickets of the HR service was carried out;
- Digitalisation and sharing of some HR documents with other internal services through DRIVE and intranet;
- Internal sessions, addressed to the Secretariat and other attendees, on changes in HR processes and new requirements.
- Reduction of time between admission and signature of contracts to below 1 month.

9.5 MANAGEMENT SUPPORT SERVICE

Manager: Isabel Macedo

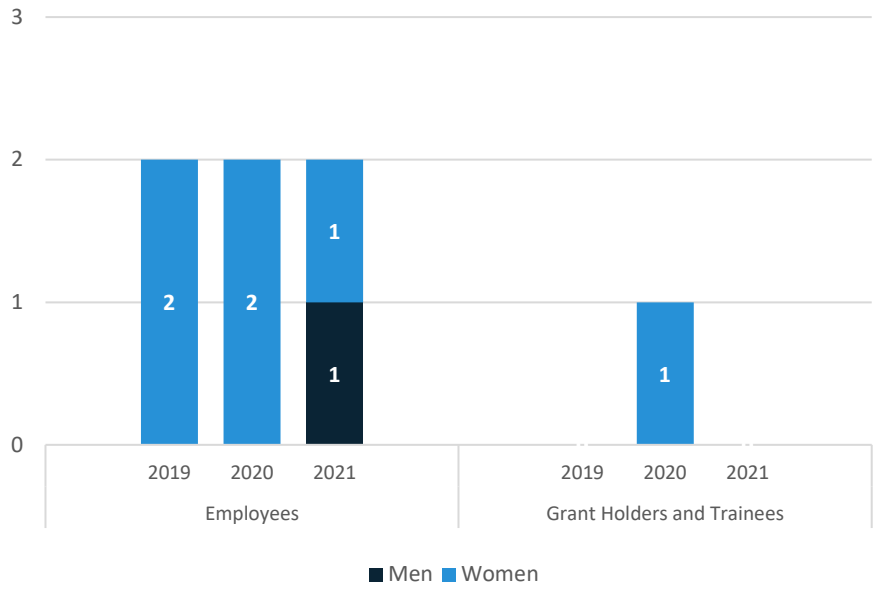


Figure 9.5.1 - AG - Team composition and evolution

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.

In 2021, the Service team was composed by two employees and one external student.

9.5.2 Highlights in 2021

Direct support to Management

- Direct assistance to the Internal Seed Projects' initiative - follow-up of the first and second calls and launch of the third call;
- Support and mediation to INESC TEC's accession to the associations PFP, BATPOWER, + ATLANTIC, HYLAB, AIOTI, ETSI and APVE.

Information Management:

- Content management and continuous update of INESC TEC's Intranet, IRIS, and Documental Repository;
- Definition and approval of a Document Management Policy that establishes archival best practices, document-specific procedures and responsibilities, based on a transversal work with INESC TEC Support Services, external benchmarking and international standards. Continuous document management support of INESC TEC Support Services;

- Collaboration in the publication of the second and third issues of the INESC TEC Science & Society magazine. Release of the latest issue in a new version of the OJS platform with a new design and with overall improvements to the edition content;
- Data Management at INESC TEC: Data publication in the INESC TEC´s RDM (Research Data Repository); support to the development of several Data Management Plans, including early developments of the FIRE-RES project DMP; application to join the EOSC Future Group;
- Continued work in data quality review and presentation of the institutional strategic performance indicators;
- Conclusion to the automatization of procedures under the liaison with FEUP library.

Continuous improvement:

- Participation and contributions to the Data Protection Work Group and to the strategic HR Workgroup on Performance Appraisal;
- Incentive to dematerialisation through the institution, supporting the continuous abandonment of paper-based filing systems triggered by COVID-19 Pandemic and remote work.

9.6 SECRETARIAL COORDINATION

Manager: 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 of INESC TEC's processes. Ana Isabel Oliveira coordinates the team of Executive Assistants to the Board of Directors and Grasiela Almeida coordinates the team of Assistants that support the Research Centres/Services.

9.6.2 Highlights in 2021

1. **Team Coordination**, through:
    a. Internal training and coaching sessions in cooperation with other services, such as "NEW PROCESS-Teaching Accumulation Request" promoted with SIG and HR; "Best practices in using email", with SAS; "Special public procurement measures" with AJ and " Awareness regarding GDPR", with DPO;
    b. Strengthening of the technical skills of the executive team;
    c. Specialised management of CRAS team of Assistants due to the maternity leave: assessment of team status and needs, internal reinforcement process, leadership of recruitment/selection process and full-time training of the new assistant, along with constant alignment through the whole process;
    d. Coordination of the remote teams, including the promotion of meetings and "Assistant Day Informal gathering" and also the production of team schedules;
    e. Performance evaluation on the team regarding 2020, overseeing the process closely with direct managers and the main services that assistants interact with;
    f. Reformulation of the digital archive plan regarding the team of Executive Assistants of the Boards of Directors, according to the institutional archive plan;
2. **Focus on Continuous Improvement**, including:
    a. Design, implementation and testing of the updated Booking Platform for rental cars (cooperation with SIG/SGI);

    The availability constraints of our partner services have not allowed us to progress on the projects we were committed to, namely the "New Process for Event Management", "Resource Booking Platform", but we expect to have the opportunity to move forward in 2022.
3. **Supplier Relationship Management** regarding services related to the daily assistant's activity, including contract management with INESC TEC suppliers in 2021, such as travel agencies, rental car companies, private transport companies and hotels).
4. **Information Management tools** designed to share information, templates and documents with the team, namely the constant update of a shared Directory.

In 2021, the team of Assistants was composed of 18 members, as presented below.

Assistant	Supports PA (Personal Assistant) or Structure (Organisational Structure)
Ana Isabel Oliveira	**PA:** José Manuel Mendonça, João Claro, Gabriel David, Luís Carneiro, José Carlos Príncipe, José Fortes. **Structure:** General Council, Audit Council, Scientific Advisory Board, Business Advisory Board, Workers Committee**. Intervention Areas/Projects:** Secretarial Coordination of Board of Directors, Board of Directors Budget, Operational Management of Mobile Communications, Continuous Improvement.

Assistant	Supports PA (Personal Assistant) or Structure (Organisational Structure)
Lídia Vilas Boas	**PA:** Luís Seca, Maria da Graça Barbosa, Manuel Ricardo, João Peças Lopes, Mário Jorge Leitão. **Structures:** Infrastructures Maintenance Service, Human Resources, Domains. **Intervention Areas /Projects:** Activity Plan, Activity Report, IES, Conference Organisation, Infrastructure Expenses Management, Commission for Social Responsibility.
Sandra Nunes	**PA:** Aníbal Matos, José Carlos Caldeira, Rui Oliveira, Bernardo Almada Lobo, Vladimiro Miranda, Pedro Guedes de Oliveira, José C. Marques Santos. **Structures:** Conflict of Interest Management Commission, Scientific Advisory Board, TEC4. **Intervention Areas/Projects**: Manufacturing Vanguard Initiative, STAYAWAY App, Quarternaire, Science Management Model.
Ana Paula Silva	**Structure:** Information Systems and Computer Graphics Centre.
Bárbara Oliveira	**Structure:** Robotics Autonomous Systems @ISEP LSA **Intervention Areas/Projects:** TEC4SEA.
Catarina Fernandes	**Structure:** High-Assurance Software Laboratory.
Cláudia Almeida ***Maternity leave***	**Structure:** Robotics Autonomous Systems @ISEP LSA **Intervention Areas/Projects:** TEC4SEA.
Flávia Ferreira	**Structure:** Robotics Industry Intelligent Systems Centre, iiLAB.
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 Relations Service **Project:** International Partnership Office, INESC Brussels HUB.

9.7 FUNDING OPPORTUNITIES OFFICE

Manager: Marta Barbas

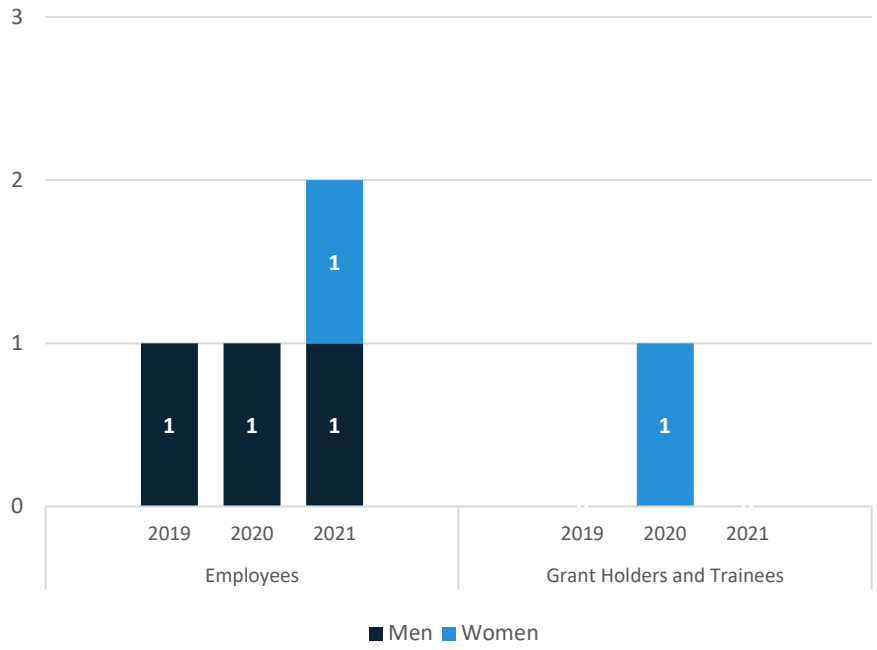


Figure 9.7.1 - SAAF - Team composition and evolution

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 2021

Since the capacity of the service has been reinforced in 2020 with an extra team member focused on supporting European applications INESC TEC capacity to support submissions to HEurope calls increased significantly.

Despite the COVID 19 pandemic constraints still felt throughout the year it was possible to develop several activities and support researchers as planned.

From all the activities developed we shall highlight, for its relevance, the information sessions regarding FCT call for R&D Project in All Scientific Domains and Individual Call to Scientific Employment Stimulus, and also several meetings with HEurope National Contact Points and principal researchers of coordinated proposals. Last, but not the least, the service also accompanied the negotiation of the Associate Laboratory funding which is crucial to fund INESC TEC most basic research activities.

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

- FCT Call for R&D Project in All Scientific Domains 2021: 131 proposals
- FCT call for exploratory international cooperation projects UT Austin Portugal – 2021: 2 proposals
- FCT call for exploratory international cooperation projects MIT Portugal – 2021: 1 proposal
- FCT call for exploratory international cooperation projects CMU Portugal – 2021: 10 proposals
- ERASMUS + KA2: 3 proposals

- ERANET LEAP-RE Joint Call: 1 proposal
- ERANET NEURON: 1 proposal
- ERANET JP-Cofund: 1 proposal
- Individual Call to Scientific Employment Stimulus - 5th Edition: 30 proposals
- Agendas Mobilizadoras e Pactos de Inovação Verdes (PRR): 42 proposals
- Agendas Mobilizadoras Bioeconomia: 3 proposals
- HORIZON Europe: 51 proposals were submitted in 26 different calls but we shall highlight 1 successful proposal coordinated by INESC TEC, which submission were strongly supported by the service: SoTecIn Factory submitted to the call HORIZON-CL4-2021-RESILIENCE-01 in September.
- ESA ESAAO/1-10866/21/NL/GLC/RK - SCREEN - Space Composite Structures Life-Cycle Monitoring – EXPRO PLUS: 1 proposal.

9.8 TECHNOLOGY LICENSING OFFICE

Manager: Daniel Marques de Vasconcelos

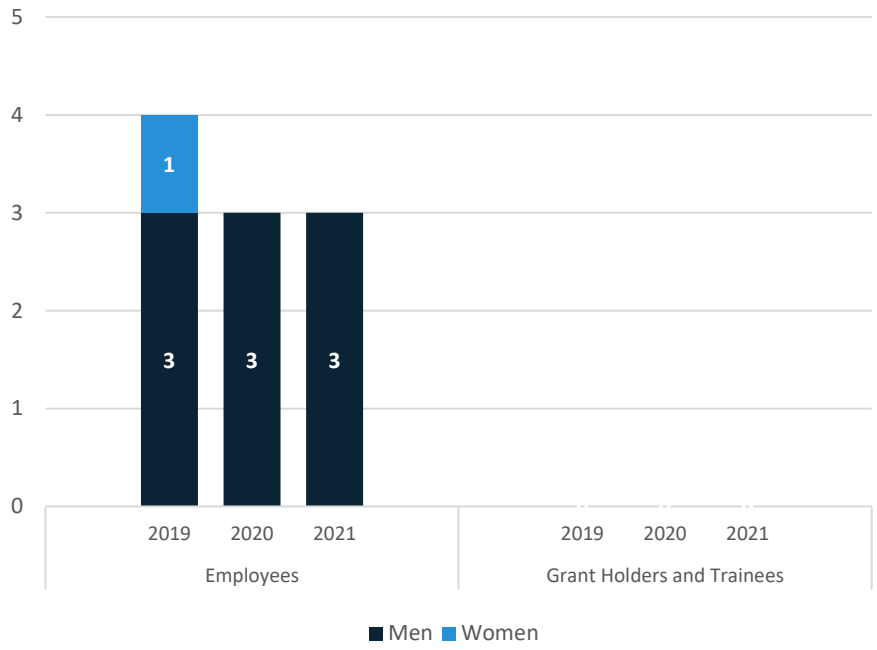


Figure 9.8.1 - SAL - Team composition and evolution

9.8.1 Presentation of the Service

The Technology Licensing Office (TLO) is to create and capture value along the full knowledge value chain – from early-stage R&D results (scouting and registration) to IP exploitation (strategy, marketing, and negotiation of commercial agreements), enlarging its responsibilities on INESC TEC spin-offs in 2021.

To carry out its mission, the office has a new organisation based on tech managers specialised in the same industry sectors as TEC4s, fostering synergies between the two INESC TEC structures and bringing market insights to improve problem-solution fit. SAL is also more international and connected the excellence in knowledge transfer.

9.8.2 Highlights in 2021

As planned in 2021, SAL changed its internal organisation and more market-driven IP strategy to boost the societal impact of INESC TEC R&D activities. Following the main objectives stated in the Plan for 2021, the achievements and highlights are briefly presented:

1. **Rebalance of the TLO's efforts towards marketing and licensing activities:**

   1.1. INESC **TEC sold a patent family (C4MIR), the first patent assignment agreement in its history** and one of the few cases ever in Portugal. This remarkable achievement motivates not only INESC TEC but all the national ecosystem to invest in IP management and exploitation;

   1.2. **The iHandU technology was licensed to the spin-off inSignals Neurotech** with SAL also supporting strategic decisions on regulatory affairs and product development;

   1.3. **Increased number of meetings, many with European and US tech and industry experts**, to learn on key industry sectors and foster technology exploitation;

2. **Improvement of scouting and self-report of new R&D results by INESC TEC researchers:**

   2.1. **A 5 min short invention disclosure** was created and deployed in 2021 and INESC TEC is now **one of the first academic entities in the world** with a such lean scouting approach. **The number of new R&D results reported to SAL almost doubled** in 2021 (38 in 2021 vs 20 in 2020 and 9 in 2019).

3. **Adoption of a smarter and more business-driven Intellectual Property Strategy:**

   3.1. **Two INESC TEC Agritech technologies** (SpecTOM and Smart TRAP) **are finalists in the top 4 of the Prémio Empreendedorismo e Inovação Crédito Agrícola 2021** (waiting final results), which applications were led by the TLO;

   3.2. **The VALOREM technology was a finalist in the acceleration program EIT Jumpstarter 2021,** a joint result from the synergy between CPES and the TLO;

   3.3. Implementation of a **new IP portfolio management matrix** based on best-in-class technology transfer practices and strategic management. INESC TEC technologies are now scored according to critical internal and external (market) factors, helping SAL decision-making and leading to more accountable and transparent IP management.

   3.4. **Sound and quality-focused IP strategy – more granted patents** (11 vs 7 in 2020 and 4 in 2019) in key global markets and sustainable new priority filings every year. In 2021, INESC TEC was in the top five national entities with the most patent applications filed at the European Patent Office (EPO), the only Portuguese entity achieving this patenting level for four years in a row.

4. **Increase the TLO's connectivity and network**

   4.1. **A TLO member was granted the prestigious AUTM-Life Arc fellowship** to support the transition of scientists to the role a tech transfer executive.

   4.2. **Successful connections to best-in-class TTOs** such as Fraunhofer and Trinity College were established and led to a share of best practices on IP management, Spin-off support, and Open Source Software.

   4.3. **INESC TEC joined the EPO network PATLIB**, helping SMEs to manage their intellectual property rights, complementing INESC TEC participation in the **European IP Helpdesk** program backed by the European Commission. In 2021, SAL presented two Portuguese success stories at the EU Industry Days.

   4.4. **TLO members were invited speakers in national and international webinars (CEIPI Business Academy)** on Tech Transfer, IP management, and IP-driven economic growth.

9.9 INTERNATIONAL RELATIONS OFFICE

Manager: Andreia Passos

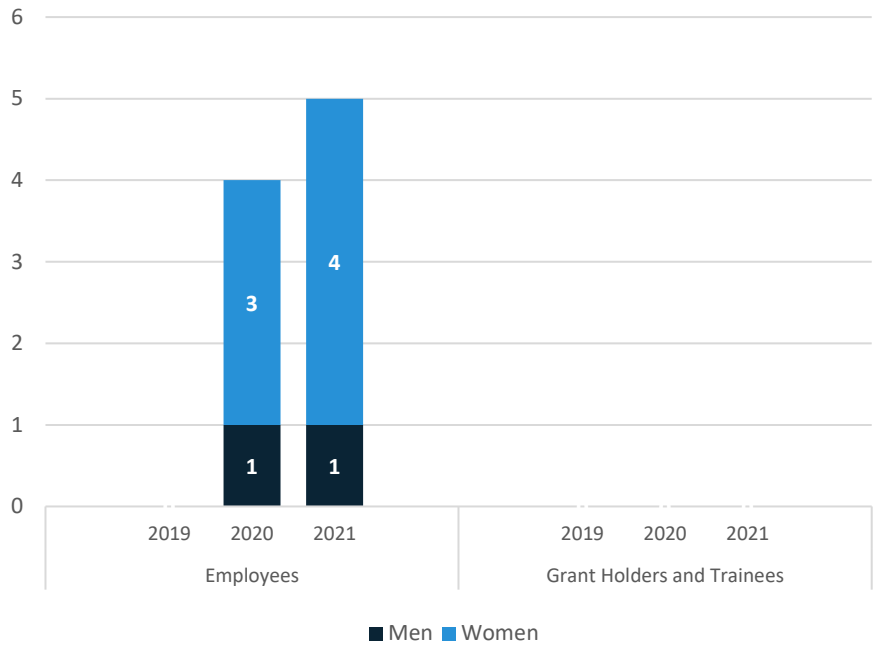


Figure 9.9.1 - SRI - Team composition and evolution

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 2021

At the end of 2020, the SRI set a number of goals for the following year. Such goals had been aligned with the BoD's expectations about the service, considering the organisation's internationalisation ambitions and the uncertainty that still existed in relation to how the pandemic would evolve and impact institutions.

What goals did the service set itself in 2021	Highlights – How well did the service live up to its goals
Work with Domains to bring internationalisation to their agendas using results obtained through the implementation of the Internationalisation Tool	After the first workshop with the Centres making up the Computer Science Domain, the SRI convened with HASLab to further discuss the tool and collect their perceptions about its usefulness. However, later on, the service deliberately decided not to extend its use to other Domains because the tool needed to be refined and, at a certain point, the institution began discussing the continuation of Domains as we knew them. Therefore, the SRI took a step back and opted for mapping out international collaborations of INESC TEC researchers through a survey designed in 2021 and eventually launched at the beginning of 2022. The SRI expects to give more focused and streamlined assistance to INESC TEC's research community through this survey.

Assist in bilateral and multilateral cooperation and sentineling and liaising with potential overseas institutional partners or relevant brokers (such as embassies) in areas deemed strategic for the institution. This also includes supporting FCT in coordinating the long-standing international partnership UT Austin Portugal.	The SRI stepped up its efforts to help shape institutional collaborations with foreign actors throughout 2021. Some examples of this enhanced role included: 1) Liaising INESC TEC's Licensing Service with several Technology Transfer Offices in Germany, Ireland, the UK and Japan for exploratory meetings aimed at best practice sharing and identification of cooperation opportunities, including staff exchange; 2) Organising workshops or exploratory meetings between INESC TEC's researchers and research teams affiliated to MoU partners (e.g., National Institute of Advanced Industrial Science and Technology - Japan) or between the service and prospective partners provided a match between the latter and INESC TEC's competencies or cooperation interests had been flagged up by the service (e.g., Carnegie Mellon University's Robotics Institute and CRIIS; Centre Nationale D'Études Spatiales and INESC TEC's Work Group for Space); 3) Supporting the hosting of international delegations (e.g., National Research Council Canada; Universidade Técnica do Atlântico; Sportsmaster Singapore) and the negotiation and drafting of MoUs with Cape Verde (Universidade Técnica do Atlântico); Cyprus (The Cyprus Institute); and the US (the International Institute for Astronautical Sciences). The service carried on coordinating FCT's partnership with UT Austin to the highest standards and, whenever appropriate, drew attention to synergies benefiting both the Program and INESC TEC's community. If it were not for the pandemic, the plan proposed at the beginning of 2021 would have been fully met.
Provide the institution with an overview of the level of progress of MoUs and similar international agreements signed in the past five years to assess their actual or expected outcomes. This should be linked to the effort of providing clear guidance on what MoUs and similar international agreements mean and monitoring them throughout their lifespan.	Unfortunately, the service did not progress much in assessing the outcomes of active international MoUs, as such a task was intended to be part of a broader process that included national cooperation agreements and could not be solely led by the service. Nevertheless, in close collaboration with the Management Support team, the SRI improved its International Agreements database to keep it updated and manageable and send out alerts when an MoU was close to its expiration or renewal date.
Further strengthen the support initiated in 2020 to inbound and outbound mobility, making the Welcome Appointment Sessions (for foreign nationals) as well as the reporting of international exchanges upon the return of our staff from host institutions fully established procedures.	International Mobility is perhaps where the service stood out the most in 2021. The team: 1) produced and made available several supporting documents such as the Welcome Appointment Guidelines or the Quick Mobility Guide for Foreign Newcomers; 2) advised over 46% of all foreign candidates selected for admission to INESC TEC in 2021 on several immigration and settlement matters; 3) bridged with UP and IPP to find ways for the service to play its part in reducing the time for academic degree recognition requests to be submitted and analysed and improving their compliance with official requirements; 4) proactively sought for opportunities in support of research exchanges, raising awareness of calls for applications, grants and scholarships or setting up meetings with actors offering such opportunities (such as Fundação Luso-Americana para o Desenvolvimento or Fulbright Portugal). In the last quarter of 2021, the SRI submitted a proposal for a Visiting Researcher Programme at INESC TEC.

Promote the international profile of the institution through refreshed internal and external communication. This entails working with SCOM to produce informative and appealing content and formats and proposing, in dialogue with other internal stakeholders, enhanced indicators to best capture the international performance of the institution. Preliminary work in this field started in 2020.	The SRI worked with SCOM to produce a new series of videos showcasing foreign staff at INESC TEC – the Intercultural Corner section. The main goal was to raise awareness of the institution's multicultural workplace community. In the last quarter of 2021, the service teamed up with SCOM again to write a script for a new video in support of INESC TEC's strategy to capture and retain international talent. It also organised the fifth edition of CENTRA's annual meeting, CENTRA community's most important event. Despite its hybrid format and the many constraints faced throughout its planning, the CENTRA 5 meeting went quite well and mobilised delegates from several countries. As for the work on internationalisation-related indicators, the service made progress, most notably on mobility indicators.
Continue to develop relations with Brazil and India markets.	Brazil and India Offices are designations meant to provide a reference interface to specific geographies, acting within the scope of activity of the SRI. In 2021, the pandemic caused an almost suspension of the activities towards India and reduced the activities aimed at promoting INESC TEC in Brazil. Regarding India, plans to organise new joint workshops with Indian partners were postponed. Some activity was maintained towards the IIT Madras, with contacts kept in the robotics area (CRAS), leading to the joint submission of proposals. Also, connections were kept with the CEMENT alliance, most specifically with the IIT Goa, leading to the participation of INESC TEC in a Conference organised in Goa, with a keynote speech (Vladimiro Miranda) and presentations from members of CRIIS in robotics applied to smart farming. Regarding Brazil, the support to the joint participation of INESC TEC and INESC P&D Brasil was maintained regarding 8 R&D and advanced consulting projects with activity during 2021, involving the Centres CRAS, CAP, CESE, CSIG and CPES. Five projects were developed in Brazil with the participation of INESC TEC centres; two projects were contracted by INESC TEC to INESC P&D Brazil and one project put together INESC TEC and INESC P&D Brasil, within a joint call EU-Brazil contracted by the European Commission and the Brazilian Government. Finally, the network of contacts allowed in Brazil the dissemination of job positions at INESC TEC, channelling to the institute candidates of quality, some of which came to be hired.
Continue with the strategy designed by INESC Brussels HUB before the pandemic started in 2020.	2021 was a year focused on building internal capacity, representation and visibility, lobbying and networking. **Capacity-building** is one of the three main pillars of the HUB strategic plan. This entails a wide range of activities from training sessions to info days to all activities that contribute to both a better understanding of EU policies, their relation and impact in funding programmes, to organisational culture and practices to maximise results in specific programmes to more technical/administrative issues that can range from management to communication in EU projects and beyond. There is another dimension of capacity-building being developed by the HUB, which is a medium to long-term

	endeavour: the creation of a *think tank* type of analytical capacity in specific issues of strategic importance for INESC and central to define future EU agendas (i.e. technology and research infrastructures, open science, etc.). In 2021, time was devoted to strengthening the internal capacity of the HUB with the hiring of a Communications Officer and the development of 3 EU applications with the direct participation of the HUB's staff. **Representation and visibility** is also a core pillar of the HUB strategic plan. Increased effort and creativity were required in 2021, with positive results reported quantitatively and qualitatively. In 2021, the HUB established a digital presence for the whole INESC community, boosted networking with the European Commission and Brussels-based representations; implemented a website directed explicitly to the European partners and institutions; started active social network accounts and established a highly visible profile on LinkedIn and Twitter; redesigned the initial newsletter into a daily format: the Morning Brief; resumed podcasts based on thematic programmes led by HUB thematic workgroups; strengthen INESC presence in key European networks, such as EARTO and started a collaboration with Science Business intending to promote INESC's visibility; continued building and establishing a database of contacts with EU representations to facilitate networking and consortia building. The website and social media impact stats have grown considerably along the year in Portugal and across Europe and the world. **Networking and lobbying** were pursued through many of the activities mentioned above in the other two core pillars. They included bilateral meetings with regional management authorities at both national and international levels; representation in EARTO workgroups and conferences; representation and facilitation of participation in Science Business events as well as in diverse European Commission events; Networking with other Brussels-based representative offices to ensure inclusion of INESC as a core player in strategic planning activities taking place within the so-called "Brussels bubble".

9.10 COMMUNICATION SERVICE

Manager: Joana Coelho

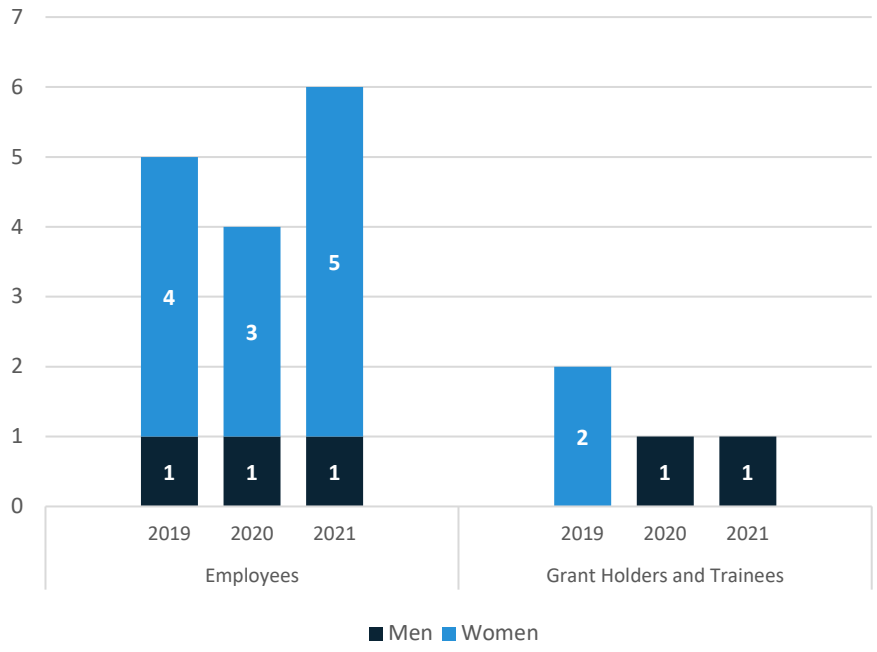


Figure 9.10.1 - SCOM - Team composition and evolution

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 2021

EXTERNAL COMMUNICATION

- In 2021, **1410 news pieces** were **published in the national media, with an Automatic Advertising Value of more than 15 million euros**. The Communication Service released **28 press releases** to the media throughout the year; in addition, it obtained exclusives with Agência Lusa, and the ECO and Expresso newspapers, thanks to editorial proposals. Regarding the highest impact among the national media, namely in terms of the number of news published, it is important to highlight the presentation and launching of the *Mar Profundo* research ship (44 news), the IDINA project, winner of the IN3+ award (36 news), and the beginning of the EU-SCORES project (32 news). It is also worth mentioning the media relevance of the study Diaries of a Pandemic, a research action carried out by the Institute of Public Health of the University of Porto (ISPUP) and INESC TEC, in partnership with the newspaper PÚBLICO.
- Regarding the **international press office**, the ***Medium* portal** remained a key tool for the global dissemination of relevant results achieved by INESC TEC. More specifically, **four opinion pieces** were published on *Medium*, **reaching 745 views**.
- Regarding the **BIP**, INESC TEC's newsletter, in 2021, there was an **increase in the number of subscribers** (3%), when compared to 2020. Moreover, there were **21.522 visits to the online platform**, with an average duration of 1 minute and 53 seconds. The News, Editorial and Opinion sections were the most

viewed in 2021, representing 74% of total visits. News related to acknowledgments and awards generated the most views.

- The visits to the **INESC TEC website** in 2021 translated into a **total of 59.354, with 209.143 page views**. The English pages had a higher number of views (over 116.000) than the Portuguese versions (over 92.000). The most viewed sections - in both languages - were the "Opportunities" and "People". In the case of the "Opportunities" section, the number of page views represented 36% of the total. The “People” section represented 13.5% of the total amount.
- Also at the digital level**, INESC TEC reinforced its presence on social networks**, through a general increase in the number of followers on the different profiles, **with emphasis on the *LinkedIn* page**: the increase in followers was 16.6%.
- SCOM was actively involved in the **production** (including content review and translation, layout, illustration, and printing) **and dissemination of the two issues of INESC TEC Science & Society Magazine**, launched in June and December 2021, and whose **digital versions had a total of 2600 views**.
- Despite the restrictions imposed by the COVID-19 pandemic, **INESC TEC organised (or co-organised) seven events**. At the national level, the highlight goes to the Autumn Forum, which did not take place in 2020, but rather in 2021. Internationally, the EUCNC & 6G Summit was the event with the highest influence, thanks to the online presence of more than 2300 participants over four days. In total, **INESC TEC was present in 19 events.**
- Honouring the commitment to support science communication initiatives, **INESC TEC was involved in a series of activities that took place in different formats**, namely the Science Summit (promoted by MCTES and the National Agency Ciência Viva), the Mostra UP, the European Researchers' Night and FICA – International Science Festival. Other activities initially scheduled were, however, cancelled due to the pandemic.
- **In all events**, whether in a face-to-face, online, or even hybrid format, **the multimedia/design team was actively involved, with the creation of graphic productions, exclusive design works or internal resources**; it also monitored companies responsible for providing said services, in order to preserve INESC TEC's identity and to make sure that the Institute would always be duly represented among different audiences.
- The Communication Service continued to play an **active role in** carrying out various **communication and dissemination tasks within the scope of European projects**, namely, drawing up communication plans, developing the graphic identity, digital marketing activities, advertising, public relations, and direct marketing. The projects TRUSTAI; PortXXI; Atlantis; EEN Network; iilab; BigHPC; AIDA; RISC2; IDINA and InterConnect are some of the cases. SCOM also contributed to the elaboration of project proposals, in particular to the definition of communication and dissemination strategies, within the scope of applications for European funding.

INTERNAL COMMUNICATION

- Regarding internal initiatives - and taking into account the limitations imposed by the pandemic -, the **organisation of internal events to promote the socialisation of the members of the INESC TEC community** was deemed essential. Although many activities were cancelled (On Foot or Team Building activities), there were three initiatives: the Strategic (Re)Gathering and the Roasted Chestnuts party (in person), and the INESC TEC *Season Party* (online); all the events complied with the guidelines of the healthcare authorities.
- SCOM supported the translation and proofreading of institutional texts from Portuguese to English and vice-versa, namely applications for programmes and/or funding, projects, activity and operational plans, as well as legal documents like contracts, addenda, regulations for grant holders or notices.

NEW COMMUNICATION CONTRIBUTIONS

- In 2021, one of the main actions in terms of **international press office was the *Alphagalileo* (AG) registration**. This led to **two press releases with more than 190 views**, **each generating 3.000 email notifications to journalists worldwide - resulting in six press clippings**. SCOM's work in terms of international communication **led to the release of 11 news pieces among foreign media**.
- As to **BIP**, INESC TEC's newsletter**, two brand new sections were introduced in 2021: *Spotlight* and *Intercultural Corner***. *Spotlight* is a science communication section dedicated to research carried out at INESC TEC, delving deeply into topics and issues researchers from our institution are solving, according to the major trends in science communication. *Intercultural Corner* is a section that seeks to present INESC TEC's multicultural environment, through the testimonies of foreign researchers. During last year, there were two episodes for each new section.
- SCOM was also **responsible for reformulating the presentations of each of the scientific domains**, within the scope of the visit by the Scientific Advisory Board (SAB*)* - an external assessment committee that regularly visits the Institute.
- In addition, it also **supported the production of videos about the TEC4s**. More specifically, SCOM contributed to four six-minute videos for the TECH3 show, broadcast periodically. Additional one-minute versions of said videos were produced, for dissemination purposes at events and fairs, or to engage with potential partners. The TEC4SEA video, the only one not produced in 2021, will be completed in 2022, in accordance with the strategy defined by the coordination of said TEC4.
- In addition to the videos, the **SCOM team also started to design flyers for the five TEC4s**, with an updated image and message, in line with the strategy of each TEC4. These flyers are being produced according to the needs of each TEC4.
- Another goal was to increase the sense of belonging among the members of the INESC TEC community, through the **installation of a video wall (Internal TV) at the main building's entrance hall, and the design of proposals for the creation and restructuring of image and signage resources at different spaces, e.g., iiLab and HASLab.**
- A ***slide deck*** was **created to present INESC TEC at meetings or events**. This *slide deck* can be used in its original version, due to the institutional content it presents, or it can be edited to better serve the purposes for which it is necessary.

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. This service maintains INESC TEC's voice and data communication networks and is responsible for the development, implementation and maintenance of network-based services as well as for providing the respective support to end-users. 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).

9.11.2 Highlights in 2021

As was the case of 2020, a great amount of this year's team's activity was related to enabling and supporting smooth and efficient remote work for INESC TEC's users, mainly by improving the central infrastructure, but also by providing support to remote users with their local networks and systems.

With the lifting of the lockdown that took place in 2021 and the transition to more hybrid work scenarios, additional challenges were presented to the service, particularly the ones related to enabling hybrid sessions, in which users participate both in presence and remotely. That was the case of e.g. INESC TEC's strategic meeting and the Scientific Advisory Board meetings, events which dimension required developing and provisioning different multimedia solutions than the ones that were in place.

Other planned and unplanned highlights include:

- Conclusion of the "follow-user" printing solution, with the associated replacement of all the printers of building A of INESC TEC's headquarters;
- Transition of voice communications to the new VoIP solution, allowing the decommissioning of the outdated infrastructure;
- Hardening of cybersecurity and cyber resilience procedures and measures, like e.g.:
    - The implementation and transition to production of a new architecture for centralised logging;
    - The collection and storage of network flow information for forensic analysis;
    - The fine tunning of the Intrusion Detection System;
    - The continuous effort to reduce the overall security risk exposures by transitioning legacy systems to firewall protected networks;
    - Significant steps towards a disaster recovery solution with geographic diversity, namely by the deployment of optical fibre and the preparation of a physical space in UMinho, and the provisioning of networking equipment.

9.12 MANAGEMENT INFORMATION SYSTEMS SERVICE

Manager: José Carlos Sousa

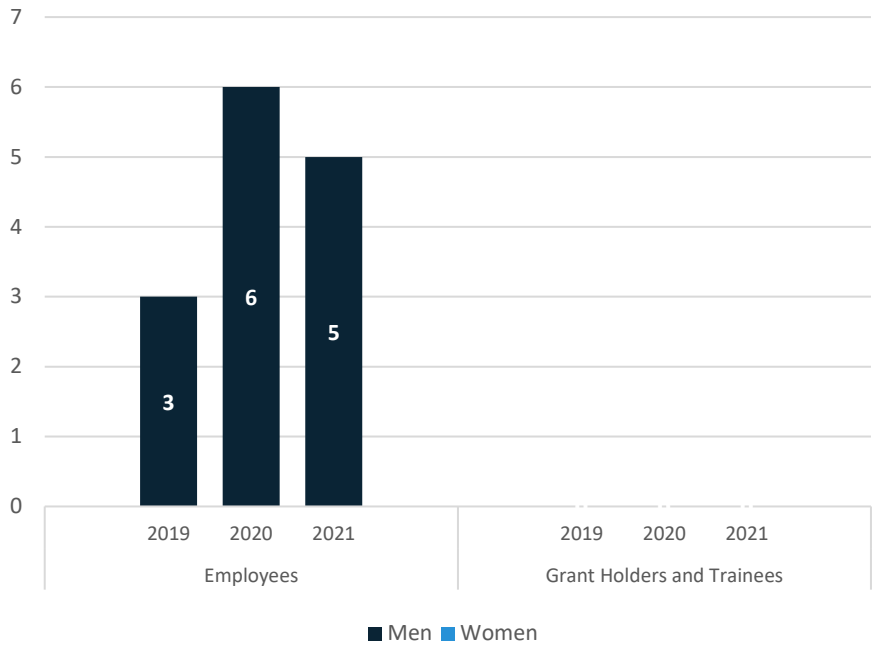


Figure 9.12.1 - SIG - Team composition and evolution

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, the Website, and the UOne Connect, a project management system specialised on European projects. SIG also supports the several services in their interaction with the financial SAP system.

The team size in 2021 has been 5.8 FTE, totalizing six technicians.

9.12.2 Highlights in 2021

The main new functionalities added to the Intranet system were:

- Integration of Electronic Invoicing from an external provider with the INESC TEC information system;
- Car Booking system with fleet management and automatic communication with the rent-a-car agency;
- Automatic generation of the scholarship contracts;
- Automatic publication of research job offers on the European Commission EURAXESS portal;
- Webservice for integrating INESC TEC collaborators in the FEUP Library user records.

The IRIS kept growing through the addition of more modules:

- Management of external teaching activities by INESC TEC employees, that includes submission, evaluation and approval;

- Tuition fees and Grants module, that allows to issue a payment plan for all grant holders and manage the financial reporting, planning and the actual payment to the IES;
    - HR Multiassignment module, allowing the management of HR assignment to multiple operational units as a step towards a timecards module.

A new CRM system has been established, interoperable with the INESC TEC information system. It mainly focuses on:

- Management of contacts and entities;
- Opportunities workflow implementation;
- Integration with the Project Proposals process.

Extending uONEConnect features to fully support European projects management needs. It has been completely implemented and is now used as the default European project management platform. New features developed in 2021:

- Financial report workflow to manage the validation process;
- Work package progress and gender reports;
- Export information for financial reports and progress reports;
- Milestones management;
- Version management for budget and work breakdown structure (addenda).

9.13 SYSTEM ADMINSTRATION SERVICE

Manager: Jaime Dias

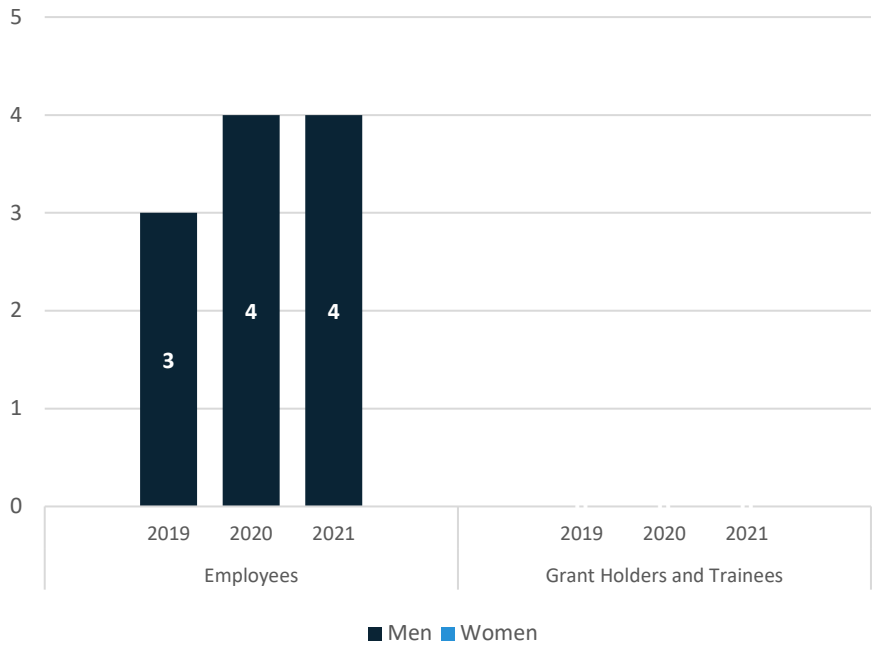


Figure 9.13.1 - SAS - Team composition and evolution

9.13.1 Presentation of the Service

The System Administration Service is responsible for managing servers, computers 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 2021

Teleworking at INESC TEC, due to the COVID-19 pandemic, continued to increase the usage of computational resources, collaborative services, and the helpdesk support as well, along 2021. The transition to hybrid work led to a strategic gradual change from desktops to laptops, which posed new challenges on how to deal with the administration of those systems and guarantee the overall security of those devices and data.

The year 2021 has seen a sharp increase on the number and complexity of attack attempts on machines, web sites and services like email mailbox servers, exposed to the Internet, but also phishing and malware through email to end users. SAS had to increase both preventive and reactive measures and team procedures to act swiftly, assist users in determining if their accounts may have been compromised or perform forensic analysis of potentially compromised machines. SAS provided internal best practices workshops and provides continuous recommendations to end-users.

Next are listed the highlights in 2021:

- Storage and computing infrastructures.
    - A more performant storage with higher capacity was acquired and integrated with existing computing platforms, and virtual machines were migrated from the old storage.

  - Four new servers were acquired and integrated to deal with the growing demand of virtual machines, which surpassed the 400 mark.
  - A new openstack cluster was deployed – the "Computing Cloud", CCloud. Effort was put on an openstack cluster that takes advantages of more recent versions of openstack services, more mature and stable, and integrate it with the new acquired storage and the INESC TEC Directory.

- **Resource usage monitoring**. A monitoring platform was deployed to track down virtual machines' potentially unused resources so that these can be made available to others.
- **Disaster recovery.** To increase the overall data availability in case of a disaster, SAS acquired and installed a tape library to store important weekly backups and move the tapes to an off-site secure location (cold site) in Porto. SAS also begun the planning and provisioning of equipment for a hot site at the University of Minho.
- **Collaborative applications.** The Gitlab, Chat and Drive services were improved with new functionalities. The on-premises Jitsi videoconference service (integrated with the Chat service) was upgraded to support more performant video codecs. The Drive service was expanded with more resources to deal with the growing number of users and data, and configured to present lower update latencies between client applications. This was done gradually, with minimal downtimes outside working hours, to guarantee the continuous operation of the services during working hours.
- **DevOps.** DevOps ecosystems in general and Kubernetes in particular are evolving rapidly, but still into a myriad of possible solutions, not compatible with the adoption of a single platform for INESC TEC. To deal with it, SAS has been deploying VMs for continuous integration to be used with Gitlab, and created Kubernetes clusters on-demand to allow more flexibility while ensuring that a Kubernetes cluster does not disrupt others.
  - **Security.** SAS improved the vulnerability assessment service to detect vulnerabilities on machines and applications, and the procedures to reduce the response time to fix them when those machines and applications are not managed by SAS.
  - SAS configured a scalable security patching service for Wordpress websites that accounts for more than 3/4 of the hundred websites hosted at INESC TEC.
  - SAS provided internal workshops to INESC TEC services and secretariat on Email and Electronic Signature best practices to help identifying phishing attacks attempts, and to recognize valid electronic signatures beyond the basic validation of the applications.
  - The email mailbox servers were reconfigured to be more resilient against cyber attacks.
  - The Antivirus availability was extended to MacOS computers, and the security policies were optimised to increase the overall security of the endpoints.
- Digital certificates.
  - The HTTP services were migrated to HTTPS.
  - A personal certificates service was made available and HowTos were created.
- **Data protection.** SAS continues contributing to Data Protection Impact Assessments; technology, infrastructures and data handling procedures analysis; and to aid on the identification of research projects with potential privacy and data protection implications.
- **Helpdesk.** To tackle with the increased number of helpdesk requests, which continued to grow in 2021, two junior collaborators joined the SAS team on the Q4 of 2021. They are still on the learning curve but already providing important aid on the helpdesk and first line support.

9.14 INFRASTRUCTURE MANAGEMENT SERVICE

Manager: Jorge Couto

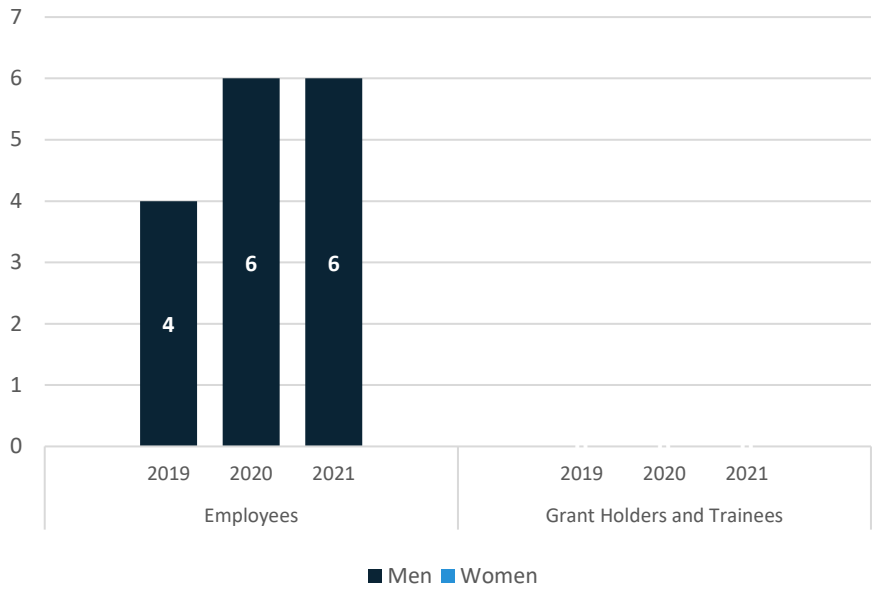


Figure 9.14.1 - SGI - Team composition and evolution

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 2021

- 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 2.6, painting of ceilings and walls;
- Renovation and alteration of workspaces in C8, R/ch, 3.7 (human resources) and ex-bar in building A;
- Replacement of the transformer station cells, due to a malfunction that caused them to burst;
- Extraordinary contracting of a cleaning company due to the bankruptcy of the contracted company to ensure the payment of the employees;
- Opening of tender and contracting of a company to provide cleaning services;
- Opening of tender and hiring of a company to provide security services;
- Purchase of an electric Renault Kangoo van for the service.

10 ANNEX I

10.1 CTM – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	13	10	9	-1
		Academic Staff	15	14	13	-1
		Grant Holders and Trainees	46	52	45	-7
		Total Core Researchers	**74**	**76**	**67**	**-9**
		Total Core PhD	**27**	**26**	**21**	**-5**
	Affiliated Researchers		7	9	8	-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		**82**	**86**	**76**	**-10**
	Total Integrated PhD		**34**	**35**	**29**	**-6**

Table 10.1.2 - CTM – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	474	470	396	-73
PN-PICT	National R&D Programmes - S&T Integrated Projects	95		4	4
PN-COOP	National Cooperation Programmes with Industry	248	322	150	-173
PUE-FP	EU Framework Programmes	245	240	205	-35
PUE-DIV	EU Cooperation Programmes - Other		-3		3
SERV-NAC	R&D Services and Consulting - National	302	295	708	413
SERV-INT	R&D Services and Consulting - International	89	123	37	-86
OP	Other Funding Programmes	23	51	59	8
Closed Projects		11			
Total Funding		**1 487**	**1 498**	**1 559**	**60**

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

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	35	40	45
Indexed Conferences	53	41	41
Books	0	0	0
Book Chapters	7	2	3
Concluded PhD Theses - Members	4	3	4
Concluded PhD Theses – Supervised	7	3	7

Table 10.1.4 - CTM - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	3	1	2
Software copyright registrations at IGAC	1	0	0
Patent first priority filings (New inventions)	0	0	1
Patent applications (Internationalisation)	12	4	4
Granted patents	3	2	5
Licence agreements	1	1	1
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.1.4 - CTM - Summary of dissemination activities

Type of Activity	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	3	5	10
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	5	4	7
International events in which INESC TEC members participate in the program committees	52	35	30
Participation in events such as fairs, exhibitions or similar	5	2	1
Conferences, workshops and scientific sessions organised by the Centre	5	3	12
Participants in the conferences, workshops and scientific sessions organised by the Centre	300	150	2700
Advanced training courses organised by the Centre	10	2	1

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	30/04/2022
PN-FCT	CLARE	Jaime Cardoso	01/07/2018	31/12/2021
PN-FCT	LUCAS	Hélder Filipe Oliveira	26/07/2018	25/01/2022
PN-FCT	PEPCC	João Canas Ferreira	01/10/2018	31/12/2021
PN-FCT	GROW	Rui Lopes Campos	01/10/2018	30/09/2021
PN-FCT	AUTOMOTIVE	Ana Filipa Sequeira	01/10/2018	30/11/2021
PN-FCT	S-MODE	Hélder Filipe Oliveira	01/07/2018	31/12/2021
PN-FCT	HELP-MD	Matthew Davies	01/10/2018	30/09/2022
PN-FCT	NeurOxide	Vítor Grade Tavares	01/10/2018	30/09/2022
PN-FCT	XPERIMUS	Rui Penha	26/11/2018	25/11/2022
PN-FCT	MATinMOL	Maria Inês Carvalho	01/03/2021	29/02/2024
PN-PICT	DECARBONIZE-1	Rui Lopes Campos	01/01/2021	31/12/2022
PN-COOP	5G	Manuel Ricardo	01/01/2018	30/06/2021
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
PN-COOP	FLY_PT-1	Hélder Martins Fontes	01/07/2020	30/06/2023
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	30/11/2022
PUE-FP	InterConnect-1	Filipe André Ribeiro	01/10/2019	30/09/2023
SERV-NAC	EasyRide	Jaime Cardoso	01/01/2019	30/09/2021
SERV-NAC	TenisApp2	Pedro Miguel Carvalho	01/10/2019	15/03/2021
SERV-NAC	STRx_Licenciamento	Filipe André Ribeiro	11/05/2020	11/05/2022
SERV-NAC	SLID	Luís Manuel Pessoa	01/11/2019	30/06/2022
SERV-NAC	5GforUtilities	Filipe André Ribeiro	01/01/2021	31/01/2022
SERV-NAC	CholdaDigital-1	Rui Lopes Campos	17/06/2021	28/02/2022
SERV-NAC	WaveCorkCal	Filipe André Ribeiro	25/06/2021	26/06/2021
SERV-NAC	CadPath	Filipe André Ribeiro	01/06/2021	30/06/2022
SERV-INT	SMART	Rui Lopes Campos	31/03/2021	31/03/2022
OP	Inphinit	Paula Viana	01/12/2019	01/12/2022
OP	VISUM2021	Ana Maria Rebelo	01/11/2020	31/07/2021
OP	EuCNC6GSummit	Filipe André Ribeiro	01/01/2021	01/10/2021

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

10.1.2 List of Publications

International Journals with Scientific Referees

1. Albuquerque, T, Cruz, R, Cardoso, JS, "Ordinal losses for classification of cervical cancer risk", Peerj Computer Science, vol.7, pp.457, 2021
2. Allahdadi, A, Pernes, D, Cardoso, JS, Morla, R, "Hidden Markov models on a self-organizing map for anomaly detection in 802.11 wireless networks", Neural Computing and Applications, 2021
3. Almeida, EN, Coelho, A, Ruela, J, Campos, R, Ricardo, M, "Joint Traffic-Aware UAV Placement and Predictive Routing for Aerial Networks", Ad Hoc Networks, vol.abs/2004.07371, 2021
4. Almeida, J, Vilaca, L, Teixeira, IN, Viana, P, "Emotion Identification in Movies through Facial Expression Recognition", Applied Sciences, vol.11, pp.6827, 2021
5. Andrade, C, Teixeira, LF, Vasconcelos, MJM, Rosado, L, "Data Augmentation Using Adversarial Image-to-Image Translation for the Segmentation of Mobile-Acquired Dermatological Images", Journal of Imaging, vol.7, pp.2, 2021
6. Azevedo, F, Cardoso, JS, Ferreira, A, Fernandes, T, Moreira, M, Campos, L, "Efficient reactive obstacle avoidance using spirals for escape", Drones, vol.5, pp.51, 2021
7. Carvalho, G, Pereira, M, Kiazadeh, A, Tavares, VG, "A Neural Network Approach towards Generalized Resistive Switching Modelling", MICROMACHINES, vol.12, SEP, 2021
8. Carvalho, P, Pereira, A, Viana, P, "Automatic TV Logo Identification for Advertisement Detection without Prior Data", Applied Sciences, vol.11, pp.7494, 2021
9. Castro, H, Andrade, MT, Viana, P, "FiM's DE-the communication package for the creative pipeline", Multimedia Tools and Applications, 2021
10. Castro, HF, Cardoso, JS, Andrade, MT, "A Systematic Survey of ML Datasets for Prime CV Research Areas—Media and Metadata", Data, vol.6, pp.12, 2021
11. Clement, A, Moreira, L, Rosa, M, Bernardes, G, "Musical Control Gestures in Mobile Handheld Devices: Design Guidelines Informed by Daily User Experience", Multimodal Technologies and Interaction, vol.5, pp.32, 2021
12. Costa, P, Smailagic, A, Cardoso, JS, Campilho, A, "Epistemic and Heteroscedastic Uncertainty Estimation in Retinal Blood Vessel Segmentation", U.Porto Journal of Engineering, vol.7, pp.93-100, 2021
13. Dionisio, R, Torres, P, Ramalho, A, Ferreira, R, "Magnetoresistive Sensors and Piezoresistive Accelerometers for Vibration Measurements: A Comparative Study", Journal of Sensor and Actuator Networks, vol.10, pp.22, MAR, 2021
14. Esteves, T, Pinto, JR, Ferreira, PM, Costa, PA, Rodrigues, LA, Antunes, I, Lopes, G, Gamito, P, Abrantes, AJ, Jorge, PM, Lourenco, A, Sequeira, AF, Cardoso, JS, Rebelo, A, "AUTOMOTIVE: A case study on Automatic multiMOdal drowsiness detecTIon for smart VEhicles", IEEE Access, pp.1-1, 2021
15. Faria, H, Paiva, S, Pinto, P, "An Advertising Overflow Attack Against Android Exposure Notification System Impacting COVID-19 Contact Tracing Applications", IEEE Access, vol.9, pp.103365-103375, 2021
16. Fernandes, L, Carvalho, S, Carneiro, I, Henrique, R, Tuchin, VV, Oliveira, HP, Oliveira, LM, "Diffuse reflectance and machine learning techniques to differentiate colorectal cancer ex vivo", Chaos, vol.31, pp.053118, 2021
17. Ferreira, PM, Pernes, D, Rebelo, A, Cardoso, JS, "DeSIRe: Deep Signer-Invariant Representations for Sign Language Recognition", IEEE Transactions on Systems, Man, and Cybernetics: Systems, pp.1-16, 2021
18. Freitas, C, Sousa, C, Machado, F, Serino, M, Santos, V, Cruz Martins, N, Teixeira, A, Cunha, A, Pereira, T, Oliveira, HP, Costa, JL, Hespanhol, V, "The Role of Liquid Biopsy in Early Diagnosis of Lung Cancer", Frontiers in Oncology, vol.11, 2021

19. Gouveia, PF, Oliveira, HP, Monteiro, JP, Teixeira, JF, Silva, NL, Pinto, D, Mavioso, C, Anacleto, J, Martinho, M, Duarte, I, Cardoso, JS, Cardoso, F, Cardoso, MJ, "3D Breast Volume Estimation", European Surgical Research, pp.1-6, 2021

20. Granhao, D, Ferreira, JC, "Transparent Control Flow Transfer between CPU and Accelerators for HPC", Electronics, vol.10, pp.406, 2021

21. Hussain, B, Salgado, HM, Pessoa, LM, "Wide Scanning Angle Millimetre Wave 1 x 4 Planar Antenna Array on InP at 300 GHz", APPLIED SCIENCES-BASEL, vol.11, pp.7117, AUG, 2021

22. Martins, C, da Silva, JM, Guimaraes, D, Martins, L, da Silva, MV, "MONITORIA: The start of a new era of ambulatory heart failure monitoring? Part I – Theoretical Rationale [MONITORIA: o início de uma nova era na monitoração da insuficiência cardíaca? Parte I – Fundamentação teórica]", Revista Portuguesa de Cardiologia, 2021

23. Martins, C, da Silva, JM, Guimaraes, D, Martins, L, Da Silva, MV, "MONITORIA: The start of a new era of ambulatory heart failure monitoring? Part II – Design [MONITORIA: uma nova era na monitoração ambulatória da insuficiência cardíaca? Parte II – Desenho]", Revista Portuguesa de Cardiologia, 2021

24. Montenegro, H, Silva, W, Cardoso, JS, "Privacy-Preserving Generative Adversarial Network for Case-Based Explainability in Medical Image Analysis", IEEE Access, vol.9, pp.148037-148047, 2021

25. Morgado, AC, Andrade, C, Teixeira, LF, Vasconcelos, MJM, "Incremental Learning for Dermatological Imaging Modality Classification", Journal of Imaging, vol.7, pp.180, SEP, 2021

26. Morgado, J, Pereira, T, Silva, F, Freitas, C, Negrao, E, de Lima, BF, da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Costa, JL, Cunha, A, Oliveira, HP, "Machine Learning and Feature Selection Methods for EGFR Mutation Status Prediction in Lung Cancer", Applied Sciences, vol.11, pp.3273, 2021

27. Novais, M, Henriques, T, Vidal Alves, MJ, Magalhaes, T, "When Problems Only Get Bigger: The Impact of Adverse Childhood Experience on Adult Health", Frontiers in Psychology, vol.12, 2021

28. Oliveira, J, Pinto, P, Santos, H, "Distributed Architecture to Enhance Systems Protection against Unauthorized Activity via USB Devices", Journal of Sensor And Actuator Networks, vol.10, MAR, 2021

29. Oliveira, SP, Neto, PC, Fraga, J, Montezuma, D, Monteiro, A, Monteiro, J, Ribeiro, L, Goncalves, S, Pinto, IM, Cardoso, JS, "CAD systems for colorectal cancer from WSI are still not ready for clinical acceptance", Scientific Reports, vol.11, 2021

30. Paulino, N, Bispo, J, Ferreira, JC, Cardoso, JMP, "A Binary Translation Framework for Automated Hardware Generation", IEEE Micro, pp.1-1, 2021

31. Pedreira, V, Barros, D, Pinto, P, "A Review of Attacks, Vulnerabilities, and Defenses in Industry 4.0 with New Challenges on Data Sovereignty Ahead", SENSORS, vol.21, pp.5189, AUG, 2021

32. Pereira, T, Freitas, C, Costa, JL, Morgado, J, Silva, F, Negrao, E, de Lima, BF, da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Cunha, A, Oliveira, HP, "Comprehensive Perspective for Lung Cancer Characterisation Based on AI Solutions Using CT Images", Journal of Clinical Medicine, vol.10, pp.118, 2021

33. Pereira, T, Morgado, J, Silva, F, Pelter, MM, Dias, VR, Barros, R, Freitas, C, Negrao, E, de Lima, BF, da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Costa, JL, Cunha, A, Oliveira, HP, "Sharing Biomedical Data: Strengthening AI Development in Healthcare", Healthcare, vol.9, pp.827, 2021

34. Pinto, AS, Bock, S, Cardoso, JS, Davies, MEP, "User-driven fine-tuning for beat tracking", Electronics (Switzerland), vol.10, pp.1518, 2021

35. Pinto, JR, Correia, MV, Cardoso, JS, "Secure Triplet Loss: Achieving Cancelability and Non-Linkability in End-to-End Deep Biometrics", IEEE Transactions on Biometrics, Behavior, and Identity Science, pp.1-1, 2021

36. Rodrigues, C, Ramos, M, Esteves, R, Correia, J, Clemente, D, Goncalves, F, Mathias, N, Gomes, M, Silva, J, Duarte, C, Morais, T, Rosa Santos, P, Taveira Pinto, F, Pereira, A, Ventura, J, "Integrated study of

triboelectric nanogenerator for ocean wave energy harvesting: Performance assessment in realistic sea conditions", NANO ENERGY, vol.84, pp.105890, JUN, 2021

37. Saffari, M, Khodayar, M, Saadabadi, MSE, Sequeira, AF, Cardoso, JS, "Maximum Relevance Minimum Redundancy Dropout with Informative Kernel Determinantal Point Process", Sensors, vol.21, pp.1846, 2021
38. Salselas, I, Penha, R, Bernardes, G, "Sound design inducing attention in the context of audiovisual immersive environments", Personal and Ubiquitous Computing, 2021
39. Santos, LC, dos Santos, FN, Morais, R, Duarte, C, "Potential Non-Invasive Technique for Accessing Plant Water Contents Using a Radar System", Agronomy, vol.11, pp.279, 2021
40. Sequeira, AF, Goncalves, T, Silva, W, Pinto, JR, Cardoso, JS, "An exploratory study of interpretability for face presentation attack detection", IET Biometrics, 2021
41. Silva, F, Pereira, T, Morgado, J, Frade, J, Mendes, J, Freitas, C, Negrao, E, De Lima, BF, Da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Costa, JL, Cunha, A, Oliveira, HP, "EGFR Assessment in Lung Cancer CT Images: Analysis of Local and Holistic Regions of Interest Using Deep Unsupervised Transfer Learning", IEEE Access, vol.9, pp.58667-58676, 2021
42. Sulun, S, Davies, MEP, "On Filter Generalization for Music Bandwidth Extension Using Deep Neural Networks", IEEE Journal of Selected Topics in Signal Processing, vol.abs/2011.07274, 2021
43. Teixeira F.B., Ferreira B.M., Moreira N., Abreu N., Villa M., Loureiro J.P., Cruz N.A., Alves J.C., Ricardo M., Campos R., "A Novel Simulation Platform for Underwater Data Muling Communications Using Autonomous Underwater Vehicles", Computers, vol.10, pp.119, 2021
44. Teixeira, JF, Dias, M, Batista, E, Costa, J, Teixeira, LF, Oliveira, HP, "Adversarial Data Augmentation on Breast MRI Segmentation", APPLIED SCIENCES-BASEL, vol.11, pp.4554, MAY, 2021
45. Torres, N, Pinto, P, Lopes, SI, "Security Vulnerabilities in LPWANs-An Attack Vector Analysis for the IoT Ecosystem", APPLIED SCIENCES-BASEL, vol.11, pp.3176, APR, 2021

International Conference Proceedings with Scientific Referees

1. Albuquerque, T, Cardoso, JS, "Embedded regularization for classification of colposcopic images", Proceedings - International Symposium on Biomedical Imaging, vol.2021-April, pp.1920-1923, 2021
2. Albuquerque, T, Moreira, A, Cardoso, JS, "Deep Ordinal Focus Assessment for Whole Slide Images", IEEE/CVF International Conference on Computer Vision Workshops, ICCVW 2021, Montreal, BC, Canada, October 11-17, 2021, pp.657-663, 2021
3. Araújo, R, Pinto, A, Pinto, P, "A Performance Assessment of Free-to-Use Vulnerability Scanners - Revisited", IFIP Advances in Information and Communication Technology, vol.625, pp.53-65, 2021
4. Assis, M, Andrade, MT, Viana, P, "Context-Based Cultural Visits", Advances in Intelligent Systems and Computing, vol.1372 AISC, pp.362-371, 2021
5. Barboza, JR, Magalhaes, E, Bernardes, G, "Towards Best Practices in Spatial Audio Post Production: A Case Study of Brazilian Popular Music", 2021 Immersive and 3D Audio: from Architecture to Automotive (I3DA), 2021
6. Bernardo, G, Bernardes, G, "Leveraging Compatibility and Diversity in Computational Music Mashup Creation", Audio Mostly 2021, 2021
7. Boutros, F, Damer, N, Kolf, JN, Raja, K, Kirchbuchner, F, Ramachandra, R, Kuijper, A, Fang, P, Zhang, C, Wang, F, Montero, D, Aginako, N, Sierra, B, Nieto, M, Erakin, ME, Demir, U, Ekenel, HK, Kataoka, A, Ichikawa, K, Kubo, S, Zhang, J, He, M, Han, D, Shan, S, Grm, K, Struc, V, Seneviratne, S, Kasthuriarachchi, N, Rasnayaka, S, Neto, PC, Sequeira, AF, Pinto, JR, Saffari, M, Cardoso, JS, "MFR 2021: Masked Face Recognition Competition", International IEEE Joint Conference on Biometrics, IJCB 2021, vol.abs/2106.15288, 2021

8. Brito C., Pinto L., Marinho V., Paiva S., Pinto P., "A Review on Recent Advances in Implanted Medical Devices Security", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021
9. Capozzi, L, Carvalho, P, Sousa, A, Pinto, C, Pinto, JR, Cardoso, JS, "Impact of Visual Noise in Activity Recognition Using Deep Neural Networks - An Experimental Approach", 2021 IEEE 2nd International Conference on Pattern Recognition and Machine Learning (PRML), 2021
10. Capozzi, L, Pinto, JR, Cardoso, JS, Rebelo, A, "End-to-End Deep Sketch-to-Photo Matching Enforcing Realistic Photo Generation", Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications - Lecture Notes in Computer Science, pp.451-460, 2021
11. Capozzi, L, Pinto, JR, Cardoso, JS, Rebelo, A, "Optimizing Person Re-Identification Using Generated Attention Masks", Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications - Lecture Notes in Computer Science, pp.248-257, 2021
12. Carvalho N., Gonzalez-Gutierrez S., Merchan Sanchez-Jara J., Bernardes G., Navarro-Cáceres M., "Encoding, Analysing and Modeling I-Folk: A New Database of Iberian Folk Music", 8th International Conference on Digital Libraries for Musicology, 2021
13. Carvalho, N, Bernardes, G, "SyVMO: Synchronous Variable Markov Oracle for Modeling and Predicting Multi-part Musical Structures", Artificial Intelligence in Music, Sound, Art and Design - Lecture Notes in Computer Science, pp.37-51, 2021
14. Carvalho, PH, Rocha, I, Azevedo, F, Peixoto, PS, Segundo, MA, Oliveira, HP, "Cost-Efficient Color Correction Approach on Uncontrolled Lighting Conditions", Computer Analysis of Images and Patterns - Lecture Notes in Computer Science, pp.90-99, 2021
15. Coelho, A, Fontes, H, Campos, R, Ricardo, M, "Traffic-aware Gateway Placement for High-capacity Flying Networks", 2021 IEEE 93rd Vehicular Technology Conference (VTC2021-Spring), 2021
16. 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, 2021
17. Costa P., Campilho A., Cardoso J., "A Study on Annotation Efficient Learning Methods for Segmentation in Prostate Histopathological Images", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12702 LNCS, pp.55-64, 2021
18. Costa, A, Rodrigues, D, Castro, M, Assis, S, Oliveira, HP, "Embedding Anatomical Characteristics in 3D Models of Lower-limb Sockets through Statistical Shape Modelling", Proceedings of the 16th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, 2021
19. Costa, DG, Vasques, F, Portugal, P, "A Mathematical Model to Evaluate Visual Sensing Coverage of Emergency Signs on Moving Vehicles", IEEE International Smart Cities Conference, ISC2 2021, Manchester, United Kingdom, September 7-10, 2021, pp.1-7, 2021
20. Costa, P, Campilho, A, Cardoso, JS, "A Study on Annotation Efficient Learning Methods for Segmentation in Prostate Histopathological Images", Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications - Lecture Notes in Computer Science, pp.55-64, 2021
21. Cruz, R, Prates, RM, Simas, EF, Costa, JFP, Cardoso, JS, "Background Invariance by Adversarial Learning", 2020 25th International Conference on Pattern Recognition (ICPR), pp.5883-5888, 2021
22. Damas, J, Lima, B, Araujo, AJ, "AOCO - A Tool to Improve the Teaching of the ARM Assembly Language in Higher Education", 2021 30th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE), 2021
23. Guerrero, LG, Graham, C, George, J, Renaud, C, George, G, Hussain, B, Salgado, HM, Pessoa, LM, Hinojosa, A, Fernandez, J, Porcel, MAG, "Design and Fabrication of sub-THz Steerable Photonic Transmitter 1x4 Array for Short-Distance Wireless Links", 2021 Joint European Conference On Networks And Communications & 6G Summit (EUCNC/6G SUMMIT), pp.490-495, 2021

24. Hussain B., Wang J., Al-Khalidi A., Wasige E., Salgado H.M., Pessoa L.M., "Resonant cavity assisted broadband CPW to rectangular waveguide transition on InP at 300 GHz", International Conference on Infrared, Millimeter, and Terahertz Waves, IRMMW-THz, vol.2021-August, 2021

25. Lamela, V, Fontes, H, Ruela, J, Ricardo, M, Campos, R, "Reproducible MIMO operation in ns-3 using trace-based wi-fi rate adaptation", ACM International Conference Proceeding Series, pp.49-56, 2021

26. Lemos, C, Cocharro, D, Bernardes, G, "Understanding Cross-Genre Rhythmic Audio Compatibility: A Computational Approach", Audio Mostly 2021, 2021

27. Malafaia, M, Pereira, T, Silva, F, Morgado, J, Cunha, A, Oliveira, HP, "Ensemble Strategies for EGFR Mutation Status Prediction in Lung Cancer", 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), 2021

28. Matta, A, Pinto, JR, Cardoso, JS, "Mixture-Based Open World Face Recognition", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.653-662, 2021

29. Moranguinho, J, Pereira, T, Ramos, B, Morgado, J, Costa, JL, Oliveira, HP, "Attention Based Deep Multiple Instance Learning Approach for Lung Cancer Prediction using Histopathological Images", 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2021, Mexico, November 1-5, 2021, pp.2852-2855, 2021

30. Neto, PC, Boutros, F, Pinto, JR, Darner, N, Sequeira, AF, Cardoso, JS, "FocusFace: Multi-task Contrastive Learning for Masked Face Recognition", 16th IEEE International Conference on Automatic Face and Gesture Recognition, vol.abs/2110.14940, 2021

31. Neto, PC, Boutros, F, Pinto, JR, Saffari, M, Damer, N, Sequeira, AF, Cardoso, JS, "My Eyes Are Up Here: Promoting Focus on Uncovered Regions in Masked Face Recognition", 20th Annual International Conference of the Biometrics-Special-Interest-Group (BIOSIG), vol.abs/2108.00996, 2021

32. Paulino, N, Pessoa, LM, Branquinho, A, Goncalves, E, "Evaluating a Novel Bluetooth 5.1 AoA Approach for Low-Cost Indoor Vehicle Tracking via Simulation", 2021 Joint European Conference on Networks and Communications & 6G Summit (EUCNC/6G SUMMIT), pp.259-264, 2021

33. Pinho, P, Rio Torto, I, Teixeira, LF, "Improving Automatic Quality Inspection in the Automotive Industry by Combining Simulated and Real Data", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.13017 LNCS, pp.278-290, 2021

34. Ramos, B, Pereira, T, Moranguinho, J, Morgado, J, Costa, JL, Oliveira, HP, "An Interpretable Approach for Lung Cancer Prediction and Subtype Classification using Gene Expression", 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2021, Mexico, November 1-5, 2021, pp.1707-1710, 2021

35. Reis, P, Carvalho, PH, Peixoto, PS, Segundo, MA, Oliveira, HP, "Mobile Application for Determining the Concentration of Sulfonamides in Water Using Digital Image Colorimetry", Universal Access in Human-Computer Interaction. Access to Media, Learning and Assistive Environments - 15th International Conference, UAHCI 2021, Held as Part of the 23rd HCI International Conference, HCII 2021, Virtual Event, July 24-29, 2021, Proceedings, Part II, vol.12769, pp.468-484, 2021

36. Santos, G, Martins, J, Coelho, A, Fontes, H, Ricardo, M, Campos, R, "A Fast Gateway Placement Algorithm for Flying Networks", IEEE 93rd Vehicular Technology Conference (VTC-Spring), vol.abs/2010.06732, 2021

37. Santos, T, Paulino, N, Bispo, J, Cardoso, JMP, Ferreira, JC, "On the Performance Effect of Loop Trace Window Size on Scheduling for Configurable Coarse Grain Loop Accelerators", International Conference on Field-Programmable Technology, (IC)FPT 2021, Auckland, New Zealand, December 6-10, 2021, pp.1-4, 2021

38. Silva, F, Pereira, T, Morgado, J, Cunha, A, Oliveira, HP, "The Impact of Interstitial Diseases Patterns on Lung CT Segmentation", 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), 2021

39. Silva, PF, Bispo, J, Paulino, N, "FPGAs as General-Purpose Accelerators for Non-Experts via HLS: The Graph Analysis Example", International Conference on Field-Programmable Technology, (IC)FPT 2021, Auckland, New Zealand, December 6-10, 2021, pp.1-4, 2021
40. Torres, N, Martins, P, Pinto, P, Lopes, SI, "Smart & Sustainable Mobility on Campus: A secure IoT tracking system for the BIRA Bicycle", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021
41. Ventura, A, Pereira, T, Silva, F, Freitas, C, Cunha, A, Oliveira, HP, "Stacking Approach for Lung Cancer EGFR Mutation Status Prediction from CT Scans", IEEE International Conference on Bioinformatics and Biomedicine, BIBM 2021, Houston, TX, USA, December 9-12, 2021, pp.3099-3105, 2021

Books

Blank

Chapter/Paper in Books

1. Cocharro, D, Bernardes, G, Bernardo, G, Lemos, C, "A Review of Musical Rhythm Representation and (Dis)similarity in Symbolic and Audio Domains", Current Research in Systematic Musicology - Perspectives on Music, Sound and Musicology, pp.189-208, 2021
2. Costa, TS, Andrade, MT, Viana, P, "Inferring Contextual Data from Real-World Photography", Advances in Intelligent Systems and Computing - Intelligent Systems Design and Applications, pp.853-862, 2021
3. Pinto, JR, Cardoso, JS, "ECG Biometrics", Encyclopedia of Cryptography, Security and Privacy, pp.1-4, 2021

Publications (Editor)

1. Tucker, A, Abreu, PH, Cardoso, JS, Rodrigues, PP, Riaño, D, "Artificial Intelligence in Medicine - 19th International Conference on Artificial Intelligence in Medicine, AIME 2021, Virtual Event, June 15-18, 2021, Proceedings", AIME, vol.12721, 2021

Dissertations (PhD)

1. Araújo, R., “Computer Vision for Blood Vessel Segmentation and Related Applications”
2. Cunha, D., “Learning from multi-entity data”
3. Bessa, S., “Personalized 3D Breast Cancer Models: from Multimodal Registration to Predictive Shape Modelling”
4. Cruz, R., “Rethinking a Deep Learning Pipeline for Images”

10.2 CAP – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	9	10	11	1
		Academic Staff	8	8	8	0
		Grant Holders and Trainees	13	18	11	-7
		Total Core Researchers	**30**	**36**	**30**	**-6**
		Total Core PhD	**15**	**15**	**16**	**1**
	Affiliated Researchers		5	5	5	0
	Administrative and Technical	Employees	2	1	1	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**2**	**1**	**1**	**0**
		Total Integrated HR	**37**	**42**	**36**	**-6**
		Total Integrated PhD	**20**	**20**	**20**	**0**

Table 10.2.2 - CAP - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	370	289	191	-98
PN-PICT	National R&D Programmes - S&T Integrated Projects	81	22	1	-22
PN-COOP	National Cooperation Programmes with Industry			46	46
PUE-FP	EU Framework Programmes	22	211	260	48
PUE-DIV	EU Cooperation Programmes - Other	70	38	47	8
SERV-NAC	R&D Services and Consulting - National	46	46	-3	-49
SERV-INT	R&D Services and Consulting - International		4	17	13
OP	Other Funding Programmes			9	9
Closed Projects		19			
	Total Funding	**608**	**610**	**567**	**-43**

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

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	25	20	38
Indexed Conferences	29	2	5
Books	0	0	0
Book Chapters	0	0	0
Concluded PhD Theses - Members	0	0	2
Concluded PhD Theses – Supervised	1	0	4

Table 10.2.4 - CAP - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	1	2	3
Software copyright registrations at IGAC	0	0	0
Patent first priority filings (New inventions)	0	2	3
Patent applications (Internationalisation)	4	9	13
Granted patents	0	0	1
Commercial contracts – Licenses and Assignments	0	0	0
Spin-offs established	0	0	0
Spin-offs in development	1	1	1

Table 10.2.5 - CAP - Summary of dissemination activities

Type of Activity	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	5	16	4
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	1	2	3
International events in which INESC TEC members participate in the program committees	6	5	1
Participation in events such as fairs, exhibitions or similar	1	1	0
Conferences, workshops and scientific sessions organised by the Centre	8	1	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	80	300	20
Advanced training courses organised by the Centre	0	0	0

Table 10.2.6 - CAP - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	FLAPSYS	Pedro Jorge	01/03/2018	28/02/2022
PN-FCT	SolSensors	Luís Carlos Coelho	01/05/2018	31/12/2021
PN-FCT	ENDOR	Orlando Frazão	01/06/2018	31/12/2021
PN-FCT	MetBots	Rui Costa Martins	26/07/2018	30/11/2021
PN-FCT	GreenNanoSensing	Ariel Guerreiro	01/07/2018	30/06/2022
PN-COOP	CorkSurf	Pedro Jorge	01/07/2020	30/06/2023
PUE-DIV	SAFEWATER	Pedro Jorge	03/04/2018	31/12/2021
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	FlexOPlan-1	Ireneu Dias	01/05/2019	31/12/2021
SERV-NAC	DFOSREN	Ireneu Dias	01/10/2021	01/10/2022
SERV-INT	ESAPlastics-1	Ireneu Dias	01/10/2019	27/07/2021
SERV-INT	LIRA	Orlando Frazão	01/11/2021	01/05/2023
OP	SpecTOM_BIPProof2020	Rui Costa Martins	12/03/2021	30/11/2021

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. Aguiar, AS, Magalhaes, SA, dos Santos, FN, Castro, L, Pinho, T, Valente, J, Martins, R, Boaventura Cunha, J, “Grape Bunch Detection at Different Growth Stages Using Deep Learning Quantized Models”, Agronomy, vol.11, pp.1890, 2021
2. Amorim, VA, Maia, JM, Viveiros, D, Marques, PVS, “Mach-Zehnder interferometer-based evanescent refractometer inscribed at the surface of Eagle2000 by femtosecond laser writing”, IEEE Sensors Journal, pp.1-1, 2021
3. Amorim, VA, Viveiros, D, Maia, JM, Marques, PVS, “Intensity-modulated refractometer based on mode-mismatch in surface waveguides inscribed by femtosecond laser direct writing”, Optics and Laser Technology, vol.135, MAR, 2021
4. Caldas, P, Rego, G, “Optical Fiber Interferometers Based on Arc-Induced Long Period Gratings at INESC TEC”, SENSORS, vol.21, pp.7400, NOV, 2021
5. Cardoso, MP, Silva, AO, Romeiro, AF, Giraldi, MTR, Costa, JCWA, Santos, JL, Baptista, JM, Guerreiro, A, “Multi-Plasmonic Resonance Based Sensor for the Characterization of Optical Dispersion Using a D-Shaped Photonic Crystal Fiber”, IEEE Instrumentation & Measurement Magazine, vol.24, pp.63-68, AUG, 2021

6. Cardoso, MP, Silva, AO, Romeiro, AF, Giraldi, MTR, Costa, JCWA, Santos, JL, Baptista, JM, Guerreiro, A, “Second-Order Dispersion Sensor Based on Multi-Plasmonic Surface Resonances in D-Shaped Photonic Crystal Fibers”, Photonics, vol.8, JUN, 2021
7. Cardoso, VHR, Caldas, P, Giraldi, MTR, Frazao, O, de Carvalho, CJR, Costa, JCWA, Santos, JL, “Experimental investigation of a strain gauge sensor based on Fiber Bragg Grating for diameter measurement”, Optical Fiber Technology, vol.61, pp.102428, 2021
8. Carvalho, IA, Silva, NA, Rosa, CC, Coelho, LCC, Jorge, PAS, “Particle Classification through the Analysis of the Forward Scattered Signal in Optical Tweezers”, Sensors, vol.21, pp.6181, 2021
9. Da Silva, PM, Coelho, LCC, Almeida, JMMMD, “Single Fiber Reflectance Spectroscopy for the Monitoring of Cement Paste”, CHEMOSENSORS, vol.9, pp.312, NOV, 2021
10. Dias, B, Santos, P, Jorge, PAS, de Almeida, JMMM, Coelho, LCC, “Spectral Reconstruction and Bayesian Model Framework for Characterization of Long Period Fiber Gratings”, IEEE Instrumentation & Measurement Magazine, vol.24, pp.56-62, AUG, 2021
11. Dos Santos, PSS, De Almeida, JMMM, Pastoriza Santos, I, Coelho, LCC, “Advances in plasmonic sensing at the nir—a review”, Sensors, vol.21, pp.1-48, 2021
12. Ferreira, TD, Novo, J, Silva, NA, Guerreiro, A, Bertolami, O, “Pressureless static solutions in a Newton-Yukawa gravity model”, PHYSICAL REVIEW D, vol.103, 2021
13. Figueira, RB, de Almeida, JM, Ferreira, B, Coelho, L, Silva, CJR, “Optical fiber sensors based on sol–gel materials: design, fabrication and application in concrete structures”, Materials Advances, 2021
14. Gomes, AD, Bartelt, H, Frazao, O, “Optical Vernier Effect: Recent Advances and Developments”, Laser & Photonics Reviews, pp.2000588, 2021
15. Gomes, AD, Zhao, JBT, Tuniz, A, Schmidt, MA, “Direct observation of modal hybridization in nanofluidic fiber [Invited]”, Optical Materials Express, vol.11, pp.559-568, 2021
16. Ivanov, OV, Caldas, P, Rego, G, “Simulation of the Transmission Spectrum of Long-Period Fiber Gratings Structures with a Propagating Acoustic Shock Front”, SENSORS, vol.21, pp.7212, NOV, 2021
17. Maia, JM, Amorim, VA, Viveiros, D, Marques, PVS, “Femtosecond laser micromachining of an optofluidics-based monolithic whispering-gallery mode resonator coupled to a suspended waveguide”, Scientific Reports, vol.11, 2021
18. Mesonero Santos, P, Fernandez Medina, A, Coelho, LCC, Viveiros, D, Jorge, PA, Belenguer, T, Heredero, RL, “Effect of low-doses of gamma radiation on electric arc-induced long period fiber gratings”, Sensors, vol.21, pp.2318, 2021
19. Monteiro Silva, F, Queiros, C, Leite, A, Rodriguez, MT, Rojo, MJ, Torroba, T, Martins, RC, Silva, AMG, Rangel, M, “Synthesis of Catechol Derived Rosamine Dyes and Their Reactivity toward Biogenic Amines”, Molecules, vol.26, pp.5082, AUG, 2021
20. Monteiro, CS, Raposo, M, Ribeiro, PA, Silva, SO, Frazao, O, “Acoustic Optical Fiber Sensor Based on Graphene Oxide Membrane”, Sensors, vol.21, pp.2336, 2021
21. Monteiro, CS, Rodrigues, AV, Viveiros, D, Linhares, C, Mendes, H, Silva, SO, Marques, PVS, Tavares, SMO, Frazao, O, “Optical Fiber Sensors for Structural Monitoring in Power Transformers”, Sensors, vol.21, pp.6127, 2021
22. Peixoto, R, Pires, JPS, Monteiro, CS, Raposo, M, Ribeiro, PA, Silva, SO, Frazao, O, Lopes, JMVP, “Environmental Sensitivity of Fabry-Perot Microcavities Induced by Layered Graphene-Dielectric Hybrid Coatings”, Physical Review Applied, vol.16, 2021
23. Raposo, M, Xavier, C, Monteiro, C, Silva, S, Frazao, O, Zagalo, P, Ribeiro, PA, “Thermally Stimulated Desorption Optical Fiber-Based Interrogation System: An Analysis of Graphene Oxide Layers’ Stability”, Photonics, vol.8, pp.70, 2021
24. Rego, G, Caldas, P, Ivanov, OV, “Arc-Induced Long-Period Fiber Gratings at INESC TEC. Part I: Fabrication, Characterization and Mechanisms of Formation”, SENSORS, vol.21, pp.4914, JUL, 2021

25. Rego, G, Caldas, P, Ivanov, OV, “Arc-induced long-period fiber gratings at inesc tec. Part ii: Properties and applications in optical communications and sensing”, Sensors, vol.21, pp.5914, 2021

26. Ribeiro, R, Capela, D, Ferreira, M, Martins, R, Jorge, P, Guimaraes, D, Lima, A, “X-ray Fluorescence and Laser-Induced Breakdown Spectroscopy Analysis of Li-Rich Minerals in Veins from Argemela Tin Mine, Central Portugal”, Minerals, vol.11, pp.1169, 2021

27. Robalinho, P, Frazao, O, “Giant Displacement Sensitivity Using Push-Pull Method in Interferometry”, Photonics, vol.8, pp.23, 2021

28. Robalinho, P, Frazao, O, “Nano-Displacement Measurement Using an Optical Drop-Shaped Structure”, IEEE Photonics Technology Letters, vol.33, pp.65-68, 2021

29. Robalinho, P, Gomes, A, Frazao, O, “Colossal enhancement of strain sensitivity using the push-pull deformation method”, IEEE Sensors Journal, pp.1-1, 2021

30. Santos, JL, “Optical Sensors for Industry 4.0”, IEEE Journal of Selected Topics in Quantum Electronics, vol.27, NOV, 2021

31. Saraiva, C, Silva, AC, Garcia Diez, J, Cenci Goga, B, Grispoldi, L, Silva, AF, Almeida, JM, “Antimicrobial Activity of Myrtus communis L. and Rosmarinus officinalis L. Essential Oils against Listeria monocytogenes in Cheese”, FOODS, vol.10, pp.1106, MAY, 2021

32. Silva, LH, Santos, P, Coelho, LCC, Jorge, P, Baptista, JM, “Development of a Long Period Fiber Grating Interrogation System Using A Multimode Laser Diode”, Sensors, vol.21, pp.749, 2021

33. Silva, NA, Ferreira, T, Guerreiro, A, “Hardware-neutral tools for the exploration of optical phenomena in near-resonant atomic systems”, International Journal of Modern Physics C, 2021

34. Silva, NA, Ferreira, TD, Guerreiro, A, “Reservoir computing with solitons”, New Journal of Physics, 2021

35. Soares, L, Cruz, P, Novais, S, Ferreira, A, Frazao, O, Silva, S, “Application of a Fiber Optic Refractometric Sensor to Measure the Concentration of Paracetamol in Crystallization Experiments”, IEEE Instrumentation & Measurement Magazine, vol.24, pp.36-40, AUG, 2021

36. Vasconcelos, H, Coelho, LCC, Matias, A, Saraiva, C, Jorge, PAS, de Almeida, JMMM, “Biosensors for Biogenic Amines: A Review”, Biosensors, vol.11, pp.82, 2021

37. Vasconcelos, H, de Almeida, JMMM, Matias, A, Saraiva, C, Jorge, PAS, Coelho, LCC, “Detection of biogenic amines in several foods with different sample treatments: An overview”, Trends in Food Science & Technology, vol.113, pp.86-96, 2021

38. Viveiros, D, de Almeida, JMMM, Coelho, L, Vasconcelos, H, Maia, JM, Amorim, VA, Jorge, PAS, Marques, PVS, “Turn Around Point Long Period Fiber Gratings With Coupling to Asymmetric Cladding Modes Fabricated by a Femtosecond Laser and Coated With Titanium Dioxide”, JOURNAL OF LIGHTWAVE TECHNOLOGY, vol.39, pp.4784-4793, 2021

International Conference Proceedings with Scientific Referees

1. Ferreira, TD, Novo, J, Bertolami, O, Silva, NA, Guerreiro, A, “Analogue cosmology: using techniques from nonlinear optics to study modified theories of gravity with non-minimal coupling between curvature and matter”, Nonlinear Optics and Applications XII, 2021

2. Ferreira, TD, Silva, NA, Guerreiro, A, “Superfluid effects in defocusing nematic liquid crystals”, Nonlinear Optics and Applications XII, 2021

3. Marques, PVS, Amorim, VA, Maia, JM, Viveiros, D, “Loss mechanisms in femtosecond laser written optical waveguides”, Proceedings of SPIE – The International Society for Optical Engineering, vol.11676, 2021

4. Silva, NA, Ferreira, TD, Guerreiro, A, “Exploring quantum-like turbulence with a two-component paraxial fluid of light”, Results in Optics, pp.100025, 2021

5. Silva, NAA, Ferreira, TD, Silva, DJ, Guerreiro, A, "Reservoir computing with optical solitons", Proceedings of SPIE - The International Society for Optical Engineering, vol.11770, 2021

Books

Blank

Chapter/paper in Books

Blank

Publications (Editor)

Blank

Dissertations (PhD)

1. Maia, J., “Fabrication of Optofluidic Systems by Femtosecond Laser Micromachining”
2. Amorim, V., “Fast prototyping of advanced sensing devices using three-dimensional direct writing with femtosecond laser”

10.3 CRAS – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	12	18	20	2
		Academic Staff	11	12	12	0
		Grant Holders and Trainees	25	32	38	6
		Total Core Researchers	**48**	**62**	**70**	**8**
		Total Core PhD	**14**	**16**	**16**	**0**
	Affiliated Researchers		0	0	0	0
	Administrative and Technical	Employees	3	3	4	1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**3**	**3**	**4**	**1**
		Total Integrated HR	**51**	**65**	**74**	**9**
		Total Integrated PhD	**14**	**16**	**16**	**0**

Table 10.3.2 - CRAS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	482	507	355	-152
PN-PICT	National R&D Programmes - S&T Integrated Projects	13			0
PN-COOP	National Cooperation Programmes with Industry	147	210	328	117
PUE-FP	EU Framework Programmes	276	767	950	183
PUE-DIV	EU Cooperation Programmes – Other	201	124	262	139
SERV-NAC	R&D Services and Consulting – National	61	73	30	-43
SERV-INT	R&D Services and Consulting - International	132	222	312	90
OP	Other Funding Programmes	7	28	1	-27
Closed Projects		60			
	Total Funding	**1 380**	**1 932**	**2 239**	**307**

Table 10.3.3 - CRAS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	16	10	15
Indexed Conferences	29	16	15
Books	0	0	1
Book Chapters	0	1	1
Concluded PhD Theses - Members	0	1	0
Concluded PhD Theses – Supervised	0	1	0

Table 10.3.4 - CRAS - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	1	0	3
Software copyright registrations at IGAC	1	0	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	2	4	3
Granted patents	0	0	0
Commercial contracts – Licenses and Assignments	1	0	0
Spin-offs established	0	0	1
Spin-offs in development	1	1	0

Table 10.3.5 - CRAS - Summary of dissemination activities

Type of Activity	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	1	8	10
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	1	1	5
International events in which INESC TEC members participate in the program committees	5	19	10
Participation in events such as fairs, exhibitions or similar	4	22	46
Conferences, workshops and scientific sessions organised by the Centre	4	2	16
Participants in the conferences, workshops and scientific sessions organised by the Centre	150	320	1800
Advanced training courses organised by the Centre	0	2	1

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	30/04/2022
PN-FCT	EMSO-PT	Aníbal Matos	01/07/2017	31/03/2022
PN-FCT	DIIUS	Andry Maykol Pinto	26/07/2018	25/07/2022
PN-FCT	GROW-1	Bruno Filipe Ferreira	01/10/2018	30/09/2021
PN-FCT	QuALTOS	Nuno Cruz	01/01/2020	31/12/2022
PN-FCT	Connect2Oceans	Alfredo Martins	20/03/2021	19/03/2024
PN-COOP	FEEDFIRST	Eduardo Silva	01/01/2018	30/06/2021
PN-COOP	HiperSea	Eduardo Silva	01/07/2018	30/09/2022
PN-COOP	NESSIE	Aníbal Matos	01/01/2019	30/06/2022
PN-COOP	FLY_PT	Andry Maykol Pinto	01/07/2020	30/06/2023
PN-COOP	REV@CONSTRUCTION-1	Andry Maykol Pinto	01/07/2020	30/06/2023
PN-COOP	K2D	Aníbal Matos	01/07/2020	01/07/2023
PN-COOP	NEWSAT-2	Susana Alexandra Barbosa	30/06/2020	30/06/2023
PN-COOP	MARIMAR	José Miguel Almeida	31/12/2020	30/06/2023
PUE-DIV	PROTOATLANTIC	Eduardo Silva	01/11/2017	31/10/2021
PUE-DIV	INTENDU	Aníbal Matos	01/03/2018	31/08/2021
PUE-DIV	Prince	Hugo Miguel Silva	01/01/2019	31/12/2022
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	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	Ana Cristina Pires	01/01/2020	31/12/2022
PUE-FP	ATLANTIS	Andry Maykol Pinto	01/01/2020	30/06/2023
PUE-FP	UNEXUP	José Miguel Almeida	01/01/2020	31/12/2022
PUE-FP	EUSCORES-3	José Miguel Almeida	01/09/2021	31/08/2025
PUE-FP	FIRELOGUE	Hugo Miguel Silva	01/11/2021	31/10/2025
SERV-NAC	Modulmar	Eduardo Silva	01/01/2019	26/02/2021
SERV-INT	ESAPlastics	Eduardo Silva	01/10/2019	27/07/2021
SERV-INT	PORT XXI	Aníbal Matos	15/11/2020	31/01/2022
SERV-INT	AutoMon	Nuno Cruz	18/09/2017	31/12/2021
SERV-INT	NoduleMiner6k	José Miguel Almeida	06/11/2020	31/05/2021
SERV-INT	KRISO 2021	José Miguel Almeida	16/04/2021	15/12/2021
SERV-INT	AECUD	José Miguel Almeida	01/01/2021	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

10.3.2 List of Publications

International Journals with Scientific Referees

1. Brito da Costa, AM, Martins, D, Rodrigues, D, Fernandes, L, Moura, R, Madureira Carvalho, A, "Ground Penetrating Radar for Buried Explosive Devices Detection: A Case Studies Review", Australian Journal of Forensic Sciences, pp.1-20, 2021
2. Campos, DF, Matos, A, Pinto, AM, "Multi-domain inspection of offshore wind farms using an autonomous surface vehicle", SN Applied Sciences, vol.3, 2021
3. Carneiro, JF, Pinto, JB, de Almeida, FG, Cruz, NA, "Variable Buoyancy or Propeller-Based Systems for Hovering Capable Vehicles: An Energetic Comparison", IEEE Journal of Oceanic Engineering, vol.46, pp.414-433, APR, 2021
4. da Silva, MF, Honorio, LMD, dos Santos, MF, Neto, AFD, Cruz, NA, Matos, ACC, Westin, LGF, "Project and Control Allocation of a 3 DoF Autonomous Surface Vessel With Aerial Azimuth Propulsion System", IEEE ACCESS, vol.9, pp.5212-5227, 2021
5. Freitas, S, Silva, H, Silva, E, "Remote Hyperspectral Imaging Acquisition and Characterization for Marine Litter Detection", Remote Sensing, vol.13, pp.2536, 2021
6. Leite, PN, Pinto, AM, "Exploiting Motion Perception in Depth Estimation Through a Lightweight Convolutional Neural Network", IEEE ACCESS, vol.9, pp.76056-76068, 2021
7. Loureiro, G, Dias, A, Martins, A, Almeida, J, "Emergency Landing Spot Detection Algorithm for Unmanned Aerial Vehicles", Remote Sensing, vol.13, pp.1930, 2021
8. Matias, M, Almeida, F, Moura, R, Barraca, N, "High resolution NDT in the characterization of the inner structure and materials of heritage buildings walls and columns", Construction And Building Materials, vol.267, pp.121726, 2021
9. Oliveira, AJ, Ferreira, BM, Cruz, NA, "A Performance Analysis of Feature Extraction Algorithms for Acoustic Image-Based Underwater Navigation", Journal of Marine Science and Engineering, vol.9, pp.361, 2021
10. Pereira, MI, Claro, RM, Leite, PN, Pinto, AM, "Advancing Autonomous Surface Vehicles: A 3D Perception System for the Recognition and Assessment of Docking-Based Structures", IEEE ACCESS, vol.9, pp.53030-53045, 2021
11. Pereira, MI, Leite, PN, Pinto, AM, "A 3-D Lightweight Convolutional Neural Network for Detecting Docking Structures in Cluttered Environments", Marine Technology Society Journal, vol.55, pp.88-98, 2021
12. Teixeira F.B., Ferreira B.M., Moreira N., Abreu N., Villa M., Loureiro J.P., Cruz N.A., Alves J.C., Ricardo M., Campos R., "A Novel Simulation Platform for Underwater Data Muling Communications Using Autonomous Underwater Vehicles", Computers, vol.10, pp.119, 2021
13. Teixeira, B, Silva, H, "Deep learning point cloud odometry: Existing approaches and open challenges", U.Porto Journal of Engineering, vol.7, pp.70-79, 2021
14. Tinoco, V, Malheiro, B, Silva, MF, "Design, Modeling, and Simulation of a Wing Sail Land Yacht", Applied Sciences, vol.11, pp.2760, 2021
15. Veloso, B, Gama, J, Malheiro, B, Vinagre, J, "Hyperparameter self-tuning for data streams", Information Fusion, 2021

International Conference Proceedings with Scientific Referees

1. Agostinho, LR, Ricardo, NC, Silva, RJ, Pinto, AM, "A Modular Inductive Wireless Charging Solution for Autonomous Underwater Vehicles", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), pp.68-73, 2021

2. Alves, PM, Filipe, RA, Malheiro, B, "Towards Top-Up Prediction on Telco Operators", Progress in Artificial Intelligence - 20th EPIA Conference on Artificial Intelligence, EPIA 2021, Virtual Event, September 7-9, 2021, Proceedings, vol.12981, pp.573-583, 2021
3. Amado, M, Lopes, F, Dias, A, Martins, A, "LiDAR-based Power Assets Extraction based on Point Cloud Data", IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2021, Santa Maria da Feira, Portugal, April 28-29, 2021, pp.221-227, 2021
4. Boularas, M, Szmytke, Z, Smith, L, Isik, K, Ruusunen, J, Malheiro, B, Justo, J, Ribeiro, C, Silva, MF, Ferreira, P, Guedes, P, "Smart Bicycle Probe – An EPS@ISEP 2020 Project", Educating Engineers for Future Industrial Revolutions - Advances in Intelligent Systems and Computing, pp.115-126, 2021
5. Campos, D, Restivo, A, Ferreira, HS, Ramos, A, "Automatic Program Repair as Semantic Suggestions: An Empirical Study", 14th IEEE Conference on Software Testing, Verification and Validation, ICST 2021, Porto de Galinhas, Brazil, April 12-16, 2021, pp.217-228, 2021
6. dos Santos, PL, Perdicoulis, TPA, "A Non-Parametric LPV Approach to the Indentification of Linear Periodic Systems", IFAC PAPERSONLINE, vol.54, pp.13-19, 2021
7. Feys, AV, Nicoara, GG, Carasel, IS, Karpiak, M, Kocheski, N, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Reconfigurable and Ergonomic Smart Desk - An EPS@ISEP 2021 Project", TEEM'21: Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality, Barcelona, Spain, October 26 - 29, 2021, pp.464-470, 2021
8. Fohanno, B, Pires, B, Ionescu, C, Ladka, E, Perek, M, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Crowd Orchestration - An EPS@ISEP 2021 Project", TEEM'21: Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality, Barcelona, Spain, October 26 - 29, 2021, pp.411-416, 2021
9. Gaspar, AR, Nunes, A, Matos, A, "Evaluation of Bags of Binary Words for Place Recognition in Challenging Scenarios", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2021, pp.19-24, 2021
10. Leal, F, Veloso, B, Malheiro, B, Burguillo, JC, "Crowdsourced Data Stream Mining for Tourism Recommendation", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.260-269, 2021
11. Mendes, A, Tatuc, E, Joos, F, Wyka, J, Petrevski, K, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Sustainable Food Production Through Vermicomposting - An EPS@ISEP 2021 Project", TEEM'21: Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality, Barcelona, Spain, October 26 - 29, 2021, pp.553-559, 2021
12. Moura, A, Antunes, J, Dias, A, Martins, A, Almeida, J, "Graph-SLAM Approach for Indoor UAV Localization in Warehouse Logistics Applications", IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2021, Santa Maria da Feira, Portugal, April 28-29, 2021, pp.4-11, 2021
13. Priebe, J, Swiatek, K, Vidinha, M, Vaduva, MR, Tiits, M, Sorescu, TG, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Elderly Monitoring – An EPS@ISEP 2020 Project", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.575-584, 2021
14. Resende, J, Barbosa, P, Almeida, J, Martins, A, "Autonomous High-Resolution Image Acquisition System for Plankton", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2021
15. Tuluc, C, Verberne, F, Lasota, S, de Almeida, T, Malheiro, B, Justo, J, Ribeiro, C, Silva, MF, Ferreira, P, Guedes, P, "The MopBot Cleaning Robot – An EPS@ISEP 2020 Project", Educating Engineers for Future Industrial Revolutions - Advances in Intelligent Systems and Computing, pp.79-90, 2021

Books

1. Almeida, L, Gaitán, M, Oliveira, W, "Book of Abstracts of the 4th Symposium on Electrical and Computer Engineering", 2021

Chapter/Paper in Books

1. Veloso, B, Gama, J, Malheiro, B, "Classification and Recommendation with Data Streams", Encyclopedia of Information Science and Technology, Fifth Edition - Advances in Information Quality and Management, pp.675-684, 2021

Publications (Editor)

Blank

Dissertations (PhD)

Blank

10.4 C-BER – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	2	5	4	-1
		Academic Staff	7	6	5	-1
		Grant Holders and Trainees	11	11	14	3
		Total Core Researchers	**20**	**22**	**23**	**1**
		Total Core PhD	**10**	**9**	**8**	**-1**
	Affiliated Researchers		1	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	**22**	**24**	**25**	**1**
		Total Integrated PhD	**11**	**9**	**9**	**0**

Table 10.4.2 – CBER - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	215	153	95	-59
PN-PICT	National R&D Programmes - S&T Integrated Projects	52			0
PN-COOP	National Cooperation Programmes with Industry		28	98	69
PUE-FP	EU Framework Programmes				0
PUE-DIV	EU Cooperation Programmes – Other				0
SERV-NAC	R&D Services and Consulting – National	3	35	24	-11
SERV-INT	R&D Services and Consulting - International				0
OP	Other Funding Programmes			2	2
Closed Projects		2			
	Total Funding	**272**	**216**	**218**	**2**

Table 10.4.3 – CBER - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	22	25	23
Indexed Conferences	32	17	29
Books	0	0	0
Book Chapters	4	0	0
Concluded PhD Theses - Members	0	0	2
Concluded PhD Theses - Supervised	1	0	2

Table 10.4.4 – CBER - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	2	3	6
Software copyright registrations at IGAC	0	1	2
Patent first priority filings (New inventions)	0	2	1
Patent applications (Internationalisation)	8	6	6
Granted patents	2	4	4
Commercial contracts – Licenses and Assignments	0	0	3
Spin-offs established	1	0	0
Spin-offs in development	2	2	2

Table 10.4.5 – CBER - Summary of dissemination activities

Type of Activity	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	1	4	7
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	3	4	4
International events in which INESC TEC members participate in the program committees	5	11	13
Participation in events such as fairs, exhibitions or similar	3	2	9
Conferences, workshops and scientific sessions organised by the Centre	4	1	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	125	130	40
Advanced training courses organised by the Centre	0	0	0

Table 10.4.6 – CBER - List of projects

Type of Project	Short Nme	Leader	Starting date	Ending date (planned)
PN-FCT	PERFECT-1	João Paulo Cunha	01/07/2018	30/06/2021
PN-FCT	LUCAS-1	João Paulo Cunha	26/07/2018	25/01/2022
PN-FCT	WalkingPAD-1	Miguel Velhote Correia	11/11/2019	10/11/2022
PN-FCT	CAGED	Miguel Coimbra	01/03/2021	29/02/2024
PN-COOP	TexBoost	Miguel Velhote Correia	01/07/2017	31/12/2020
PN-COOP	TAMI-1	Aurélio Campilho	01/04/2020	31/03/2023
PN-COOP	VitalPROVID	Duarte Filipe Dias	31/08/2020	31/12/2021
SERV-NAC	iHandU_v2	João Paulo Cunha	28/07/2021	31/12/2021
SERV-NAC	iHandUApp	Duarte Filipe Dias	01/09/2021	01/07/2022
SERV-NAC	Bio_Support	Duarte Filipe Dias	01/08/2021	01/03/2023
OP	C4MiR_BIP_Proof	Miguel Velhote Correia	01/09/2020	31/12/2021

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. Arribas, J, Antonelli, G, Frazzoni, L, Fuccio, L, Ebigbo, A, van der Sommen, F, Ghatwary, N, Palm, C, Coimbra, M, Renna, F, Bergman, JJGHM, Sharma, P, Messmann, H, Hassan, C, Dinis Ribeiro, MJ, "Standalone performance of artificial intelligence for upper GI neoplasia: a meta-analysis", GUT, vol.70, pp.1458-1468, AUG, 2021
2. Azevedo, F, Cardoso, JS, Ferreira, A, Fernandes, T, Moreira, M, Campos, L, "Efficient reactive obstacle avoidance using spirals for escape", Drones, vol.5, pp.51, 2021
3. Costa, P, Smailagic, A, Cardoso, JS, Campilho, A, "Epistemic and Heteroscedastic Uncertainty Estimation in Retinal Blood Vessel Segmentation", U.Porto Journal of Engineering, vol.7, pp.93-100, 2021
4. Faria, MT, Rodrigues, S, Campelo, M, Dias, D, Rego, R, Rocha, H, Sa, F, Tavares Silva, M, Pinto, R, Pestana, G, Oliveira, A, Pereira, J, Cunha, JPS, Rocha Goncalves, F, Goncalves, H, Martins, E, "Heart rate variability in patients with refractory epilepsy: The influence of generalized convulsive seizures", Epilepsy Research, vol.178, pp.106796, 2021
5. Fonseca, P, Goethel, M, Vilas Boas, JP, Gutierres, M, Correia, MV, "A Bibliometric Analysis of Intraoperative Neuromonitoring in Spine Surgery", World Neurosurgery, vol.154, pp.3-12, 2021
6. Fonseca, P, Goethel, MF, Sebastiao, R, Sousa, MV, Vilas Boas, JP, Correia, MV, Gutierres, M, "A new coupling method for accurate measurement of pedicle screw electrical properties for surgical procedures", Applied Sciences (Switzerland), vol.11, pp.9861, 2021
7. Freitas, C, Sousa, C, Machado, F, Serino, M, Santos, V, Cruz Martins, N, Teixeira, A, Cunha, A, Pereira, T, Oliveira, HP, Costa, JL, Hespanhol, V, "The Role of Liquid Biopsy in Early Diagnosis of Lung Cancer", Frontiers in Oncology, vol.11, 2021

8. Guimaraes, V, Sousa, I, Correia, MV, "A Deep Learning Approach for Foot Trajectory Estimation in Gait Analysis Using Inertial Sensors", SENSORS, vol.21, pp.7517, NOV, 2021

9. Guimaraes, V, Sousa, I, Correia, MV, "Orientation-Invariant Spatio-Temporal Gait Analysis Using Foot-Worn Inertial Sensors", SENSORS, vol.21, pp.3940, JUN, 2021

10. Kazwiny, Y, Pedrosa, J, Zhang, ZQ, Boesmans, W, D'hooge, J, Vanden Berghe, P, "Extracting neuronal activity signals from microscopy recordings of contractile tissue using B-spline Explicit Active Surfaces (BEAS) cell tracking", Scientific Reports, vol.11, 2021

11. Marques, S, Schiavo, F, Ferreira, CA, Pedrosa, J, Cunha, A, Campilho, A, "A multi-task CNN approach for lung nodule malignancy classification and characterization", Expert Systems with Applications, pp.115469, 2021

12. Morgado, J, Pereira, T, Silva, F, Freitas, C, Negrao, E, de Lima, BF, da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Costa, JL, Cunha, A, Oliveira, HP, "Machine Learning and Feature Selection Methods for EGFR Mutation Status Prediction in Lung Cancer", Applied Sciences, vol.11, pp.3273, 2021

13. Narciso, D, Melo, M, Rodrigues, S, Cunha, JP, Vasconcelos Raposo, J, Bessa, M, "A systematic review on the use of immersive virtual reality to train professionals", Multimedia Tools and Applications, 2021

14. Oliveira J.H., Renna F., Costa P., Nogueira D., Oliveira C., Ferreira C., Jorge A., Mattos S., Hatem T., Tavares T., Elola A., Rad A., Sameni R., Clifford G.D., Coimbra M.T., "The CirCor DigiScope Dataset: From Murmur Detection to Murmur Classification", IEEE Journal of Biomedical and Health Informatics, vol.abs/2108.00813, 2021

15. Pedrosa, J, Aresta, G, Ferreira, C, Atwal, G, Phoulady, HA, Chen, XY, Chen, RZ, Li, JL, Wang, LS, Galdran, A, Bouchachia, H, Kaluva, KC, Vaidhya, K, Chunduru, A, Tarai, S, Nadimpalli, SPP, Vaidya, S, Kim, I, Rassadin, A, Tian, ZH, Sun, ZW, Jia, YZ, Men, XJ, Ramos, I, Cunha, A, Campilho, A, "LNDb Challenge on automatic lung cancer patient management", Medical Image Analysis, pp.102027, 2021

16. Pereira, T, Freitas, C, Costa, JL, Morgado, J, Silva, F, Negrao, E, de Lima, BF, da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Cunha, A, Oliveira, HP, "Comprehensive Perspective for Lung Cancer Characterisation Based on AI Solutions Using CT Images", Journal of Clinical Medicine, vol.10, pp.118, 2021

17. Pereira, T, Morgado, J, Silva, F, Pelter, MM, Dias, VR, Barros, R, Freitas, C, Negrao, E, de Lima, BF, da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Costa, JL, Cunha, A, Oliveira, HP, "Sharing Biomedical Data: Strengthening AI Development in Healthcare", Healthcare, vol.9, pp.827, 2021

18. Pinto, JR, Correia, MV, Cardoso, JS, "Secure Triplet Loss: Achieving Cancelability and Non-Linkability in End-to-End Deep Biometrics", IEEE Transactions on Biometrics, Behavior, and Identity Science, pp.1-1, 2021

19. Silva, AS, Correia, MV, Silva, HP, "Invisible ECG for High Throughput Screening in eSports", SENSORS, vol.21, pp.7601, NOV, 2021

20. Silva, F, Pereira, T, Morgado, J, Frade, J, Mendes, J, Freitas, C, Negrao, E, De Lima, BF, Da Silva, MC, Madureira, AJ, Ramos, I, Hespanhol, V, Costa, JL, Cunha, A, Oliveira, HP, "EGFR Assessment in Lung Cancer CT Images: Analysis of Local and Holistic Regions of Interest Using Deep Unsupervised Transfer Learning", IEEE Access, vol.9, pp.58667-58676, 2021

21. Vilas Boas, MD, Rocha, AP, Cardoso, MN, Fernandes, JM, Coelho, T, Cunha, JPS, "Supporting the Assessment of Hereditary Transthyretin Amyloidosis Patients Based On 3-D Gait Analysis and Machine Learning", IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol.29, pp.1350-1362, 2021

22. Zhang, O, Ding, C, Pereira, T, Xiao, R, Gadhoumi, K, Meisel, K, Lee, RJ, Chen, YR, Hu, X, "Explainability Metrics of Deep Convolutional Networks for Photoplethysmography Quality Assessment", IEEE Access, vol.9, pp.29736-29745, 2021

23. Zhao, D, Quill, GM, Gilbert, K, Wang, VY, Houle, HC, Legget, ME, Ruygrok, PN, Doughty, RN, Pedrosa, J, D'hooge, J, Young, AA, Nash, MP, "Systematic Comparison of Left Ventricular Geometry Between 3D-

Echocardiography and Cardiac Magnetic Resonance Imaging", Frontiers in Cardiovascular Medicine, vol.8, 2021

International Conference Proceedings with Scientific Referees

1. Abrantes, R, Mestre, P, Cunha, A, "Exploring Dataset Manipulation via Machine Learning for Botnet Traffic", Procedia Computer Science, vol.196, pp.133-141, 2021
2. Aguiar, P, Cunha, A, Bakon, M, Ruiz Armenteros, AM, Sousa, JJ, "Multivariate Outlier Detection in Postprocessing of Multi-temporal PS-InSAR Results using Deep Learning", Procedia Computer Science, vol.181, pp.1146-1153, 2021
3. Carneiro, G, Pádua, L, Sousa, JJ, Peres, E, Morais, R, Cunha, A, "Grapevine Variety Identification Through Grapevine Leaf Images Acquired in Natural Environment", 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021
4. Carneiro, GA, Magalhães, R, Neto, A, Sousa, JJ, Cunha, A, "Grapevine Segmentation in RGB Images using Deep Learning", Procedia Computer Science, vol.196, pp.101-106, 2021
5. Carneiro, GS, Ferreira, A, Morais, R, Sousa, JJ, Cunha, A, "Analyzing the Fine Tuning's impact in Grapevine Classification", Procedia Computer Science, vol.196, pp.364-370, 2021
6. Carvalho, R, Pedrosa, J, Nedelcu, T, "Multimodal Multi-tasking for Skin Lesion Classification Using Deep Neural Networks", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.13017 LNCS, pp.27-38, 2021
7. Costa, P, Campilho, A, Cardoso, JS, "A Study on Annotation Efficient Learning Methods for Segmentation in Prostate Histopathological Images", Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications - Lecture Notes in Computer Science, pp.55-64, 2021
8. Faustino, P, Oliveira, J, Coimbra, MT, "Crackle and wheeze detection in lung sound signals using convolutional neural networks", 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2021, Mexico, November 1-5, 2021, pp.345-348, 2021
9. Fonseca, F, Nunes, B, Salgado, M, Cunha, A, "Abnormality classification in small datasets of capsule endoscopy images", Procedia Computer Science, vol.196, pp.469-476, 2021
10. Guimarães, V, Sousa, I, Correia, MV, "Gait events detection from heel and toe trajectories: comparison of methods using multiple datasets", IEEE International Symposium on Medical Measurements and Applications, MeMeA 2021, Lausanne, Switzerland, June 23-25, 2021, pp.1-6, 2021
11. Leite, D, Campelos, M, Fernandes, A, Batista, P, Beirão, J, Menéres, P, Cunha, A, "Machine Learning automatic assessment for glaucoma and myopia based on Corvis ST data", Procedia Computer Science, vol.196, pp.454-460, 2021
12. Lopes, EM, Van Rafelghem, L, Dias, D, Nunes, MC, Hordt, M, Noachtar, S, Kaufmann, E, Cunha, JPS, "Changes in heart rate variability after transcranial direct current stimulation in patients with refractory epilepsy", International IEEE/EMBS Conference on Neural Engineering, NER, vol.2021-May, pp.1053-1056, 2021
13. Lopes, EM, Vilas Boas, MD, Rego, R, Santos, A, Cunha, JPS, "Video-EEG and PerceptTM PC Deep Brain Neurostimulator Fine-Grained Synchronization for Multimodal Neurodata Analysis", 2021 10TH INTERNATIONAL IEEE/EMBS CONFERENCE ON NEURAL ENGINEERING (NER), vol.2021-May, pp.963-966, 2021
14. Malafaia, M, Pereira, T, Silva, F, Morgado, J, Cunha, A, Oliveira, HP, "Ensemble Strategies for EGFR Mutation Status Prediction in Lung Cancer", 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), 2021
15. Neto, A, Camera, J, Oliveira, S, Cláudia, A, Cunha, A, "Optic disc and cup segmentations for glaucoma assessment using cup-to-disc ratio", Procedia Computer Science, vol.196, pp.485-492, 2021
16. Oliveira, J, Nogueira, DM, Renna, F, Ferreira, CA, Jorge, AM, Coimbra, MT, "Do we really need a segmentation step in heart sound classification algorithms?", 43rd Annual International Conference of

the IEEE Engineering in Medicine & Biology Society, EMBC 2021, Mexico, November 1-5, 2021, pp.286-289, 2021

17. Oliveira, T, da Silva, JML, da Silva, JA, "Virtual Reality Web Application for Automotive Data Visualization", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), pp.37-42, 2021
18. Renna, F, Martins, ML, Coimbra, MT, "Joint Training of Hidden Markov Model and Neural Network for Heart Sound Segmentation", Computing in Cardiology, CinC 2021, Brno, Czech Republic, September 13-15, 2021, pp.1-4, 2021
19. Renna, F, Plumbley, MD, Coimbra, MT, "Source Separation of the Second Heart Sound via Alternating Optimization", Computing in Cardiology, CinC 2021, Brno, Czech Republic, September 13-15, 2021, pp.1-4, 2021
20. Ribeiro, J, Nóbrega, S, Cunha, A, "Polyps Detection in Colonoscopies", Procedia Computer Science, vol.196, pp.477-484, 2021
21. Rocha, J, Pereira, S, Campilho, A, Mendonça, AM, "Segmentation of COVID-19 Lesions in CT Images", 2021 IEEE EMBS International Conference on Biomedical and Health Informatics (BHI), 2021
22. Rodrigues, C, Correia, M, Abrantes, JMCS, Benedetti Rodrigues, MA, Nadal, J, "Fractal Brownian Motion Assessment of the Center of Pressure Excursion During Impulse Phase on Standard Vertical Jump", 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), 2021
23. Silva, B, Sousa, JJ, Lazecky, M, Cunha, A, "Deformation Fringes Detection in SAR interferograms Using Deep Learning", Procedia Computer Science, vol.196, pp.151-158, 2021
24. Silva, DM, Bernardin, T, Fanton, K, Nepaul, R, Pádua, L, Sousa, JJ, Cunha, A, "Automatic detection of Flavescense Dorée grapevine disease in hyperspectral images using machine learning", Procedia Computer Science, vol.196, pp.125-132, 2021
25. Silva, F, Pereira, T, Morgado, J, Cunha, A, Oliveira, HP, "The Impact of Interstitial Diseases Patterns on Lung CT Segmentation", 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), 2021
26. Sousa, MQE, Pedrosa, J, Rocha, J, Pereira, SC, Mendonça, AM, Campilho, A, "Chest Radiography Few-Shot Image Synthesis for Automated Pathology Screening Applications", 2021 IEEE International Conference on Bioinformatics and Biomedicine (BIBM), 2021
27. Ventura, A, Pereira, T, Silva, F, Freitas, C, Cunha, A, Oliveira, HP, "Stacking Approach for Lung Cancer EGFR Mutation Status Prediction from CT Scans", IEEE International Conference on Bioinformatics and Biomedicine, BIBM 2021, Houston, TX, USA, December 9-12, 2021, pp.3099-3105, 2021
28. Wanderley D., Ferreira C., Campilho A., Silva J., "Ovarian Structures Detection using Convolutional Neural Networks", Procedia Computer Science, vol.196, pp.542-549, 2021
29. Williams, H, Pedrosa, J, Cattani, L, Housmans, S, Vercauteren, T, Deprest, J, D'hooge, J, "Interactive Segmentation via Deep Learning and B-Spline Explicit Active Surfaces", Medical Image Computing and Computer Assisted Intervention – MICCAI 2021 - Lecture Notes in Computer Science, pp.315-325, 2021

Books

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Chapter/Paper in Books

Blank

Publications (Editor)

Blank

Dissertations (PhD)

1. Aresta, G., “Detection of lung nodules in computed tomography images”
2. Araújo, T., “Diabetic Retinopathy Grading in Color Eye Fundus Images”

10.5 CPES – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	21	28	39	11
		Academic Staff	10	9	10	1
		Grant Holders and Trainees	48	42	33	-9
		Total Core Researchers	**79**	**79**	**82**	**3**
		Total Core PhD	**26**	**25**	**25**	**0**
	Affiliated Researchers		7	7	4	-3
	Administrative and Technical	Employees	1	3	2	-1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**1**	**3**	**2**	**-1**
		Total Integrated HR	**87**	**89**	**88**	**-1**
		Total Integrated PhD	**32**	**32**	**29**	**-3**

Table 10.5.2 - CPES – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	488	246	179	-67
PN-PICT	National R&D Programmes - S&T Integrated Projects	4		44	44
PN-COOP	National Cooperation Programmes with Industry	21	25	367	342
PUE-FP	EU Framework Programmes	977	1 693	1 648	-45
PUE-DIV	EU Cooperation Programmes – Other	88		8	8
SERV-NAC	R&D Services and Consulting - National	796	802	850	47
SERV-INT	R&D Services and Consulting - International	12	131	123	-8
OP	Other Funding Programmes	155	157	11	-146
Closed Projects		42			
	Total Funding	**2 583**	**3 055**	**3 230**	**175**

Table 10.5.3 - CPES– Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	97	114	98
Indexed Conferences	91	55	40
Books	0	1	0
Book Chapters	5	6	3
Concluded PhD Theses - Members	1	3	4
Concluded PhD Theses - Supervised	2	4	6

Table 10.5.4 - CPES – Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	1	12	5
Software copyright registrations at IGAC	0	0	0
Patent first priority filings (New inventions)	1	2	0
Patent applications (Internationalisation)	1	4	1
Granted patents	1	0	1
Commercial contracts – Licenses and Assignments	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	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	10	20	17
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	1	2	3
International events in which INESC TEC members participate in the program committees	29	17	3
Participation in events such as fairs, exhibitions or similar	3	0	1
Conferences, workshops and scientific sessions organised by the Centre	3	6	12
Participants in the conferences, workshops and scientific sessions organised by the Centre	637	1265	720
Advanced training courses organised by the Centre	1	3	4

Table 10.5.6 – CPES - List of projects

Type 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	31/03/2022
PN-FCT	UNiTED	João Catalão	01/06/2018	31/07/2021
PN-PICT	DECARBONIZE	David Emanuel Rua	01/01/2021	31/12/2022
PN-COOP	NEXTSTEP	Clara Sofia Gouveia	01/12/2016	30/11/2021
PN-COOP	GPDER	Ricardo Jorge Bessa	01/08/2019	28/10/2022
PN-COOP	BATERIAS2030	Clara Sofia Gouveia	01/07/2020	30/06/2023
PN-COOP	CITYCATALIST	David Emanuel Rua	01/07/2020	01/07/2023
PN-COOP	SCALE	Clara Sofia Gouveia	01/01/2021	30/06/2023
PN-COOP	AI4PV	Ricardo Jorge Bessa	01/07/2021	30/06/2023
PN-COOP	DIGITALCER	Clara Sofia Gouveia	01/09/2020	01/03/2023
PN-COOP	SmartGlow	Clara Sofia Gouveia	01/04/2021	30/06/2023
PUE-DIV	AsprelaSustentável	Alexandre Lucas	15/05/2021	15/05/2024
PUE-FP	InteGrid	Ricardo Jorge Bessa	01/01/2017	31/10/2020
PUE-FP	EU-SysFlex	Bernardo Silva	01/11/2017	28/02/2022
PUE-FP	FEEdBACk	Filipe Joel Soares	01/11/2017	30/04/2021
PUE-FP	AmBIENCe	Tiago André Soares	01/06/2019	31/05/2022
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	Filipe Joel Soares	01/03/2020	28/02/2023
PUE-FP	EUniversal	Clara Sofia Gouveia	01/02/2020	31/07/2023
PUE-FP	OneNet	Alexandre Lucas	01/10/2020	30/09/2023
PUE-FP	EUSCORES	Bernardo Silva	01/09/2021	31/08/2025
PUE-FP	MAGPIE	David Emanuel Rua	01/10/2021	01/10/2026
SERV-NAC	EFACEC-DMS	Jorge Correia Pereira	15/04/2001	31/12/2030
SERV-NAC	HEAD-1	Leonel Magalhães Carvalho	01/01/2018	30/11/2021
SERV-NAC	FLEXERGY	Clara Sofia Gouveia	01/09/2018	25/05/2021
SERV-NAC	IeM_QST	José Nuno Fidalgo	16/08/2019	30/09/2021
SERV-NAC	GridPlan	Filipe Joel Soares	01/10/2019	31/01/2021
SERV-NAC	FlexOPlan	Ricardo Jorge Bessa	01/05/2019	31/12/2021
SERV-NAC	Grid2C	Ricardo Jorge Bessa	01/12/2019	01/01/2022
SERV-NAC	SmartClima	David Emanuel Rua	15/01/2020	31/12/2021
SERV-NAC	PegoBiomassa	João Peças Lopes	15/05/2020	12/02/2021
SERV-NAC	PV_Losses	Filipe Joel Soares	01/07/2020	31/01/2021
SERV-NAC	Perfis_Perdas_2021	José Nuno Fidalgo	28/05/2020	29/01/2021
SERV-NAC	NEGOCER	José Villar	01/06/2020	31/05/2021
SERV-NAC	PV_Morgado_Agre	Bernardo Silva	01/01/2021	30/09/2021
SERV-NAC	IoT4Distribuicao	Clara Sofia Gouveia	04/01/2021	31/01/2022

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	CampusREN2021	João Peças Lopes	01/06/2021	01/11/2021
SERV-NAC	V2G_Azores	João Peças Lopes	01/07/2020	30/09/2021
SERV-NAC	SINESESTENSAO	João Peças Lopes	01/12/2020	15/03/2021
SERV-NAC	PERSA_rede	Ricardo Jorge Bessa	01/04/2021	31/05/2021
SERV-NAC	Telemetry4Water	Eric Zanghi	09/08/2021	31/01/2022
SERV-NAC	PV_Azores_DM	João Peças Lopes	01/12/2020	25/06/2021
SERV-NAC	PV_FAIAL_DM	Bernardo Silva	02/01/2021	25/06/2021
SERV-NAC	MORADIST	Leonel Magalhães Carvalho	01/02/2021	01/06/2023
SERV-NAC	Redes_GasRenov	João Peças Lopes	02/01/2021	02/12/2022
SERV-NAC	PE_Sernancelhe	Bernardo Silva	28/01/2021	30/11/2021
SERV-NAC	Ilhas_eLearning	João Tomé Saraiva	02/01/2021	30/09/2021
SERV-NAC	PDIRT2022	João Tomé Saraiva	02/01/2021	30/06/2021
SERV-NAC	TapadaOuteiroH2	João Peças Lopes	15/04/2021	01/12/2021
SERV-NAC	aIeM_QST	José Nuno Fidalgo	01/01/2021	31/12/2021
SERV-NAC	iELFOS	Ricardo Jorge Bessa	01/05/2021	28/02/2022
SERV-NAC	ContFreq_ServSis	João Peças Lopes	01/06/2021	28/02/2022
SERV-NAC	PRE_RAM	João Peças Lopes	15/05/2021	31/03/2022
SERV-NAC	FaultPredict	Luís Miguel Miranda	01/06/2021	31/03/2022
SERV-NAC	Fiabotim	Manuel Matos	10/10/2021	10/11/2021
SERV-NAC	Perfis_Perdas_2022	José Nuno Fidalgo	31/05/2021	31/03/2022
SERV-NAC	Wind_curteil_soft_2	Leonel Magalhães Carvalho	01/08/2021	01/10/2021
SERV-NAC	GridImp_PV_AO	Bernardo Silva	01/07/2021	28/02/2022
SERV-NAC	redesISOL_AO	Bernardo Silva	01/10/2021	31/03/2022
SERV-NAC	Pontas_Modelo	José Nuno Fidalgo	01/09/2021	30/04/2022
SERV-NAC	PV_BESS_Sizing	Carlos Moreira	01/09/2021	31/12/2021
SERV-NAC	CampusREN2021_2nd	João Peças Lopes	01/09/2021	30/10/2021
SERV-NAC	SM_TECH	David Emanuel Rua	01/06/2021	31/10/2021
SERV-NAC	LossPD_MT	José Nuno Fidalgo	01/09/2021	28/02/2022
SERV-NAC	Fin_Losses	Filipe Joel Soares	01/10/2021	01/05/2022
SERV-INT	PEGO_COMP_SINC	João Peças Lopes	22/03/2020	07/05/2021
SERV-INT	TSO_LoadForecasting	Ricardo Jorge Bessa	01/01/2021	30/09/2021
SERV-INT	PV_Pombal_ENER	Bernardo Silva	01/03/2021	31/12/2021
SERV-INT	CleanEU_Island	João Peças Lopes	01/03/2021	01/05/2023
SERV-INT	DT4PV	Ricardo Jorge Bessa	22/03/2021	22/03/2023
OP	Sustainable HPC	Ricardo Jorge Bessa	01/07/2021	30/06/2023
OP	PSCC2022	João Peças Lopes	01/06/2020	01/12/2022

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

10.5.2 List of publications

International Journals with Scientific Referees

1. Aghamohammadloo, H, Talaeizadeh, V, Shahanaghi, K, Aghaei, J, Shayanfar, H, Shafie khah, M, Catalao, JPS, "Integrated Demand Response programs and energy hubs retail energy market modelling", ENERGY, vol.234, 2021
2. Alavi, SA, Mehran, K, Vahidinasab, V, Catalao, JPS, "Forecast Based Consensus Control for DC Microgrids Using Distributed Long Short-Term Memory Deep Learning Models", IEEE Transactions on Smart Grid, pp.1-1, 2021
3. Baghbanzadeh, D, Salehi, J, Gazijahani, FS, Shafie khah, M, Catalao, JPS, "Resilience improvement of multi-microgrid distribution networks using distributed generation", Sustainable Energy, Grids and Networks, pp.100503, 2021
4. Baptista J., Vargas P., Ferreira J.R., "A techno-economic analysis of floating photovoltaic systems, for southern European countries", Renewable Energy and Power Quality Journal, vol.19, pp.57-62, 2021
5. Baptista, J, Sequeira, G, Solteiro Pires, EJ, "Evaluation of PV microgeneration systems and tariffs management on the energy efficiency of service buildings", Renewable Energy and Power Quality Journal, vol.19, pp.73-78, 2021
6. Botelho, DF, Dias, BH, de Oliveira, LW, Soares, TA, Rezende, I, Sousa, T, "Innovative business models as drivers for prosumers integration-Enablers and barriers", Renewable & Sustainable Energy Reviews, vol.144, pp.111057, JUL, 2021
7. Campos, FA, Villar, J, Centeno, E, "Annualization of renewable investment costs for finite horizon electricity pricing and cost recovery", Sustainability (Switzerland), vol.13, pp.1-16, 2021
8. Carvalhosa, S, Leite, H, Branco, F, Sá, CA, Moura, AM, Lopes, RC, Soares, M, "Survey on the advancements of dielectric fluids and experiment studies for distribution power transformers", Renewable Energy and Power Quality Journal, vol.19, pp.97-102, 2021
9. Cerveira, A, Pires, EJS, Baptista, J, "Wind Farm Cable Connection Layout Optimization with Several Substations", ENERGIES, vol.14, pp.3615, JUN, 2021
10. Chen, Y, Wei, W, Wang, H, Zhou, Q, Catalao, JPS, "An Energy Sharing Mechanism Achieving the Same Flexibility as Centralized Dispatch", IEEE Transactions on Smart Grid, vol.12, pp.3379-3389, JUL, 2021
11. Cicek, A, Erenoglu, AK, Erdinc, O, Bozkurt, A, Tascikaraoglu, A, Catalao, JPS, "Implementing a demand side management strategy for harmonics mitigation in a smart home using real measurements of household appliances", International Journal of Electrical Power & Energy Systems, vol.125, pp.106528, FEB, 2021
12. Cicek, A, Guzel, S, Erdinc, O, Catalao, JPS, "Comprehensive survey on support policies and optimal market participation of renewable energy", Electric Power Systems Research, vol.201, pp.107522, 2021
13. Coelho, A, Iria, J, Soares, F, "Network-secure bidding optimization of aggregators of multi-energy systems in electricity, gas, and carbon markets", Applied Energy, vol.301, pp.117460, 2021
14. Coronati, A, Andrade, JR, Bessa, RJ, "A deep learning method for forecasting residual market curves", Electric Power Systems Research, vol.190, pp.106756, 2021
15. Costa, LALDC, Fan, BR, Burgos, R, Boroyevich, D, Chen, WR, Blasko, V, "The Fast Overvoltage Protection Consideration and Design for SiC-Based Matrix Converters", IEEE Transactions on Industry Applications, vol.57, pp.6145-6154, NOV, 2021
16. Costa, LALDC, Vitorino, MA, Correa, MBD, Hartmann, LV, Ramalho, AWS, "X-Type Current Source Converters", IEEE Transactions on Power Electronics, vol.36, pp.12843-12856, NOV, 2021
17. Cunha, MF, Jacobina, CB, de Freitas, NB, "Grid-Connected Induction Motor Using a Floating DC-Link Converter Under Unbalanced Voltage Sag", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, vol.57, pp.1609-1618, 2021

18. da Silva, CT, Dias, BMD, Araujo, RE, Pellini, EL, Lagana, AAM, "Battery Model Identification Approach for Electric Forklift Application", ENERGIES, vol.14, pp.6221, OCT, 2021

19. Davoodi, E, Babaei, E, Mohammadi Ivatloo, B, Shafie Khah, M, Catalao, JPS, "Multiobjective Optimal Power Flow Using a Semidefinite Programming-Based Model", IEEE Systems Journal, vol.15, pp.158-169, 2021

20. de Lacerda, RP, Jacobina, CB, de Freitas, NB, Mello, JPRA, Cunha, MF, "Cascaded Transformer Symmetric Single-Phase Multilevel Converters With Two DC Sources", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, vol.57, pp.5157-5169, SEP, 2021

21. Dehghani, M, Rezaei, M, Shayanfard, B, Vafamand, N, Javadi, M, Catalao, JPS, "PMU-Based Power System Stabilizer Design: Optimal Signal Selection and Controller Design", IEEE Transactions on Industry Applications, pp.1-1, 2021

22. Dias, L, Ribeiro, M, Leitao, A, Guimaraes, L, Carvalho, L, Matos, MA, Bessa, RJ, "An unsupervised approach for fault diagnosis of power transformers", QUALITY AND RELIABILITY ENGINEERING INTERNATIONAL, 2021

23. Ding, T, Zeng, ZY, Qu, M, Catalao, JPS, Shahidehpour, M, "Two-Stage Chance-Constrained Stochastic Unit Commitment for Optimal Provision of Virtual Inertia in Wind-Storage Systems", IEEE Transactions on Power Systems, pp.1-1, 2021

24. Dorokhova, M, Ribeiro, F, Barbosa, A, Viana, J, Soares, F, Wyrsch, N, "Real-World Implementation of an ICT-Based Platform to Promote Energy Efficiency", ENERGIES, vol.14, pp.2416, MAY, 2021

25. Ebrahimi, M, Gazafroudi, AS, Ebrahimi, M, Laaksonen, H, Shafie Khah, M, Catalao, JPS, "Iterative Game Approach for Modeling the Behavior of Agents in a Competitive Flexibility Trading", IEEE ACCESS, vol.9, pp.165227-165238, 2021

26. Fox, J, Ela, E, Hobbs, B, Sharp, J, Novacheck, J, Motley, A, Bessa, RJ, Pinson, P, Kariniotakis, G, "Forecasting and Market Design Advances: Supporting an Increasing Share of Renewable Energy", IEEE Power & Energy Magazine, vol.19, pp.77-85, NOV, 2021

27. Fu, YW, Chai, H, Zhen, Z, Wang, F, Xu, XJ, Li, KP, Shafie Khah, M, Dehghanian, P, Catalao, JPS, "Sky Image Prediction Model Based on Convolutional Auto-encoder for Minutely Solar PV Power Forecasting", IEEE Transactions on Industry Applications, pp.1-1, 2021

28. Gazijahani, FS, Salehi, J, Shafie khah, M, Catalao, JPS, "Spatiotemporal Splitting of Distribution Networks into Self-Healing Resilient Microgrids using an Adjustable Interval Optimization", IEEE Transactions on Industrial Informatics, pp.1-1, 2021

29. Gehrke, BS, Jacobina, CB, de Sousa, RPR, da Silva, IRFMP, de Freitas, NB, Correa, MBD, "Single-Phase Three-Wire Power Converters Based on Two-Level and Three-Level Legs Using a Space-Vector PWM-Based Voltage Balancing", IEEE Transactions on Industry Applications, vol.57, pp.2654-2665, 2021

30. Ghadi, MJ, Azizivahed, A, Mishra, DK, Li, L, Zhang, JF, Shafie khah, M, Catalao, JPS, "Application of small-scale compressed air energy storage in the daily operation of an active distribution system", ENERGY, vol.231, 2021

31. Goncalves, C, Bessa, RJ, Pinson, P, "A critical overview of privacy-preserving approaches for collaborative forecasting", International Journal of Forecasting, 2021

32. Goncalves, C, Bessa, RJ, Pinson, P, "Privacy-Preserving Distributed Learning for Renewable Energy Forecasting", IEEE Transactions on Sustainable Energy, vol.12, pp.1777-1787, 2021

33. Goncalves, C, Cavalcante, L, Brito, M, Bessa, RJ, Gama, J, "Forecasting conditional extreme quantiles for wind energy", Electric Power Systems Research, vol.190, 2021

34. Goncalves, C, Pinson, P, Bessa, RJ, "Towards Data Markets in Renewable Energy Forecasting", IEEE Transactions on Sustainable Energy, pp.1-1, 2021

35. Gouveia, J, Moreira, CL, Lopes, JAP, "Influence of Load Dynamics on Converter-Dominated Isolated Power Systems", Applied Sciences, vol.11, pp.2341, 2021

36. Gouveia, J, Moreira, CL, Lopes, JAP, "Rule-based adaptive control strategy for grid-forming inverters in islanded power systems for improving frequency stability", ELECTRIC POWER SYSTEMS RESEARCH, vol.197, AUG, 2021

37. Habibi, M, Vahidinasab, V, Pirayesh, A, Shafie Khah, M, Catalao, JPS, "An Enhanced Contingency-Based Model for Joint Energy and Reserve Markets Operation by Considering Wind and Energy Storage Systems", IEEE Transactions on Industrial Informatics, vol.17, pp.3241-3252, 2021

38. Habibi, M, Vahidinasab, V, Shafie khah, M, Catalao, JPS, "Coordinated scheduling of energy storage systems as a fast reserve provider", INTERNATIONAL JOURNAL OF ELECTRICAL POWER & ENERGY SYSTEMS, vol.130, pp.106941, SEP, 2021

39. Habibifar, R, Ranjbar, H, Shafie Khah, M, Ehsan, M, Catalao, JPS, "Network-Constrained Optimal Scheduling of Multi-Carrier Residential Energy Systems: A Chance-Constrained Approach", IEEE Access, vol.9, pp.86369-86381, 2021

40. Hakimi, SM, Hasankhani, A, Shafie khah, M, Catalao, JPS, "Stochastic planning of a multi-microgrid considering integration of renewable energy resources and real-time electricity market", Applied Energy, vol.298, pp.117215, 2021

41. Hashemipour, N, Aghaei, J, Kavousi Fard, A, Taher, N, Salimi, L, del Granado, PC, Shafie khah, M, Wang, F, Catalao, JPS, "Optimal Singular Value Decomposition Based Big Data Compression Approach in Smart Grids", IEEE Transactions on Industry Applications, pp.1-1, 2021

42. Hemmati, R, Mehrjerdi, H, Shafie khah, M, Siano, P, Catalao, JPS, "Managing Multitype Capacity Resources for Frequency Regulation in Unit Commitment Integrated With Large Wind Ramping", IEEE Transactions On Sustainable Energy, vol.12, pp.705-714, JAN, 2021

43. Heymann, F, vom Scheidt, F, Soares, FJ, Duenas, P, Miranda, V, "Forecasting Energy Technology Diffusion in Space and Time: Model Design, Parameter Choice and Calibration", IEEE Transactions on Sustainable Energy, pp.1-1, 2021

44. Jalali, SMJ, Ahmadian, S, Khosravi, A, Shafie khah, M, Nahavandi, S, Catalao, JPS, "A Novel Evolutionary-based Deep Convolutional Neural Network Model for Intelligent Load Forecasting", IEEE Transactions on Industrial Informatics, pp.1-1, 2021

45. Jang, YE, Kim, YJ, Catalao, JPS, "Optimal HVAC System Operation Using Online Learning of Interconnected Neural Networks", IEEE Transactions on Smart Grid, pp.1-1, 2021

46. Javadi, MS, Nezhad, AE, Nardelli, PHJ, Gough, M, Lotfi, M, Santos, S, Catalao, JPS, "Self-scheduling model for home energy management systems considering the end-users discomfort index within price-based demand response programs", Sustainable Cities and Society, vol.68, pp.102792, 2021

47. Jordehi, AR, Javadi, MS, Catalao, JPS, "Day-ahead scheduling of energy hubs with parking lots for electric vehicles considering uncertainties", ENERGY, vol.229, pp.120709, 2021

48. Jordehi, AR, Javadi, MS, Catalao, JPS, "Optimal placement of battery swap stations in microgrids with micro pumped hydro storage systems, photovoltaic, wind and geothermal distributed generators", International Journal of Electrical Power and Energy Systems, vol.125, 2021

49. Jordehi, AR, Javadi, MS, Shafie khah, M, Catalao, JPS, "Information gap decision theory (IGDT)-based robust scheduling of combined cooling, heat and power energy hubs", Energy, vol.231, pp.120918, 2021

50. Khajeh, H, Gazafroudi, AS, Laaksonen, H, Shafie Khah, M, Siano, P, Catalao, JPS, "Peer-to-Peer Electricity Market Based on Local Supervision", IEEE ACCESS, vol.9, pp.156647-156662, 2021

51. Li S., Ding T., Jia W., Huang C., Catalao J.P.S., Li F.F., "A Machine Learning-based Vulnerability Analysis for Cascading Failures of Integrated Power-Gas Systems", IEEE Transactions on Power Systems, pp.1-1, 2021

52. Li, MX, Wei, W, Chen, Y, Ge, MF, Catalao, JPS, "Learning the Optimal Strategy of Power System Operation With Varying Renewable Generations", IEEE Transactions On Sustainable Energy, vol.12, pp.2293-2305, OCT, 2021

53. Lotfi, M, Osorio, GJ, Javadi, MS, Ashraf, A, Zahran, M, Samih, G, Catalao, JPS, "A Dijkstra-Inspired Graph Algorithm for Fully Autonomous Tasking in Industrial Applications", IEEE Transactions on Industry Applications, pp.1-1, 2021

54. Lu, XX, Ge, XX, Li, KP, Wang, F, Shen, HT, Tao, P, Hu, JJ, Lai, JG, Zhen, Z, Shafie khah, M, Catalao, JPS, "Optimal Bidding Strategy of Demand Response Aggregator Based on Customers Responsiveness Behaviors Modeling under Different Incentives", IEEE Transactions on Industry Applications, pp.1-1, 2021

55. Mahdavi, M, Kimiyaghalam, A, Alhelou, HH, Javadi, MS, Ashouri, A, Catalao, JPS, "Transmission Expansion Planning Considering Power Losses, Expansion of Substations and Uncertainty in Fuel Price Using Discrete Artificial Bee Colony Algorithm", IEEE ACCESS, vol.9, pp.135983-135995, 2021

56. Manojkumar, R, Kumar, C, Ganguly, S, Catalao, JPS, "Optimal Peak Shaving Control Using Dynamic Demand and Feed-In Limits for Grid-Connected PV Sources With Batteries", IEEE Systems Journal, pp.1-11, 2021

57. Mansouri, SA, Ahmarinejad, A, Nematbakhsh, E, Javadi, MS, Jordehi, AR, Catalao, JPS, "Energy management in microgrids including smart homes: A multi-objective approach", Sustainable Cities and Society, vol.69, 2021

58. Mansouri, SA, Javadi, MS, Ahmarinejad, A, Nematbakhsh, E, Zare, A, Catalao, JPS, "A coordinated energy management framework for industrial, residential and commercial energy hubs considering demand response programs", Sustainable Energy Technologies and Assessments, vol.47, pp.101376, 2021

59. MansourLakouraj, M, Sanjari, MJ, Javadi, MS, Shahabi, M, Catalao, JPS, "Exploitation of Microgrid Flexibility in Distribution System Hosting Prosumers", IEEE Transactions on Industry Applications, pp.1-1, 2021

60. Marcelino, CG, Torres, V, Carvalho, L, Matos, M, Miranda, V, "Multi-objective identification of critical distribution network assets in large interruption datasets", International Journal of Electrical Power and Energy Systems, pp.107747, 2021

61. Martinez, SD, Campos, FA, Villar, J, Rivier, M, "Joint energy and capacity equilibrium model for centralized and behind-the-meter distributed generation", International Journal of Electrical Power & Energy Systems, vol.131, pp.107055, OCT, 2021

62. Mehrjerdi, H, Hemmati, R, Shafie khah, M, Catalao, JPS, "Zero Energy Building by Multi-Carrier Energy Systems including Hydro, Wind, Solar and Hydrogen", IEEE Transactions on Industrial Informatics, pp.1-1, 2021

63. Menci, SP, Bessa, RJ, Herndler, B, Korner, C, Rao, BV, Leimgruber, F, Madureira, AA, Rua, D, Coelho, F, Silva, JV, Andrade, JR, Sampaio, G, Teixeira, H, Simoes, M, Viana, J, Oliveira, L, Castro, D, Krisper, U, Andre, R, "Functional Scalability and Replicability Analysis for Smart Grid Functions: The InteGrid Project Approach", Energies, vol.14, pp.5685, 2021

64. Mindu, AJ, Capece, JA, Araujo, RE, Oliveira, AC, "Feasibility of Utilizing Photovoltaics for Irrigation Purposes in Moamba, Mozambique", SUSTAINABILITY, vol.13, pp.10998, OCT, 2021

65. Mirzaei, MA, Nazari Heris, M, Mohammadi Ivatloo, B, Zare, K, Marzband, M, Shafie Khah, M, Anvari Moghaddam, A, Catalao, JPS, "Network-Constrained Joint Energy and Flexible Ramping Reserve Market Clearing of Power- and Heat-Based Energy Systems: A Two-Stage Hybrid IGDT-Stochastic Framework", IEEE SYSTEMS JOURNAL, vol.15, pp.1547-1556, JUN, 2021

66. Momen, H, Abessi, A, Jadid, S, Shafie khah, M, Catalao, JPS, "Load restoration and energy management of a microgrid with distributed energy resources and electric vehicles participation under a two-stage stochastic framework", International Journal of Electrical Power & Energy Systems, vol.133, DEC, 2021

67. Nematkhah, F, Bahrami, S, Aminifar, F, Catalao, JPS, "Exploiting the Potentials of HVAC Systems in Transactive Energy Markets", IEEE Transactions on Smart Grid, pp.1-1, 2021

68. Nikoobakht, A, Aghaei, J, Mokarram, MJ, Shafie khah, M, Catalao, JPS, "Adaptive robust co-optimization of wind energy generation, electric vehicle batteries and flexible AC transmission system devices", ENERGY, vol.230, 2021

69. Nikpour, A, Nateghi, A, Shafie khah, M, Catalao, JPS, "Day-ahead optimal bidding of microgrids considering uncertainties of price and renewable energy resources", ENERGY, vol.227, pp.120476, 2021

70. Nikpour, A, Nateghi, A, Shafie khah, M, Catalao, JPS, "Hybrid stochastic risk-based approach for a microgrid participating in coupled active and reactive power market", International Journal of Electrical Power and Energy Systems, vol.131, pp.107080, 2021

71. Oliveira, ED, Junior, ICS, de Oliveira, LW, de Mendonca, IM, Vilaca, P, Saraiva, JT, "A two-stage constructive heuristic algorithm to handle integer investment variables in transmission network expansion planning", Electric Power Systems Research, vol.192, pp.106905, MAR, 2021

72. Osorio, GJ, Lotfi, M, Gough, M, Javadi, M, Espassandim, HMD, Shafie khah, M, Catalao, JPS, "Modeling an electric vehicle parking lot with solar rooftop participating in the reserve market and in ancillary services provision", Journal of Cleaner Production, vol.318, pp.128503, 2021

73. Osorio, JG, Gough, M, Lotfi, M, Santos, FS, Espassandim, MDH, Shafie khah, M, Catalao, PSJ, "Rooftop photovoltaic parking lots to support electric vehicles charging: A comprehensive survey", International Journal of Electrical Power and Energy Systems, vol.133, pp.107274, 2021

74. Rashidizadeh Kermani, H, Vahedipour Dahraie, M, Shafie khah, M, Catalao, JPS, "Joint Energy and Reserve Scheduling of a Wind Power Producer in a Peer-to-Peer Mechanism", IEEE SYSTEMS JOURNAL, vol.15, pp.4315-4324, SEP, 2021

75. Ren, H, Zhang, AW, Wang, F, Yan, XH, Li, Y, Duic, N, Shafie khah, M, Catalao, JPS, "Optimal scheduling of an EV aggregator for demand response considering triple level benefits of three-parties", International Journal of Electrical Power and Energy Systems, vol.125, 2021

76. Rodrigues, J, Moreira, C, Lopes, JP, "Fault-Ride-Through Approach for Grid-Tied Smart Transformers without Local Energy Storage", ENERGIES, vol.14, pp.5622, SEP, 2021

77. Santos, BH, Peças Lopes, JA, "Hydrogen and the transition from gas networks to a new energy carrier paradigm: Portuguese challenges of the national roadmap", U.Porto Journal of Engineering, vol.7, pp.137-150, 2021

78. Shahbazi, A, Aghaei, J, Pirouzi, S, Niknam, T, Shafie khah, M, Catalao, JPS, "Effects of resilience-oriented design on distribution networks operation planning", Electric Power Systems Research, vol.191, pp.106902, 2021

79. Shahbazi, A, Aghaei, J, Pirouzi, S, Niknam, T, Vahidinasab, V, Shafie khah, M, Catalao, JPS, "Holistic approach to resilient electrical energy distribution network planning", International Journal of Electrical Power & Energy Systems, vol.132, NOV, 2021

80. Shahbazi, A, Aghaei, J, Pirouzi, S, Shafie khah, M, Catala, JPS, "Hybrid stochastic/robust optimization model for resilient architecture of distribution networks against extreme weather conditions", International Journal of Electrical Power and Energy Systems, vol.126, pp.106576, 2021

81. Shams, MH, Shahabi, M, MansourLakouraj, M, Shafie khah, M, Catalao, JPS, "Adjustable robust optimization approach for two-stage operation of energy hub-based microgrids", ENERGY, vol.222, pp.119894, 2021

82. Sharifinia, S, Allahbakhshi, M, Arefi, MM, Tajdinian, M, Shafie khah, M, Niknam, T, Catalao, JPS, "Extended Kalman Filter-Based Approach for Nodal Pricing in Active Distribution Networks", IEEE Syst. J., vol.15, pp.487-496, 2021

83. Shayeghi, H, Monfaredi, F, Dejamkhooy, A, Shafie khah, M, Catalao, JPS, "Assessing hybrid supercapacitor-battery energy storage for active power management in a wind-diesel system", International Journal of Electrical Power and Energy Systems, vol.125, 2021

84. Sheikhahmadi, P, Bahramara, S, Mazza, A, Chicco, G, Catalao, JPS, "Bi-level optimization model for the coordination between transmission and distribution systems interacting with local energy markets", International Journal of Electrical Power and Energy Systems, vol.124, 2021

85. Shen, ZQ, Wei, W, Wu, L, Shafie khah, M, Catalao, JPS, "Economic dispatch of power systems with LMP-dependent demands: A non-iterative MILP model", ENERGY, vol.233, 2021

86. Silva, R, Alves, E, Ferreira, R, Villar, J, Gouveia, C, "Characterization of TSO and DSO Grid System Services and TSO-DSO Basic Coordination Mechanisms in the Current Decarbonization Context", ENERGIES, vol.14, pp.4451, AUG, 2021

87. Soares, F, Madureira, A, Pages, A, Barbosa, A, Coelho, A, Cassola, F, Ribeiro, F, Viana, J, Andrade, J, Dorokhova, M, Morais, N, Wyrsch, N, Sorensen, T, "FEEdBACk: An ICT-Based Platform to Increase Energy Efficiency through Buildings' Consumer Engagement", Energies, vol.14, pp.1524, 2021

88. Soltaniyan, S, Salehizadeh, MR, Tascikaraoglu, A, Erdinc, O, Catalao, JPS, "An interactive multi-criteria decision-making framework between a renewable power plant planner and the independent system operator", Sustainable Energy Grids & Networks, vol.26, pp.100447, JUN, 2021

89. Tostado Veliz, M, Matos, MA, Lopes, JAP, Jurado, F, "An improved version of the Continuous Newton's method for efficiently solving the Power-Flow in Ill-conditioned systems", International Journal of Electrical Power and Energy Systems, vol.124, 2021

90. Vahedipour Dahraie, M, Rashidizadeh Kermani, H, Shafie Khah, M, Catalao, JPS, "Risk-Averse Optimal Energy and Reserve Scheduling for Virtual Power Plants Incorporating Demand Response Programs", IEEE Trans. Smart Grid, vol.12, pp.1405-1415, 2021

91. Vahid Ghavidel, M, Javadi, MS, Santos, SF, Gough, M, Mohammadi Ivatloo, B, Shafie Khah, M, Catalao, JPS, "Novel Hybrid Stochastic-Robust Optimal Trading Strategy for a Demand Response Aggregator in the Wholesale Electricity Market", IEEE Transactions on Industry Applications, vol.57, pp.5488-5498, SEP, 2021

92. Varajao, D, Araujo, RE, "Modulation Methods for Direct and Indirect Matrix Converters: A Review", ELECTRONICS, vol.10, pp.812, APR, 2021

93. Vinagre, J, Jorge, AM, Rocha, C, Gama, J, "Statistically robust evaluation of stream-based recommender systems", IEEE Transactions on Knowledge and Data Engineering, pp.1-1, 2021

94. Wang, JY, Wang, C, Liang, YL, Bi, TS, Shafie khah, M, Catalao, JPS, "Data-Driven Chance-Constrained Optimal Gas-Power Flow Calculation: A Bayesian Nonparametric Approach", IEEE Transactions on Power Systems, pp.1-1, 2021

95. Wei, W, Wang, ZJ, Liu, F, Shafie khah, M, Catalao, JPS, "Cost-Efficient Deployment of Storage Unit in Residential Energy Systems", IEEE Transactions on Power Systems, vol.36, pp.525-528, JAN, 2021

96. Yan, JCA, Hu, L, Zhen, Z, Wang, F, Qiu, G, Li, Y, Yao, LZ, Shafie, M, Catalao, JPS, "Frequency-Domain Decomposition and Deep Learning Based Solar PV Power Ultra-Short-Term Forecasting Model", IEEE Transactions on Industry Applications, pp.1-1, 2021

97. Zakernezhad, H, Nazar, MS, Shafie khah, M, Catala, JPS, "Optimal resilient operation of multi-carrier energy systems in electricity markets considering distributed energy resource aggregators", APPLIED ENERGY, vol.299, 2021

98. Zakernezhad, H, Nazar, MS, Shafie khah, M, Catalao, JPS, "Multi-level optimization framework for resilient distribution system expansion planning with distributed energy resources", Energy, vol.214, pp.118807, 2021

International Conference Proceedings with Scientific Referees

1. Afsharinejad, A, Dehghani, M, Asemani, MH, Vafamand, N, Javadi, MS, Wang, F, Catalao, JPS, "Advanced control of DC grid-connected proton exchange membrane fuel cell: A linear parameter varying approach", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

2. Alalwan, SNH, Mohammed, AM, Tascikaraoglu, A, Catalao, JPS, "An improved energy management strategy for a DC microgrid including electric vehicle fast charging stations", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

3. Bahramara, S, Sheikhahmadi, P, Chicco, G, Mazza, A, Wang, F, Catalão, JPS, "Co-optimization of Microgrid's bids in Day-ahead Energy and Reserve Markets Considering Stochastic Decisions in a Real-time Market", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-8, 2021

4. Botelho D.F., Soares T.A., Peters Barbosa P.H., Dias B.H., de Oliveira L.W., Moraes C.A., "Transações peer-to-peer de energia elétrica considerando as restrições da rede de eletricidade", 2021 14th IEEE International Conference on Industry Applications, INDUSCON 2021 - Proceedings, pp.69-75, 2021

5. Botelho, DF, Soares, TA, Barbosa, PHP, Dias, BH, de Oliveira, LW, Moraes, CA, "Peer-to-peer electricity transactions considering electricity grid constraints", 2021 14th IEEE International Conference on Industry Applications (INDUSCON), pp.69-75, 2021

6. Chen, P, Zhen, Z, Wang, F, khah, MS, Yin, R, Catalão, JPS, "Day-ahead Modified Dispatching Model Considering Power System Flexibility", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-6, 2021

7. Chen, X, Li, ZH, Wang, F, Li, KP, Catalao, JPS, "Monthly net electricity consumption prediction under high penetration of distributed photovoltaic system", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

8. Dorahaki S., Rashidinejad M., Farahmand H., Mollahassanipour M., Pourakbari-Kasmaei M., Catalao J.P.S., "An Optimal Flexible Partitioning of Smart Distribution System Considering Electrical and Gas Infrastructure", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

9. Erenoglu, AK, Erdinc, O, Sancar, S, Catalao, JPS, "Post-Event Resiliency-Driven Strategy Dispatching Mobile Power Sources Considering Transportation System Constraints", 2021 8th International Conference on Electrical and Electronics Engineering, ICEEE 2021, pp.161-167, 2021

10. Farsani K.T., Vafamand N., Arefi M.M., Asemani M.H., Javadi M.S., Catalao J.P.S., "Robust Controller Design for Frequency Regulation of Power Systems", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

11. Farsani, KT, Dehghani, M, Abolpour, R, Vafamand, N, Javadi, MS, Wang, F, Catalão, JPS, "Improved Load Frequency Control of Time-Delayed Electric Vehicle Aggregators via Direct Search Method", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-7, 2021

12. Goncalves C., Ribeiro M., Viana J., Fernandes R., Villar J., Bessa R., Correia G., Sousa J., Mendes V., Cristina Nunes A., "Explanatory and Causal Analysis of the Portuguese Manual Balancing Reserve", 2021 IEEE Madrid PowerTech, 2021

13. Gough M., Santos S.F., Almeida A., Javadi M., Alskaif T., Castro R., Catalao J.P.S., "Development of a Blockchain-Based Energy Trading Scheme for Prosumers", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

14. Gough, M, Santos, SF, Matos, JMBA, Home Ortiz, JM, Javadi, MS, Castro, R, Catalao, JPS, "Optimal scheduling of commercial demand response by technical virtual power plants", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

15. Hasankhani A., Hakimi S.M., Bodaghi M., Shafie-Khah M., Osorio G.J., Catalao J.P.S., "Day-Ahead Optimal Management of Plug-in Hybrid Electric Vehicles in Smart Homes Considering Uncertainties", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

16. Heymann F., Duenas P., Soares F.J., Miranda V., Rudisuli M., "Simulating spatiotemporal energy technology adoption patterns under different policy designs", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

17. Home Ortiz, JM, Macedo, LH, Vargas, R, Romero, R, Mantovani, JRS, Catalao, JPS, "Increasing the RES hosting capacity in distribution systems through reconfiguration with closed-loop operation and voltage control", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

18. Home-Ortiz J.M., MacEdo L.H., Mantovani J.R.S., Romero R., Vargas R., Catalao J.P.S., "Optimal Operation of Active Distribution Systems with Voltage Control and Closed-Loop Topology", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

19. Jafar Jalali, SM, Khodayar, M, Ahmadian, S, Noman, MK, Khosravi, A, Shamsul Islam, SM, Wang, F, Catalão, JPS, "A New Uncertainty-aware Deep Neuroevolution Model for Quantifying Tidal Prediction", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-6, 2021

20. Jalali, SMJ, Khodayar, M, Ahmadian, S, Shafie khah, M, Khosravi, A, Islam, SMS, Nahavandi, S, Catalao, JPS, "A new ensemble reinforcement learning strategy for solar irradiance forecasting using deep optimized convolutional neural network models", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

21. Jarrahi, MA, Roozitalab, F, Arefi, MM, Mohammadi, M, Javadi, MS, Catalao, JPS, "Allocation of FCLs in transmission networks with high penetration of DGs: A two-stage approach", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

22. Li, J, Wang, F, khah, MS, Zhen, Z, Catalão, JPS, "Improvement of Renewable Power Forecasting Indicators Based on System Flexibility", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-6, 2021

23. MacEdo P.M., Fidalgo J.N., Saraiva J.T., "Estimation of the Global Amount of Mandatory Investments for Distribution Network Expansion Planning", 2021 IEEE Madrid PowerTech, 2021

24. Mahdavi, M, Javadi, MS, Wang, F, Catalão, JPS, "An Accurate Evaluation of Consumption Pattern in Reconfiguration of Electrical Energy Distribution Systems", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-7, 2021

25. Mansouri, SA, Ahmarinejad, A, Nematbakhsh, E, Javadi, MS, Jordehi, AR, Catalao, JPS, "Energy hub design in the presence of P2G system considering the variable efficiencies of gas-fired converters", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

26. Neisarian S., Arefi M.M., Vafamand N., Javadi M., Santos S.F., Catalao J.P.S., "Finite-time Adaptive Sliding Mode Control of DC Microgrids with Constant Power Load", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

27. Paulos J.P., Fidalgo J.N., Saraiva J.T., Barbosa N., "Detection and Mitigation of Extreme Losses in Distribution Networks", 2021 IEEE Madrid PowerTech, 2021

28. Paulos J.P., Nuno Fidalgo J., Gama J., "Non-Intrusive Load Monitoring for Household Disaggregated Energy Sensing", 2021 IEEE Madrid PowerTech, 2021

29. Pisera D., Silvestro F., Joel Soares F., "A method for optimal integration of energy storage in distribution networks: A business case", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

30. Rocha R., Mello J., Villar J., Saraiva J.T., "Comparative Analysis of Self-Consumption and Energy Communities Regulation in the Iberian Peninsula", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

31. Saffari, M, Khodayar, M, Jalali, SMJ, Shafie khah, M, Catalao, JPS, "Deep convolutional graph rough variational auto-encoder for short-term photovoltaic power forecasting", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021

32. Shams M.H., Mansourlakouraj M., Shahabi M., Javadi M.S., Catalao J.P.S., "Robust Scenario-Based Approach for the Optimal Scheduling of Energy Hubs", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021

33. Shams, MH, MansourLakouraj, M, Liu, JJ, Javadi, MS, Catalao, JPS, "Bi-level two-stage stochastic operation of hydrogen-based microgrids in a distribution system", SEST 2021 - 4th International Conference on Smart Energy Systems and Technologies, 2021
34. Tabatabaei M., Nazar M.S., Shafie-Khah M., Osorio G.J., Catalao J.P.S., "Optimal Scheduling of Microgrid-Based Virtual Power Plants Considering Demand Response and Capacity Withholding Opportunities", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021
35. Tian, Y, Lu, J, Han, X, Wang, F, Zhen, Z, Catalão, JPS, "Optimal Model for Direct Power Purchase by Large Consumers Based on Blockchain", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-6, 2021
36. Vafamand, N, Arefi, MM, Asemani, MH, Javadi, MS, Wang, F, Catalão, JPS, "Dual Extended Kalman Filter Reconstruction of Actuator and Sensor Faults in DC Microgrids with Constant Power Loads", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-6, 2021
37. Vilaca P., Colmenar J.M., Duarte A., Saraiva J.T., "Designing modern heuristic algorithms to solve the Transmission Expansion Planning problem", 2021 IEEE Madrid PowerTech, PowerTech 2021 - Conference Proceedings, 2021
38. Wang, Y, Li, Z, Wang, F, Zhen, Z, Dehghanian, P, Catalão, JPS, Li, K, Firuzabad, MF, "Greedy Clustering-based Monthly Electricity Consumption Forecasting Model", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-8, 2021
39. Yuan, J, Wang, F, khah, MS, Zhen, Z, Catalão, JPS, "A New Evaluation Metric Reflecting the Lead-Lag Scenarios in Wind Power Forecasting", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-7, 2021
40. Zarghami, M, Sheikh, M, Aghaei, J, Niknam, T, Sadooghi, R, Javidtash, N, Shahriari, S, Wang, F, Catalão, JPS, "Voltage Security Constrained Optimal Power Flow considering Smart Transmission Switching Maneuvers", IEEE Industry Applications Society Annual Meeting, IAS 2021, Vancouver, BC, Canada, October 10-14, 2021, pp.1-7, 2021

Books

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Chapter/Paper in Books

1. Baptista, J, Lima, F, Cerveira, A, "Optimization of Wind Turbines Placement in Offshore Wind Farms: Wake Effects Concerns", Communications in Computer and Information Science - Optimization, Learning Algorithms and Applications, pp.102-109, 2021
2. Barros, P, Cerveira, A, Baptista, J, "An Optimization Model for Scheduling of Households Load Profiles Incorporating Electric Vehicles Charging", Advances in Intelligent Systems and Computing - Intelligent Systems Design and Applications, pp.753-763, 2021
3. Mansouri, SA, Ahmarinejad, A, Javadi, MS, Nezhad, AE, Shafie-Khah, M, Catalão, JP, "Demand response role for enhancing the flexibility of local energy systems", Distributed Energy Resources in Local Integrated Energy Systems, pp.279-313, 2021

Publications (Editor)

Blank

Dissertations (PhD)

1. Silva, J., “An optimization framework to estimate the active and reactive power flexibility in the TSO-DSO interface”
2. Mahmoud, M., “Decentralized Cloud-Based Approaches for Cross-Sector Demand Side Management”

3. Lopes, A., “Fault Diagnosis in Cooperative Vehicle Platoons”
4. Ganesan, K., “Residential Consumer Behavioural Analysis on the Participation in Demand Response Strategies”

10.6 CESE – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	21	21	22	1
		Academic Staff	5	4	4	0
		Grant Holders and Trainees	30	16	14	-2
		Total Core Researchers	**56**	**41**	**40**	**-1**
		Total Core PhD	**15**	**13**	**14**	**1**
	Affiliated Researchers		7	9	8	-1
	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	**65**	**52**	**50**	**-2**
		Total Integrated PhD	**22**	**21**	**22**	**1**

Table 10.6.2 - CESE - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	231	159	126	-33
PN-PICT	National R&D Programmes - S&T Integrated Projects	17			0
PN-COOP	National Cooperation Programmes with Industry	330	388	521	133
PUE-FP	EU Framework Programmes	576	473	440	-33
PUE-DIV	EU Cooperation Programmes – Other	38			0
SERV-NAC	R&D Services and Consulting – National	487	342	272	-70
SERV-INT	R&D Services and Consulting – International	43	2	40	38
OP	Other Funding Programmes			1	1
Closed Projects		-1			
	Total Funding	**1 720**	**1 363**	**1 400**	**37**

Table 10.6.3 - CESE - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	15	19	14
Indexed Conferences	15	18	25
Books	0	0	1
Book Chapters	0	1	6
Concluded PhD Theses - Members	4	2	0
Concluded PhD Theses – Supervised	3	2	1

Table 10.6.4 - CESE - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	0	2	5
Software copyright registrations at IGAC	0	1	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	0	0	0
Granted patents	0	0	0
Commercial contracts – Licenses and Assignments	1	2	0
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	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	5	2	3
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	0	2	0
International events in which INESC TEC members participate in the program committees	9	4	6
Participation in events such as fairs, exhibitions or similar	8	1	5
Conferences, workshops and scientific sessions organised by the Centre	1	1	8
Participants in the conferences, workshops and scientific sessions organised by the Centre	60	159	250
Advanced training courses organised by the Centre	0	3	1

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	14/10/2022
PN-FCT	Tec-FEL-1	Alexandra Sofia Marques	04/04/2018	03/11/2021
PN-FCT	FuturePharma	Jorge Pinho de Sousa	29/03/2021	28/03/2024
PN-COOP	FAMEST	Rui Diogo Rebelo	01/11/2017	30/11/2021
PN-COOP	PRODUTECH_SIF	António Correia Alves	01/10/2017	31/03/2022
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
PN-COOP	NEWSAT-1	Vasco Bernardo Teles	30/06/2020	30/06/2023
PN-COOP	CNi40FOOT	Rui Diogo Rebelo	01/06/2020	01/04/2023
PN-COOP	SADCoPQ	António Correia Alves	22/05/2021	30/06/2023
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	ConnectedFactories2	Vasco Bernardo Teles	01/12/2019	30/11/2022
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	M_Nest_II	Ana Cristina Simões	01/01/2021	31/12/2021
PUE-FP	GREAT	António Correia Alves	01/10/2020	30/09/2021
PUE-FP	CircThread	António Lucas Soares	01/06/2021	31/05/2025
PUE-FP	AI_Sov	César Toscano	01/01/2021	31/12/2021
PUE-FP	EIT_RIS_Hubs_2021	Ana Cristina Barros	01/01/2021	31/12/2022
PUE-FP	ManuSkills	Vasco Bernardo Teles	01/01/2021	31/12/2021
PUE-FP	AM_HLP	João Pedro Basto	01/01/2021	31/12/2021
PUE-FP	REDVILE	Ana Cristina Simões	01/01/2021	31/12/2021
PUE-FP	iFishCan	Ana Cristina Barros	01/01/2021	31/12/2022
PUE-FP	MAGPIE-1	António Henrique Almeida	01/10/2021	01/10/2026
PUE-FP	EduDevRIS	Ana Cristina Barros	01/07/2021	31/12/2021
SERV-NAC	LM_Escalona	Luís Guardão	01/01/2018	31/12/2021
SERV-NAC	BSLINESIM	Luís Guardão	01/11/2020	29/03/2021
SERV-NAC	MESPARTNERSHIP	Luís Guardão	25/11/2020	25/01/2026
SERV-NAC	APSPARTNERSHIP	Luís Guardão	15/11/2020	15/01/2026
SERV-NAC	AIMES40I	Rui Diogo Rebelo	06/10/2020	19/04/2021
SERV-NAC	JCRi40ERP	Rui Diogo Rebelo	01/02/2021	01/02/2022
SERV-NAC	Equipari40	Rui Diogo Rebelo	01/02/2021	27/05/2021

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	GBYPLN_EVO	Luís Guardão	01/03/2021	01/01/2022
SERV-NAC	OptiLog	Rui Diogo Rebelo	12/04/2021	31/12/2021
SERV-NAC	SERVASIS	Luís Guardão	29/03/2021	30/04/2021
SERV-NAC	Observador_AUTO	António Lucas Soares	01/04/2021	01/06/2022
SERV-NAC	SSPM	Luís Guardão	04/02/2021	30/10/2021
SERV-NAC	FFNewHQ	Luís Guardão	11/01/2021	30/06/2022
SERV-NAC	PE21007ADS	Luís Guardão	01/04/2021	01/04/2024
SERV-NAC	ACCMESAGCI	Rui Diogo Rebelo	05/05/2021	05/11/2021
SERV-NAC	ACCMESL1	Filipe David Ferreira	05/05/2021	05/11/2021
SERV-NAC	ACCMESL2	Rui Diogo Rebelo	06/05/2021	06/11/2021
SERV-NAC	C2T_Digi4Plast	Gustavo Dalmarco	01/09/2021	01/09/2021
SERV-NAC	C2T_MoDal	Gustavo Dalmarco	01/07/2021	30/09/2021
SERV-NAC	DTwin4Qual	Gustavo Dalmarco	01/07/2021	30/09/2021
SERV-NAC	JCRroadmap	António Correia Alves	30/09/2021	30/01/2022
SERV-NAC	PFAI4_v2	Rui Diogo Rebelo	15/05/2021	25/12/2021
SERV-INT	CLAMTEX	Filipe David Ferreira	22/03/2021	22/03/2022
SERV-INT	C2T_Marina_Twin	Gustavo Dalmarco	01/07/2021	30/09/2021
SERV-INT	C2T_CIMA_TWIN	Gustavo Dalmarco	01/07/2021	30/09/2021
SERV-INT	DT4PV-1	César Toscano	22/03/2021	22/03/2023

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. Avila, PS, Pires, AM, Putnik, GD, Bastos, JAS, Cruz Cunha, MM, "Value Analysis as a Mechanism to Reduce the Complexity of the Selection of the Resources System for Agile/Virtual Enterprises in the Context of Industry 4.0", FME TRANSACTIONS, vol.49, pp.806-816, 2021
2. Azevedo, A, Almeida, AH, "Grasp the Challenge of Digital Transition in SMEs—A Training Course Geared towards Decision-Makers", Education Sciences, vol.11, pp.151, 2021
3. Costa, J, Avila, P, Bastos, J, Ferreira, LP, "A new simple, flexible and low-cost machine monitoring system", DYNA, vol.96, pp.640-646, 2021
4. de Brito, FM, da Cruz, G, Frazzon, EM, Tavares Vieira Basto, JPTV, Soares Alcala, SGS, "Design Approach for Additive Manufacturing in Spare Part Supply Chains", IEEE Transactions on Industrial Informatics, vol.17, pp.757-765, FEB, 2021
5. Jiang, WX, Sousa, PSA, Moreira, MRA, Amaro, GM, "Lean direction in literature: a bibliometric approach", Production and Manufacturing Research-An Open Access Journal, vol.9, pp.241-263, 2021
6. Martins, D, Fonseca, L, Avila, P, Bastos, J, "Lean Practices Adoption in the Portuguese Industry", Journal of Industrial Engineering and Management-JIEM, vol.14, pp.345-359, 2021

7. Monteiro, MM, Silva, JDE, Haustein, S, de Sousa, JP, "Urban travel behavior adaptation of temporary transnational residents", JOURNAL OF TRANSPORT GEOGRAPHY, vol.90, pp.102935, JAN, 2021
8. Mota, A, Avila, P, Albuquerque, R, Costa, L, Bastos, J, "A Framework for Time-Cost-Quality Optimization in Project Management Problems Using an Exploratory Grid Concept in the Multi-Objective Simulated-Annealing", International Journal of Information Technology & Decision Making, vol.20, pp.1095-1120, JUL, 2021
9. Sadeghi, P, Rebelo, RD, Ferreira, JS, "Using variable neighbourhood descent and genetic algorithms for sequencing mixed-model assembly systems in the footwear industry", Operations Research Perspectives, vol.8, pp.100193, 2021
10. Silva, V, Ferreira, LP, Silva, FJG, Tjahjono, B, Avila, P, "Simulation-Based Decision Support System to Improve Material Flow of a Textile Company", SUSTAINABILITY, vol.13, MAR, 2021
11. Trindade, MAM, Sousa, PSA, Moreira, MRA, "Defining a Storage-Assignment Strategy for Precedence-Constrained Order Picking", Operations Research and Decisions, vol.31, pp.147-160, 2021
12. Trindade, MAM, Sousa, PSA, Moreira, MRA, "Improving Order-picking Operations with Precedence Constraints through Efficient Storage Location Assignment", U.Porto Journal of Engineering, vol.7, pp.34-52, 2021
13. Trindade, MAM, Sousa, PSA, Moreira, MRA, "Product allocation planning with handling constraints: a case study analysis", International Journal of Management Science and Engineering Management, pp.1-9, 2021
14. 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.ahead-of-print, 2021.

International Conference Proceedings with Scientific Referees

1. Avila, P, Mota, A, Bastos, J, Patricio, L, Pires, A, Castro, H, Cruz Cunha, MM, Varela, L, "Framework for a risk assessment model to apply in Virtual / Collaborative Enterprises", International Conference on Enterprise Information Systems / International Conference on Project Management / International Conference on Health and Social Care Information Systems and Technologies 2020 (CENTERIS/PROJMAN/HCIST 2020), vol.181, pp.612-618, 2021
2. Azevedo, A, "Process Thinking in Engineering Education", 2021 IEEE Global Engineering Education Conference (EDUCON), 2021
3. Azevedo, M, Tavares, S, Soares, AL, "The Digital Twin as a Knowledge-Based Engineering Enabler for Product Development", Boosting Collaborative Networks 4.0: 21st IFIP Wg 5.5 Working Conference on Virtual Enterprises, PRO-VE 2020, vol.598, pp.450-459, 2021
4. 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, 2021
5. Castro, H, Pinto, N, Pereira, F, Ferreira, L, Ávila, P, Bastos, J, Putnik, GD, Cruz Cunha, M, "Cyber-Physical Systems using Open Design: An approach towards an Open Science Lab for Manufacturing", Procedia Computer Science, vol.196, pp.381-388, 2021
6. Castro, H, Pinto, N, Pereira, F, Ferreira, L, Avila, P, Putnik, G, Felgueiras, C, Bastos, J, Cunha, M, "Open Science Laboratory for Manufacturing: An education tool to contribute to sustainability", ACM International Conference Proceeding Series, pp.819-823, 2021
7. Correia, R, Fontes, T, Borges, JL, "Forecasting of Urban Public Transport Demand Based on Weather Conditions", Advances in Intelligent Systems and Computing, vol.1278, pp.75-84, 2021
8. Cunha B., Sousa C., "On the Definition of Intelligible IIoT Architectures", Iberian Conference on Information Systems and Technologies, CISTI, 2021

9. Cunha, B, Hernández, E, Rebelo, R, Sousa, C, Ferreira, F, "An IIoT Solution for SME's", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.313-321, 2021
10. Cunha, L, Sousa, C, "A Model for Designing SMES' Digital Transformation Roadmap", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.439-448, 2021
11. Dalmarco, G, Teles, V, Uguen, O, Barros, AC, "Digital Innovation Hubs: One Business Model Fits All?", IFIP Advances in Information and Communication Technology, vol.629 IFIPAICT, pp.441-448, 2021
12. Dias, RC, Senna, PP, Goncalves, AF, Reis, J, Michalaros, N, Alexopoulos, K, Gomes, M, "PREFAB Framework - PRoduct quality towards zEro deFects for melAmine surface Boards industry", IFAC PAPERSONLINE, vol.54, pp.570-575, 2021
13. Medina, JC, Pinho de Sousa, J, Jimenez Perez, E, "Defining and Prioritizing Indicators to Assess the Sustainability of Mobility Systems in Emerging Cities", Advances in Intelligent Systems and Computing, vol.1278, pp.616-625, 2021
14. Murços, F, Fontes, T, Rossetti, RJF, "Are BERT embeddings able to infer travel patterns from Twitter efficiently using a unigram approach?", 2021 IEEE International Smart Cities Conference (ISC2), 2021
15. Palasciano, C, Toscano, C, Arrais, R, Sobral, NM, Floreani, F, Sesana, M, Taisch, M, "A Predictive Simulation and Optimization Architecture based on a Knowledge Engineering User Interface to Support Operator 4.0", IFAC PAPERSONLINE, vol.54, pp.331-336, 2021
16. 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, 2021
17. 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, 2021
18. Sadeghi, P, Guardão, L, Rebelo, RD, Ferreira, JS, "Scheduling footwear moulding injection machines for a long-time horizon", Proceedings of the International Conference on Industrial Engineering and Operations Management, pp.5281-5292, 2021
19. Santos, R, Toscano, C, de Sousa, JP, "A new Simulation-Based Approach in the Design of Manufacturing Systems and Real-Time Decision", IFAC PAPERSONLINE, vol.54, pp.282-287, 2021
20. Silva, H, Soares, AL, "Digital Platforms as Enablers of Smart Product-Service Systems", IFIP Advances in Information and Communication Technology, vol.629 IFIPAICT, pp.506-513, 2021
21. Silva, HD, Azevedo, M, Soares, AL, "A Vision for a Platform-based Digital-Twin Ecosystem", IFAC PAPERSONLINE, vol.54, pp.761-766, 2021
22. 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, 2021
23. Simões, AC, Ferreira, F, Almeida, A, Zimmermann, R, Castro, H, Azevedo, A, "Innovative Learning Scheme to Up-skilling and Re-skilling - Designing a Collaborative Training Program Between Industry and Academia Towards Digital Transformation", Smart and Sustainable Collaborative Networks 4.0 - 22nd IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2021, Saint-Étienne, France, November 22-24, 2021, Proceedings, vol.629, pp.729-737, 2021
24. Simoes, AC, Rodrigues, JC, Ribeiro, S, "Impacts on business models resulting from digitalization", 2021 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2021 - Proceedings, 2021
25. Sousa, C, Carvalho, M, Pereira, C, "Boosting E-Auditing Process Through E-Files Semantic Enrichment", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.449-458, 2021

Books

1. Fornasiero, R, Sardesai, S, Barros, AC, Matopoulos, A, "Next Generation Supply Chains", Lecture Notes in Management and Industrial Engineering, 2021

Chapter/Paper in Books

1. Barros, AC, Senna, PP, Marchiori, I, Kalaitzi, D, Balech, S, "Scenario-Driven Supply Chain Charaterization Using a Multi-Dimensional Approach", Lecture Notes in Management and Industrial Engineering - Next Generation Supply Chains, pp.79-101, 2021
2. Senna, PP, Stute, M, Balech, S, Zangiacomi, A, "Mapping Enabling Technologies for Supply Chains with Future Scenarios", Lecture Notes in Management and Industrial Engineering - Next Generation Supply Chains, pp.147-165, 2021
3. Simões, AC, Rodrigues, JC, Soares, AL, "Challenges in Managing Large-Scale Collaborative R&D Projects", Contributions to Management Science, pp.237-251, 2021
4. Stute, M, Sardesai, S, Parlings, M, Senna, PP, Fornasiero, R, Balech, S, "Technology Scouting to Accelerate Innovation in Supply Chain", Lecture Notes in Management and Industrial Engineering - Next Generation Supply Chains, pp.129-145, 2021
5. 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, 2021
6. Zimmermann, R, Barros, AC, Senna, PP, Pessot, E, Marchiori, I, Fornasiero, R, "Policy Recommendations for Supporting Supply Chains with Horizontal Actions", Lecture Notes in Management and Industrial Engineering - Next Generation Supply Chains, pp.265-290, 2021

Publications (Editor)

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Dissertations (PhD)

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10.7 CRIIS – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	8	13	15	2
		Academic Staff	12	12	16	4
		Grant Holders and Trainees	23	22	24	2
		Total Core Researchers	**43**	**47**	**55**	**8**
		Total Core PhD	**18**	**18**	**22**	**4**
	Affiliated Researchers		5	6	2	-4
	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	**50**	**55**	**59**	**4**
		Total Integrated PhD	**23**	**23**	**24**	**1**

Table 10.7.2 - CRIIS – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	202	269	-14	-284
PN-PICT	National R&D Programmes - S&T Integrated Projects	8			0
PN-COOP	National Cooperation Programmes with Industry	78	48	182	133
PUE-FP	EU Framework Programmes	505	535	604	69
PUE-DIV	EU Cooperation Programmes – Other	170	17	9	-8
SERV-NAC	R&D Services and Consulting – National	145	113	365	252
SERV-INT	R&D Services and Consulting – International	5			0
OP	Other Funding Programmes	32	4	4	0
Closed Projects		2			
	Total Funding	**1 147**	**986**	**1 149**	**164**

Table 10.7.3 – CRIIS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	34	40	53
Indexed Conferences	88	55	53
Books	2	1	0
Book Chapters	0	0	1
Concluded PhD Theses - Members	3	0	2
Concluded PhD Theses - Supervised	6	1	3

Table 10.7.4 - CRIIS – Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	1	7	10
Software copyright registrations at IGAC	0	4	0
Patent first priority filings (New inventions)	0	1	1
Patent applications (Internationalisation)	2	1	5
Granted patents	0	0	0
Commercial contracts – Licenses and Assignments	0	1	0
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	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	2	3	4
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	3	4	3
International events in which INESC TEC members participate in the program committees	3	5	4
Participation in events such as fairs, exhibitions or similar	3	1	1
Conferences, workshops and scientific sessions organised by the Centre	4	6	6
Participants in the conferences, workshops and scientific sessions organised by the Centre	1500	360	3
Advanced training courses organised by the Centre	2	0	1

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	31/05/2022
PN-FCT	MetBots-1	Filipe Neves Santos	26/07/2018	30/11/2021
PN-COOP	PRODUTECH_SIF-1	António Paulo Moreira	01/10/2017	31/03/2022
PN-COOP	CrossLOG-2	Manuel Santos Silva	01/11/2019	31/10/2022
PN-COOP	SMARTFARM40	Filipe Neves Santos	01/07/2020	30/06/2023
PN-COOP	PRODUTECH4SC-1	Luís Freitas Rocha	01/07/2020	30/06/2023
PN-COOP	Replant-2	Filipe Neves Santos	01/07/2020	30/06/2023
PN-COOP	PAC	Germano Veiga	01/07/2020	30/06/2023
PN-COOP	INCAFO	Filipe Neves Santos	31/08/2020	30/06/2023
PN-COOP	SMARTAGEING	Tatiana Martins Pinho	01/07/2020	30/06/2023
PN-COOP	SPIN	Filipe Neves Santos	01/06/2020	31/03/2023
PN-COOP	SMARTCUT	Filipe Neves Santos	01/12/2020	30/06/2023
PN-COOP	Continental FoF-2	António Paulo Moreira	01/10/2020	01/07/2023
PUE-FP	Fasten-1	Rafael Lírio Arrais	01/11/2017	30/04/2021
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	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	10/01/2022
PUE-FP	XWeld	Luís Freitas Rocha	01/07/2020	30/09/2021
PUE-FP	SCORPION	Filipe Neves Santos	01/01/2021	31/12/2023
PUE-FP	MARI4_YARD	Germano Veiga	01/12/2020	30/11/2024
PUE-FP	MirrorLabs2	Marcelo Petry	01/01/2021	31/12/2021
PUE-FP	REDVILE-1	Marcelo Petry	01/01/2021	31/12/2021
PUE-FP	iFishCan-1	Rafael Lírio Arrais	01/01/2021	31/12/2022
SERV-NAC	Smart-Fertilizers	Filipe Neves Santos	01/01/2019	31/12/2021
SERV-NAC	PIVOTBOT	Filipe Neves Santos	01/09/2019	01/03/2021
SERV-NAC	ROBOCARE	Filipe Neves Santos	01/03/2020	01/03/2022
SERV-NAC	Trilogy	Luís Freitas Rocha	01/09/2020	12/03/2021
SERV-NAC	RDH4COVID	Héber Miguel Sobreira	17/10/2020	07/10/2021
SERV-NAC	VINCI7D	Manuel Santos Silva	01/09/2020	01/09/2023
SERV-NAC	AR4Steel	António Paulo Moreira	01/02/2021	31/12/2021
SERV-NAC	MetalCut40	Luís Freitas Rocha	01/09/2020	31/12/2021
SERV-NAC	OptiLog-1	António Paulo Moreira	12/04/2021	31/12/2021
SERV-NAC	SIAP	Joaquim João Sousa	24/07/2020	24/12/2021
SERV-NAC	PFAI4_v2-3	Germano Veiga	15/05/2021	25/12/2021
OP	SAFE	António Valente	01/01/2019	31/12/2021

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

10.7.2 List of publications

International Journals with Scientific Referees

1. Adao, T, Pinho, T, Padua, L, Magalhaes, LG, Sousa, JJ, Peres, E, "Prototyping IoT-Based Virtual Environments: An Approach toward the Sustainable Remote Management of Distributed Mulsemedia Setups", Applied Sciences, vol.11, pp.8854, 2021
2. Aguiar, AS, dos Santos, FN, Sobreira, H, Cunha, JB, Sousa, AJ, "Particle filter refinement based on clustering procedures for high-dimensional localization and mapping systems", Robotics and Autonomous Systems, pp.103725, 2021
3. Aguiar, AS, Magalhaes, SA, dos Santos, FN, Castro, L, Pinho, T, Valente, J, Martins, R, Boaventura Cunha, J, "Grape Bunch Detection at Different Growth Stages Using Deep Learning Quantized Models", Agronomy, vol.11, pp.1890, 2021
4. Aguiar, AS, Monteiro, NN, dos Santos, FN, Pires, EJS, Silva, D, Sousa, AJ, Boaventura Cunha, J, "Bringing Semantics to the Vineyard: An Approach on Deep Learning-Based Vine Trunk Detection", Agriculture, vol.11, pp.131, 2021
5. Amorim, A, Guimares, D, Mendona, T, Neto, P, Costa, P, Moreira, AP, "Robust human position estimation in cooperative robotic cells", Robotics and Computer-Integrated Manufacturing, vol.67, FEB, 2021
6. Arrais, R, Costa, CM, Ribeiro, P, Rocha, LF, Silva, M, Veiga, G, "On the development of a collaborative robotic system for industrial coating cells", The International Journal of Advanced Manufacturing Technology, 2021
7. Baltazar, AR, dos Santos, FN, Moreira, AP, Valente, A, Cunha, JB, "Smarter robotic sprayer system for precision agriculture", Electronics (Switzerland), vol.10, 2021
8. Baltazar, AR, Petry, MR, Silva, MF, Moreira, AP, "Autonomous wheelchair for patient's transportation on healthcare institutions", SN Applied Sciences, vol.3, 2021
9. Baptista, J, Sequeira, G, Solteiro Pires, EJ, "Evaluation of PV microgeneration systems and tariffs management on the energy efficiency of service buildings", Renewable Energy and Power Quality Journal, vol.19, pp.73-78, 2021
10. Barroso, TG, Ribeiro, L, Gregorio, H, Santos, F, Martins, RC, "Point-of-Care Vis-SWNIR Spectroscopy Towards Reagent-Less Hemogram Analysis", Sensors and Actuators B: Chemical, pp.130138, 2021
11. Briga Sa, A, Paiva, A, Lanzinha, JC, Boaventura Cunha, J, Fernandes, L, "Influence of Air Vents Management on Trombe Wall Temperature Fluctuations: An Experimental Analysis under Real Climate Conditions", ENERGIES, vol.14, pp.5043, AUG, 2021
12. Camargo, C, Goncalves, J, Conde, MA, Rodriguez Sedano, FJ, Costa, P, Garcia Penalvo, FJ, "Systematic literature review of realistic simulators applied in educational robotics context", Sensors, vol.21, pp.4031, 2021
13. Cerqueira, P, Soria, MA, Madeira, LM, "Hydrogen production through chemical looping and sorption-enhanced reforming of olive mill wastewater: Thermodynamic and energy efficiency analysis", Energy Conversion and Management, vol.238, pp.114146, 2021
14. Cerveira, A, Pires, EJS, Baptista, J, "Wind Farm Cable Connection Layout Optimization with Several Substations", ENERGIES, vol.14, pp.3615, JUN, 2021
15. da Silva, DQ, Aguiar, AS, dos Santos, FN, Sousa, AJ, Rabino, D, Biddoccu, M, Bagagiolo, G, Delmastro, M, "Measuring Canopy Geometric Structure Using Optical Sensors Mounted on Terrestrial Vehicles: A Case Study in Vineyards", Agriculture, vol.11, pp.208, 2021
16. da Silva, DQ, dos Santos, FN, Sousa, AJ, Filipe, V, "Visible and Thermal Image-Based Trunk Detection with Deep Learning for Forestry Mobile Robotics", Journal of Imaging, vol.7, pp.176, 2021

17. da Silva, DQ, dos Santos, FN, Sousa, AJ, Filipe, V, Boaventura Cunha, J, "Unimodal and Multimodal Perception for Forest Management: Review and Dataset", COMPUTATION, vol.9, pp.127, DEC, 2021
18. de Aguiar, ASP, de Oliveira, MAR, Pedrosa, EF, dos Santos, FBN, "A Camera to LiDAR calibration approach through the Optimization of Atomic Transformations", Expert Systems with Applications, pp.114894, 2021
19. de Souza, JPC, Costa, CM, Rocha, LF, Arrais, R, Moreira, AP, Pires, EJS, Boaventura Cunha, J, "Reconfigurable Grasp Planning Pipeline with Grasp Synthesis and Selection Applied to Picking Operations in Aerospace Factories", Robotics and Computer-Integrated Manufacturing, vol.67, pp.102032, 2021
20. de Souza, JPC, Rocha, LF, Oliveira, PM, Moreira, AP, Boaventura Cunha, J, "Robotic grasping: from wrench space heuristics to deep learning policies", Robotics and Computer-Integrated Manufacturing, vol.71, pp.102176, 2021
21. Duarte, L, Cunha, M, Teodoro, AC, "Comparing hydric erosion soil loss models in rainy mountainous and dry flat regions in Portugal", Land, vol.10, pp.554, 2021
22. Duarte, L, Teodoro, AC, Sousa, JJ, Padua, L, "QVigourMap: A GIS Open Source Application for the Creation of Canopy Vigour Maps", Agronomy, vol.11, pp.952, 2021
23. Guo, YH, Chen, SZ, Wu, ZF, Wang, SX, Bryant, CR, Senthilnath, J, Cunha, M, Fu, YSH, "Integrating Spectral and Textural Information for Monitoring the Growth of Pear Trees Using Optical Images from the UAV Platform", Remote Sensing, vol.13, pp.1795, MAY, 2021
24. Huba, M, Oliveira, PM, Bistak, P, Vrancic, D, Zakova, K, "A Set of Active Disturbance Rejection Controllers Based on Integrator Plus Dead-Time Models", Applied Sciences, vol.11, pp.1671, 2021
25. Lourenco, P, Teodoro, AC, Goncalves, JA, Honrado, JP, Cunha, M, Sillero, N, "Assessing the performance of different OBIA software approaches for mapping invasive alien plants along roads with remote sensing data", International Journal of Applied Earth Observation and Geoinformation, vol.95, MAR, 2021
26. Magalhaes, SA, Castro, L, Moreira, G, dos Santos, FN, Cunha, M, Dias, J, Moreira, AP, "Evaluating the Single-Shot MultiBox Detector and YOLO Deep Learning Models for the Detection of Tomatoes in a Greenhouse", Sensors, vol.21, pp.3569, 2021
27. Marcos, B, Goncalves, J, Alcaraz Segura, D, Cunha, M, Honrado, JP, "A Framework for Multi-Dimensional Assessment of Wildfire Disturbance Severity from Remotely Sensed Ecosystem Functioning Attributes", REMOTE SENSING, vol.13, pp.1-25, FEB, 2021
28. Matos, D, Costa, P, Lima, J, Costa, P, "Multi AGV Coordination Tolerant to Communication Failures", Robotics, vol.10, pp.55, 2021
29. Morais, R, Mendes, J, Silva, R, Silva, N, Sousa, JJ, Peres, E, "A Versatile, Low-Power and Low-Cost IoT Device for Field Data Gathering in Precision Agriculture Practices", Agriculture, vol.11, pp.619, 2021
30. Moreira, J, Pinto, VH, Goncalves, J, Costa, P, "State Estimation of Over-Sensored Systems Applied to a Low-Cost Robotic Manipulator", Applied Sciences, vol.11, pp.2519, 2021
31. Mota, A, Briga Sa, A, Valente, A, "Development of a Wireless System to Control a Trombe Wall for Poultry Brooding", AGRIENGINEERING, vol.3, pp.853-867, DEC, 2021
32. Oliveira, LFP, Moreira, AP, Silva, MF, "Advances in Agriculture Robotics: A State-of-the-Art Review and Challenges Ahead", Robotics, vol.10, pp.52, 2021
33. Oliveira, LFP, Moreira, AP, Silva, MF, "Advances in Forest Robotics: A State-of-the-Art Survey", Robotics, vol.10, pp.53, 2021
34. Pereira, CA, Oliveira, PM, Reis, MJCD, "Drivers of the adoption of non-traditional methodologies: case study in the master- integrated of Electrical and Computer Engineering at the University Of Tras-Os-Montes and Alto Douro, Portugal", Texto Livre-Linguagem e Tecnologia, vol.14, 2021

35. Pinto, VH, Goncalves, J, Costa, P, "Design, Modeling, and Control of a Single Leg for a Legged-Wheeled Locomotion System with Non-Rigid Joint", Actuators, vol.10, pp.29, 2021

36. Pinto, VH, Soares, IN, Rocha, M, Lima, J, Goncalves, J, Costa, P, "Design, Modeling, and Control of an Autonomous Legged-Wheeled Hybrid Robotic Vehicle with Non-Rigid Joints", Applied Sciences, vol.11, pp.6116, 2021

37. Rodrigues, GC, Braga, RP, "A Simple Application for Computing Reference Evapotranspiration with Various Levels of Data Availability-ETo Tool", AGRONOMY-BASEL, vol.11, pp.2203, NOV, 2021

38. Rodrigues, GC, Braga, RP, "A Simple Procedure to Estimate Reference Evapotranspiration during the Irrigation Season in a Hot-Summer Mediterranean Climate", SUSTAINABILITY, vol.13, pp.1-13, JAN, 2021

39. Rodrigues, GC, Braga, RP, "Estimation of Daily Reference Evapotranspiration from NASA POWER Reanalysis Products in a Hot Summer Mediterranean Climate", AGRONOMY-BASEL, vol.11, pp.2077, OCT, 2021

40. Rodrigues, GC, Braga, RP, "Estimation of Reference Evapotranspiration during the Irrigation Season Using Nine Temperature-Based Methods in a Hot-Summer Mediterranean Climate", AGRICULTURE-BASEL, vol.11, pp.1-15, FEB, 2021

41. Rodrigues, GC, Braga, RP, "Evaluation of NASA POWER Reanalysis Products to Estimate Daily Weather Variables in a Hot Summer Mediterranean Climate", AGRONOMY-BASEL, vol.11, pp.1207, JUN, 2021

42. Santos M.F., Honório L.M., Moreira A.P.G.M., Garcia P.A.N., Silva M.F., Vidal V.F., "Analysis of a Fast Control Allocation approach for nonlinear over-actuated systems", ISA Transactions, 2021

43. Santos, J, Rebelo, PM, Rocha, LF, Costa, P, Veiga, G, "A* Based Routing and Scheduling Modules for Multiple AGVs in an Industrial Scenario", Robotics, vol.10, pp.72, 2021

44. Santos, LC, dos Santos, FN, Morais, R, Duarte, C, "Potential Non-Invasive Technique for Accessing Plant Water Contents Using a Radar System", Agronomy, vol.11, pp.279, 2021

45. Santos, LC, Santos, A, Santos, FN, Valente, A, "A Case Study on Improving the Software Dependability of a ROS Path Planner for Steep Slope Vineyards", Robotics, vol.10, pp.103, 2021

46. Santos, MF, Honorio, LM, Moreira, APGM, Silva, MF, Vidal, VF, "Fast Real-Time Control Allocation Applied to Over-Actuated Quadrotor Tilt-Rotor", J. Intell. Robotic Syst., vol.102, pp.65, 2021

47. Silva, D, Sousa, A, Costa, V, "A Comparative Analysis for 2D Object Recognition: A Case Study with Tactode Puzzle-Like Tiles", Journal of Imaging, vol.7, pp.65, 2021

48. Soares, I, Petry, M, Moreira, AP, "Programming Robots by Demonstration Using Augmented Reality", SENSORS, vol.21, pp.5976, SEP, 2021

49. Soares, I, Sousa, RB, Petry, M, Moreira, AP, "Accuracy and Repeatability Tests on HoloLens 2 and HTC Vive", 2021

50. Sousa, JJ, Liu, G, Fan, JH, Perski, Z, Steger, S, Bai, SB, Wei, LH, Salvi, S, Wang, Q, Tu, JA, Tong, LQ, Mayrhofer, P, Sonnenschein, R, Liu, SJ, Mao, YC, Tolomei, C, Bignami, C, Atzori, S, Pezzo, G, Wu, LX, Yan, SY, Peres, E, "Geohazards Monitoring and Assessment Using Multi-Source Earth Observation Techniques", Remote Sensing, vol.13, pp.4269, 2021

51. Tinoco, V, Malheiro, B, Silva, MF, "Design, Modeling, and Simulation of a Wing Sail Land Yacht", Applied Sciences, vol.11, pp.2760, 2021

52. Tosin, R, Pocas, I, Novo, H, Teixeira, J, Fontes, N, Graca, A, Cunha, M, "Assessing predawn leaf water potential based on hyperspectral data and pigment's concentration of Vitis vinifera L. in the Douro Wine Region", Scientia Horticulturae, vol.278, pp.109860, 2021

53. Zawadniak, PVF, Piardi, L, Brito, T, Lima, J, Costa, P, Monteiro, ALR, Costa, P, Pereira, AI, "Micromouse 3D simulator with dynamics capability: a Unity environment approach", SN APPLIED SCIENCES, vol.3, 2021

International Conference Proceedings with Scientific Referees

1. Aguiar, P, Cunha, A, Bakon, M, Ruiz Armenteros, AM, Sousa, JJ, "Multivariate Outlier Detection in Postprocessing of Multi-temporal PS-InSAR Results using Deep Learning", Procedia Computer Science, vol.181, pp.1146-1153, 2021
2. Boularas, M, Szmytke, Z, Smith, L, Isik, K, Ruusunen, J, Malheiro, B, Justo, J, Ribeiro, C, Silva, MF, Ferreira, P, Guedes, P, "Smart Bicycle Probe – An EPS@ISEP 2020 Project", Educating Engineers for Future Industrial Revolutions - Advances in Intelligent Systems and Computing, pp.115-126, 2021
3. Braun J., Lima J., Pereira A.I., Rocha C., Costa P., "Searching the Optimal Parameters of a 3D Scanner Through Particle Swarm Optimization", Communications in Computer and Information Science - Optimization, Learning Algorithms and Applications, pp.138-152, 2021
4. Braun, J, Lima, J, Costa, P, Moreira, A, "Robot@Factory Lite Competition: A Digital Twin Approach for the AGV", Proceedings of the 11th International Conference on Simulation and Modeling Methodologies, Technologies and Applications, 2021
5. Braun, J, Lima, J, Pereira, AI, Rocha, C, Costa, P, "Three-dimensional scanning system based on a low-cost infrared sensor", IEEE International Conference on Emerging Technologies and Factory Automation, ETFA, vol.2021-September, 2021
6. Brito T., Azevedo B.F., Valente A., Pereira A.I., Lima J., Costa P., "Environment Monitoring Modules with Fire Detection Capability Based on IoT Methodology", Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering - Science and Technologies for Smart Cities, pp.211-227, 2021
7. Brito T., Zorawski M., Mendes J., Azevedo B.F., Pereira A.I., Lima J., Costa P., "Optimizing Data Transmission in a Wireless Sensor Network Based on LoRaWAN Protocol", Communications in Computer and Information Science - Optimization, Learning Algorithms and Applications, pp.281-293, 2021
8. Carneiro, G, Pádua, L, Sousa, JJ, Peres, E, Morais, R, Cunha, A, "Grapevine Variety Identification Through Grapevine Leaf Images Acquired in Natural Environment", 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021
9. Castro Pereira, Sd, Solteiro Pires, EJ, Moura Oliveira, PBd, "Genetic and Ant Colony Algorithms to Solve the Multi-TSP", Intelligent Data Engineering and Automated Learning - IDEAL 2021 - 22nd International Conference, IDEAL 2021, Manchester, UK, November 25-27, 2021, Proceedings, vol.13113, pp.324-332, 2021
10. Couto, T, Costa, P, Malaca, P, Tavares, P, "Machine Learning Optimization for Robotic Welding Parametrization", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), pp.137-142, 2021
11. Cruz A., Matos D., Lima J., Costa P., Costa P., "Multi AGV Industrial Supervisory System", Communications in Computer and Information Science, vol.1488 CCIS, pp.203-218, 2021
12. de Moura Oliveira, PB, Hedengren, JD, Boaventura Cunha, J, "Bridging Theory to Practice: Feedforward and Cascade Control with TCLab Arduino Kit", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.23-32, 2021
13. de Moura Oliveira, PB, Vrancic, D, "Practical Validation of a Dual Mode Feedforward-Feedback Control Scheme in an Arduino Kit", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.538-547, 2021
14. de Souza, JPC, Rocha, LF, Filipe, VM, Boaventura Cunha, J, Moreira, AP, "Low-Cost and Reduced-Size 3D-Cameras Metrological Evaluation Applied to Industrial Robotic Welding Operations", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2021
15. Feys, AV, Nicoara, GG, Carasel, IS, Karpiak, M, Kocheski, N, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Reconfigurable and Ergonomic Smart Desk - An EPS@ISEP 2021 Project", TEEM'21: Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality, Barcelona, Spain, October 26 - 29, 2021, pp.464-470, 2021

16. Figueiredo, N, Pádua, L, Sousa, JJ, Sousa, A, "Terrace Vineyards Detection from UAV Imagery Using Machine Learning: A Preliminary Approach", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12981 LNAI, pp.16-26, 2021

17. Fohanno, B, Pires, B, Ionescu, C, Ladka, E, Perek, M, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Crowd Orchestration - An EPS@ISEP 2021 Project", TEEM'21: Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality, Barcelona, Spain, October 26 - 29, 2021, pp.411-416, 2021

18. Fonseca Ferreira, NM, Boaventura Cunha, J, "Cloud-Based Framework for Robot Operation in Hospital Environments", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.114-125, 2021

19. Lazecky, M, Wadhwa, S, Mlcousek, M, Sousa, JJ, "Simple method for identification of forest windthrows from Sentinel-1 SAR data incorporating PCA", International Conference on Enterprise Information Systems / International Conference on Project Management / International Conference on Health and Social Care Information Systems and Technologies 2020 (CENTERIS/PROJMAN/HCIST 2020), vol.181, pp.1154-1161, 2021

20. Lourenço, J, Teixeira, J, Carvalho, P, Pádua, L, Adão, T, Peres, E, Sousa, JJ, "Virtual Environments & Precision Viticulture: A Case Study", 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021

21. Magalhaes, C, Ribeiro, J, Leite, A, Pires, EJS, Pavao, J, "Automatic Fall Detection Using Long Short-Term Memory Network", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12861 LNCS, pp.359-371, 2021

22. Magalhães, SA, Moreira, AP, dos Santos, FN, Dias, J, Santos, L, "Cost-Effective 4DoF Manipulator for General Applications", Intelligent Systems and Applications - Proceedings of the 2021 Intelligent Systems Conference, IntelliSys 2021, Amsterdam, The Netherlands, 2-3 September, 2021, Volume 3, vol.296, pp.251-267, 2021

23. Martins, A, Lucas, J, Costelha, H, Neves, C, "Developing an OPC UA Server for CNC Machines", Procedia Computer Science, vol.180, pp.561-570, 2021

24. Matos D., Costa P., Lima J., Valente A., "Multiple Mobile Robots Scheduling Based on Simulated Annealing Algorithm", Communications in Computer and Information Science, vol.1488 CCIS, pp.187-202, 2021

25. Melo, P, Arrais, R, Veiga, G, "Development and Deployment of Complex Robotic Applications using Containerized Infrastructures", 19th IEEE International Conference on Industrial Informatics, INDIN 2021, Palma de Mallorca, Spain, July 21-23, 2021, pp.1-8, 2021

26. Mendes, A, Tatuc, E, Joos, F, Wyka, J, Petrevski, K, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Sustainable Food Production Through Vermicomposting - An EPS@ISEP 2021 Project", TEEM'21: Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality, Barcelona, Spain, October 26 - 29, 2021, pp.553-559, 2021

27. Mendonça H., Lima J., Costa P., Moreira A.P., Santos F., "Human Detector Smart Sensor for Autonomous Disinfection Mobile Robot", Communications in Computer and Information Science - Optimization, Learning Algorithms and Applications, pp.171-186, 2021

28. Moreira, AP, Lima, J, Costa, P, "Improving a position controller for a robotic joint", IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2021, Santa Maria da Feira, Portugal, April 28-29, 2021, pp.97-103, 2021

29. Moreira, J, Pinto, VH, Costa, P, "IMU calibration for state estimation of an over-sensored low-cost robotic manipulator", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions, ICARSC 2021, pp.79-84, 2021

30. Moutinho, D, Rebelo, P, Costa, C, Rocha, L, Veiga, G, "Force control heuristics for surpassing pose uncertainty in mobile robotic assembly platforms", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2021

31. Padilha, TC, Moreira, G, Magalhães, SA, dos Santos, FN, Cunha, M, Oliveira, M, "Tomato Detection Using Deep Learning for Robotics Application", Progress in Artificial Intelligence - Lecture Notes in Computer Science, pp.27-38, 2021

32. Palasciano, C, Toscano, C, Arrais, R, Sobral, NM, Floreani, F, Sesana, M, Taisch, M, "A Predictive Simulation and Optimization Architecture based on a Knowledge Engineering User Interface to Support Operator 4.0", IFAC PAPERSONLINE, vol.54, pp.331-336, 2021

33. Pereira A., Pinto V., Gonçalves J., Costa P., "Demonstrative educational haptic manipulator robot: A teaching aid in Mechatronics", ACM International Conference Proceeding Series, pp.30-37, 2021

34. Pinto, VH, Gonçalves, J, Costa, P, "Model of a DC Motor with Worm Gearbox", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.638-647, 2021

35. Pinto, VH, Lima, J, Gonçalves, J, Costa, P, "Modeling of an Elastic Joint: An Experimental Setup Approach", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.676-685, 2021

36. Pinto, VH, Sousa, A, Lima, J, Gonçalves, J, Costa, P, "Open Hardware and Software Robotics Competition for Additional Engagement in ECE Students - The Robot@Factory Lite Case Study", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.729-739, 2021

37. Pires, F, Ahmad, B, Moreira, AP, Leitão, P, "Digital Twin based What-if Simulation for Energy Management", 4th IEEE International Conference on Industrial Cyber-Physical Systems, ICPS 2021, Victoria, BC, Canada, May 10-12, 2021, pp.309-314, 2021

38. Pires, F, Ahmad, B, Moreira, AP, Leitão, P, "Recommendation System using Reinforcement Learning for What-If Simulation in Digital Twin", 19th IEEE International Conference on Industrial Informatics, INDIN 2021, Palma de Mallorca, Spain, July 21-23, 2021, pp.1-6, 2021

39. Priebe, J, Swiatek, K, Vidinha, M, Vaduva, MR, Tiits, M, Sorescu, TG, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Elderly Monitoring – An EPS@ISEP 2020 Project", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.575-584, 2021

40. Ruiz Armenteros, AM, Marchamalo Sacrsitan, M, Bakon, M, Lamas Fernandez, F, Delgado, JM, Sanchez Ballesteros, V, Papco, J, Gonzalez Rodrigo, B, Lazecky, M, Perissin, D, Sousa, JJ, "Monitoring of an embankment dam in southern Spain based on Sentinel-1 Time-series InSAR", International Conference on Enterprise Information Systems / International Conference on Project Management / International Conference on Health And Social Care Information Systems and Technologies 2020 (CENTERIS/PROJMAN/HCIST 2020), Vol.181, Pp.353-359, 2021

41. Sarmento, J, Aguiar, AS, Santos, FND, Sousa, AJ, "Robot navigation in vineyards based on the visual vanish point concept", 2021 International Symposium of Asian Control Association on Intelligent Robotics and Industrial Automation (IRIA), 2021

42. Sarmento, J, de Aguiar, ASP, dos Santos, FN, de Sousa, AJM, "Autonomous Robot Visual-Only Guidance in Agriculture Using Vanishing Point Estimation", Progress in Artificial Intelligence - 20th EPIA Conference on Artificial Intelligence, EPIA 2021, Virtual Event, September 7-9, 2021, Proceedings, vol.12981, pp.3-15, 2021

43. Silva, B, Pires, EJS, Reis, A, de Moura Oliveira, PB, Barroso, J, "Students Drop Out Trends: A University Study", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.442-450, 2021

44. Silva, MZ, Brito, T, Lima, JL, Silva, MF, "Industrial Robotic Arm in Machining Process Aimed to 3D Objects Reconstruction", 2021, 22ND IEEE International Conference on Industrial Technology (ICIT), pp.1100-1105, 2021

45. Soares, F, de Moura Oliveira, PB, Leão, CP, "Your Turn to Learn – Flipped Classroom in Automation Courses", Lecture Notes in Electrical Engineering - CONTROLO 2020, pp.668-675, 2021

46. Sousa, RB, Costa, PG, Moreira, AP, "A Pose Control Algorithm for Omnidirectional Robots", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2021

47. Sousa, RB, Petry, MR, Moreira, AP, "Extrinsic sensor calibration methods for mobile robots: A short review", Lecture Notes in Electrical Engineering, vol.695 LNEE, pp.559-569, 2021

48. Teixeira, FM, Silva, MF, "Simulation of a Robotic Co-transport System", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), pp.179-184, 2021

49. Teixeira, S, Arrais, R, Veiga, G, "Cloud Simulation for Continuous Integration and Deployment in Robotics", 19th IEEE International Conference on Industrial Informatics, INDIN 2021, Palma de Mallorca, Spain, July 21-23, 2021, pp.1-8, 2021

50. Terra F., Rodrigues L., Magalhaes S., Santos F., Moura P., Cunha M., "PixelCropRobot, a cartesian multitask platform for microfarms automation", 2021 International Symposium of Asian Control Association on Intelligent Robotics and Industrial Automation (IRIA), 2021

51. Tinoco, V, Silva, MF, Santos, FN, Rocha, LF, Magalhaes, S, Santos, LC, "A Review of Pruning and Harvesting Manipulators", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2021

52. Tuluc, C, Verberne, F, Lasota, S, de Almeida, T, Malheiro, B, Justo, J, Ribeiro, C, Silva, MF, Ferreira, P, Guedes, P, "The MopBot Cleaning Robot – An EPS@ISEP 2020 Project", Educating Engineers for Future Industrial Revolutions - Advances in Intelligent Systems and Computing, pp.79-90, 2021

53. Vicêncio, D, Silva, H, Soares, S, Filipe, V, Valente, A, "An Intelligent Predictive Maintenance Approach Based on End-of-Line Test Logfiles in the Automotive Industry", Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering - Industrial IoT Technologies and Applications, pp.121-140, 2021

Books

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Chapter/Paper in Books

1. Jorge, F, Costelha, H, Neves, C, "Laying Ground for Automated Manhole Inspection: A Review", Advances in Science, Technology and Innovation, pp.181-189, 2021

Publications (Editor)

Blank

Dissertations (PhD)

1. Pádua, L., “Automatic analysis of UAS-based multi-temporal data as support to a precision agroforestry management”
2. Pinto, V. “Hybrid Legged-Wheeled Locomotion System for Robotic Vehicles”

10.8 CEGI – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	8	10	6	-4
		Academic Staff	13	15	18	3
		Grant Holders and Trainees	27	28	24	-4
		Total Core Researchers	**48**	**53**	**48**	**-5**
		Total Core PhD	**26**	**28**	**26**	**-2**
	Affiliated Researchers		6	7	6	-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**	**61**	**55**	**-6**
		Total Integrated PhD	**32**	**34**	**32**	**-2**

Table 10.8.2 – CEGI – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	310	317	297	-21
PN-PICT	National R&D Programmes - S&T Integrated Projects	35			
PN-COOP	National Cooperation Programmes with Industry	34	23	39	15
PUE-FP	EU Framework Programmes	95	191	267	76
PUE-DIV	EU Cooperation Programmes – Other		20	3	-17
SERV-NAC	R&D Services and Consulting – National	104	148	119	-30
SERV-INT	R&D Services and Consulting – International		3		-3
OP	Other Funding Programmes	4		2	2
	Total Funding	**581**	**702**	**725**	**23**

Table 10.8.3 - CEGI – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	26	34	39
Indexed Conferences	10	20	9
Books	1	0	1
Book Chapters	1	3	1
Concluded PhD Theses - Members	2	4	4
Concluded PhD Theses – Supervised	5	5	5

Table 10.8.4- CEGI – Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	0	1	0
Software copyright registrations at IGAC	0	0	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	0	0	0
Granted patents	0	0	0
Commercial contracts – Licenses and Assignments	1	1	0
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	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	8	12	17
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	4	5	2
International events in which INESC TEC members participate in the program committees	10	12	15
Participation in events such as fairs, exhibitions or similar	1	0	0
Conferences, workshops and scientific sessions organised by the Centre	0	0	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	0	0	2
Advanced training courses organised by the Centre	0	0	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	ASAP	Maria Antónia Carravilla	01/06/2018	06/02/2022
PN-FCT	LASTMILE	João Pedro Pedroso	26/07/2018	25/07/2022
PN-FCT	SiuSMS	Maria Antónia Carravilla	26/07/2018	26/07/2022
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	01/06/2021
PN-COOP	CrossLOG-1	Elsa Marília Silva	01/11/2019	31/10/2022
PN-COOP	TRF4p0-1	Luís Guimarães	01/07/2020	01/07/2023
PUE-DIV	WINDEXT-1	Luís Guimarães	01/01/2020	31/12/2022
PUE-FP	FIN-TECH-1	Pedro Amorim	01/01/2019	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	HEAD	Luís Guimarães	01/01/2018	30/11/2021
SERV-NAC	MINE4HEALTH	Mário Amorim Lopes	01/01/2020	29/11/2021
SERV-NAC	BestOrder	Ana Viana	01/10/2020	07/10/2021
SERV-NAC	BEST_ORDER_II	Mário Amorim Lopes	20/10/2021	01/02/2022
SERV-NAC	SolIM62010	Vera Miguéis	15/11/2021	15/05/2022
OP	EWG2021	Pedro Amorim	01/09/2021	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

10.8.2 List of publications

International Journals with Scientific Referees

1. Amorim Lopes, M, Guimaraes, L, Alves, J, Almada Lobo, B, "Improving picking performance at a large retailer warehouse by combining probabilistic simulation, optimization, and discrete-event simulation", International Transactions in Operational Research, vol.28, pp.687-715, MAR, 2021
2. Amorim Lopes, M, Oliveira, M, Raposo, M, Cardoso Grilo, T, Alvarenga, A, Barbas, M, Alves, M, Vieira, A, Barbosa Povoa, A, "Enhancing optimization planning models for health human resources management with foresight", Omega (United Kingdom), pp.102384, 2021
3. ndrade, X, Guimaraes, L, Figueira, G, "Product line selection of fast-moving consumer goods", Omega (United Kingdom), pp.102389, 2021
4. Barros, H, Pereira, T, Ramos, AG, Ferreira, FA, "Complexity Constraint in the Distributor's Pallet Loading Problem", Mathematics, vol.9, pp.1742, 2021

5. Bianchi Aguiar, T, Hubner, A, Carravilla, MA, Oliveira, JF, "Retail shelf space planning problems: A comprehensive review and classification framework", European Journal of Operational Research, vol.289, pp.1-16, 2021

6. Biro, P, van de Klundert, J, Manlove, D, Pettersson, W, Andersson, T, Burnapp, L, Chromy, P, Delgado, P, Dworczak, P, Haase, B, Hemke, A, Johnson, R, Klimentova, X, Kuypers, D, Costa, AN, Smeulders, B, Spieksma, F, Valentin, MO, Viana, A, "Modelling and optimisation in European Kidney Exchange Programmes", European Journal of Operational Research, 2021

7. Camanho, AS, Varriale, L, Barbosa, F, Sobral, T, "Performance assessment of upper secondary schools in Italian regions using a circular pseudo-Malmquist index", European Journal of Operational Research, 2021

8. Carvalho, M, Klimentova, X, Glorie, K, Viana, A, Constantino, M, "Robust Models for the Kidney Exchange Problem", INFORMS Journal on Computing, 2021

9. Dias, L, Leitao, A, Guimaraes, L, "Resource definition and allocation for a multi-asset portfolio with heterogeneous degradation", Reliability Engineering & System Safety, vol.213, SEP, 2021

10. Dias, L, Ribeiro, M, Leitao, A, Guimaraes, L, Carvalho, L, Matos, MA, Bessa, RJ, "An unsupervised approach for fault diagnosis of power transformers", Quality and Reliability Engineering International, 2021

11. Duarte, SP, de Sousa, JP, de Sousa, JF, "A Conceptual Framework for an Integrated Information System to Enhance Urban Mobility", International Journal of Decision Support System Technology, vol.13, pp.33-49, 2021

12. Esmizadeh, Y, Bashiri, M, Jahani, H, Almada Lobo, B, "Cold chain management in hierarchical operational hub networks*", Transportation Research Part E-Logistics and Transportation Review, vol.147, MAR, 2021

13. Fátima Teles, Md, de Sousa, JF, "Sustainable development and morphological analysis: a multi-level strategic planning for the transport sector", Int. J. Inf. Decis. Sci., vol.13, pp.350-364, 2021

14. Ferreira, C, Figueira, G, Amorim, P, "Scheduling Human-Robot Teams in collaborative working cells", International Journal of Production Economics, vol.235, pp.108094, MAY, 2021

15. Ferreira, MC, Dias, TG, Cunha, JFE, "Anda: An Innovative Micro-Location Mobile Ticketing Solution Based on NFC and BLE Technologies", IEEE Transactions on Intelligent Transportation Systems, pp.1-10, 2021

16. Golalikhani, M, Oliveira, BB, Carravilla, MA, Oliveira, JF, Antunes, AP, "Carsharing: A review of academic literature and business practices toward an integrated decision-support framework", Transportation Research Part E: Logistics and Transportation Review, vol.149, pp.102280, 2021

17. Golalikhani, M, Oliveira, BB, Carravilla, MA, Oliveira, JF, Pisinger, D, "Understanding carsharing: A review of managerial practices towards relevant research insights", Research in Transportation Business & Management, pp.100653, 2021

18. Gutierrez Franco, E, Polo, A, Clavijo Buritica, N, Rabelo, L, "Multi-Objective Optimization to Support the Design of a Sustainable Supply Chain for the Generation of Biofuels from Forest Waste", SUSTAINABILITY, vol.13, JUL, 2021

19. Joa, M, Martins, S, Amorim, P, Almada Lobo, B, "A green lateral collaborative problem under different transportation strategies and profit allocation methods", Journal of Cleaner Production, vol.288, pp.125678, 2021

20. Klimentova, X, Viana, A, Pedroso, JP, Santos, N, "Fairness models for multi-agent kidney exchange programmes", Omega (United Kingdom), pp.102333, 2021

21. Korper, AK, Holmlid, S, Patricio, L, "The role of meaning in service innovation: a conceptual exploration", Journal of Service Theory and Practice, vol. ahead-of-print, 2021

22. Koskela Huotari, K, Patricio, L, Zhang, J, Karpen, IO, Sangiorgi, D, Anderson, L, Bogicevic, V, "Service system transformation through service design: Linking analytical dimensions and service design approaches", Journal of Business Research, vol.136, pp.343-355, 2021

23. Martin, M, Oliveira, JF, Silva, E, Morabito, R, Munari, P, "Three-dimensional guillotine cutting problems with constrained patterns: MILP formulations and a bottom-up algorithm", Expert Systems with Applications, pp.114257, 2021

24. Oliveira, BB, Carravilla, MA, Oliveira, JF, "A Diversity-Based Genetic Algorithm for Scenario Generation", European Journal of Operational Research, 2021

25. Oliveira, BB, Carravilla, MA, Oliveira, JF, Resende, MGC, "A C++ application programming interface for co-evolutionary biased random-key genetic algorithms for solution and scenario generation", Optimization Methods and Software, 2021

26. Oliveira, EE, Migueis, VL, Borges, JL, "On the influence of overlap in automatic root cause analysis in manufacturing", International Journal of Production Research, pp.1-17, 2021

27. Oliveira, G, Teixeira, JG, Torres, A, Morais, C, "An exploratory study on the emergency remote education experience of higher education students and teachers during the COVID-19 pandemic", British Journal of Educational Technology, 2021

28. Pereira, MA, Camanho, AS, Figueira, JR, Marques, RC, "Incorporating preference information in a range directional composite indicator: The case of Portuguese public hospitals *", European Journal of Operational Research, vol.294, pp.633-650, 2021

29. Pereira, MA, Camanho, AS, Marques, RC, Figueira, JR, "The convergence of the World Health Organization Member States regarding the United Nations' Sustainable Development Goal 'Good health and well-being'", OMEGA-Journal of Death and Dying, vol.104, pp.102495, OCT, 2021

30. Piran, FS, Lacerda, DP, Camanho, AS, Silva, MCA, "Internal benchmarking to assess the cost efficiency of a broiler production system combining data envelopment analysis and throughput accounting", International Journal of Production Economics, vol.238, AUG, 2021

31. Pires, M, Silva, E, Amorim, P, "Solving the grocery backroom layout problem", International Journal of Production Research, pp.1-26, 2021

32. Queiros, F, Oliveira, BB, "Impact of environmental concerns on the capacity-pricing problem in the car rental business", Journal of Cleaner Production, vol.322, pp.129044, 2021

33. Rios, BHO, Xavier, EC, Miyazawa, FK, Amorim, P, Curcio, E, Santos, MJ, "Recent dynamic vehicle routing problems: A survey", Computers and Industrial Engineering, vol.160, pp.107604, 2021

34. Santos, MJ, Curcio, E, Amorim, P, Carvalho, M, Marques, A, "A bilevel approach for the collaborative transportation planning problem", International Journal of Production Economics, vol.233, 2021

35. Sierra Perez, J, Teixeira, JG, Romero Piqueras, C, Patricio, L, "Designing sustainable services with the ECO-Service design method: Bridging user experience with environmental performance", Journal of Cleaner Production, vol.305, pp.127228, 2021

36. Silva, JHO, Mendes, GHS, Miguel, PCA, Amorim, M, Teixeira, JG, "Customer experience research: intellectual structure and future research opportunities", JOURNAL OF SERVICE THEORY AND PRACTICE, vol. ahead-of-print, 2021

37. Smeulders, B, Pettersson, W, Viana, A, Andersson, T, Bolotinha, C, Chromy, P, Gentile, M, Hadaya, K, Hemke, A, Klimentova, X, Kuypers, D, Manlove, D, Robb, M, Slavcev, A, Tubertini, P, Valentin, MO, van de Klundert, J, Ferrari, P, "Data and optimisation requirements for Kidney Exchange Programs", HEALTH INFORMATICS JOURNAL, vol.27, pp.146045822110099, 2021

38. Sobral, T, Galvao, T, Borges, J, "Knowledge-Assisted Visualization of Multi-Level Origin-Destination Flows Using Ontologies", IEEE Transactions on Intelligent Transportation Systems, pp.1-10, 2021

39. Wagner, L, Pinto, C, Amorim, P, "On the Value of Subscription Models for Online Grocery Retail", European Journal of Operational Research, vol.294, pp.874-894, 2021

International Conference Proceedings with Scientific Referees

1. 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, 2021
2. Correia, R, Fontes, T, Borges, JL, "Forecasting of Urban Public Transport Demand Based on Weather Conditions", Advances in Intelligent Systems and Computing, vol.1278, pp.75-84, 2021
3. Dionísio, J, Santos, Dd, Pedroso, JP, "The Sea Exploration Problem Revisited", Machine Learning, Optimization, and Data Science - 7th International Conference, LOD 2021, Grasmere, UK, October 4-8, 2021, Revised Selected Papers, Part I, vol.13163, pp.626-640, 2021
4. Duarte, SP, Campos Ferreira, M, Pinho de Sousa, J, Freire de Sousa, J, Galvão, T, "Improving Mobility Services through Customer Participation", Advances in Mobility-as-a-Service Systems - Advances in Intelligent Systems and Computing, pp.654-663, 2021
5. Ferreira, AR, Ramos, AG, Silva, E, "Analysis of the Impact of Physical Internet on the Container Loading Problem", Lecture Notes in Computer Science - Computational Logistics, pp.549-561, 2021
6. Ferreira, MC, Ferreira, C, Dias, TG, "Mobile Ticketing Customers: How to Attract Them and Keep Them Loyal", Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST, vol.364 LNICST, pp.3-15, 2021
7. Monteiro, T, Pedroso, JP, Viana, A, Klimentova, X, "Reinforcement Learning for Robust Optimization: An Application in Kidney Exchange Programs", Springer Proceedings in Mathematics and Statistics, vol.374, pp.65-77, 2021
8. Oliveira, Ó, Gamboa, D, Silva, E, "Adaptive Sequence-Based Heuristic for Two-Dimensional Non-guillotine Packing Problems", Operational Research - Springer Proceedings in Mathematics & Statistics, pp.95-107, 2021
9. Silva, M, Pedroso, JP, Viana, A, Klimentova, X, "A Branch-Price-And-Cut Algorithm for Stochastic Crowd Shipping Last-Mile Delivery with Correlated Marginals", 21st Symposium on Algorithmic Approaches for Transportation Modelling, Optimization, and Systems, ATMOS 2021, September 9-10, 2021, Lisbon, Portugal (Virtual Conference)., vol.96, pp.12:1-12:20, 2021

Books

1. Papathanasiou, J, Zaraté, P, Freire de Sousa, J, "EURO Working Group on DSS", Integrated Series in Information Systems, 2021

Chapter/Paper in Books

1. Ferreira, I, Cabral, JA, Saraiva, P, "An integrated quantitative framework for supporting product design in the mold sector", Injection Molding: Process, Design, and Applications, pp.243-265, 2021

Publications (Editor)

Blank

Dissertations (PhD)

1. Duarte, S., “A participative service design framework for urban mobility in a socio-technical transition context”
2. Saputro, T., “Leveraging Supplier Selection Within Supply Chain Management Under Uncertainty”
3. Oliveira, E., “Overlap in Automatic Root Cause Analysis in Manufacturing”
4. Pinto, A., “Strategic Insights Towards Profitability in E-commerce, An analysis of the role of Marketing and Operations in balancing revenue and costs”

10.9 CITE – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	3	5	5	0
		Academic Staff	1	2	2	0
		Grant Holders and Trainees	3	1	1	0
		Total Core Researchers	**7**	**8**	**8**	**0**
		Total Core PhD	**3**	**4**	**4**	**0**
	Affiliated Researchers		1	2	2	0
	Administrative and Technical	Employees	1	0	0	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**1**	**0**	**0**	**0**
		Total Integrated HR	**9**	**10**	**10**	**0**
		Total Integrated PhD	**5**	**6**	**6**	**0**

Table 10.9.2 – CITE – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes – FCT	16	8		-8
PN-PICT	National R&D Programmes - S&T Integrated Projects	4			
PN-COOP	National Cooperation Programmes with Industry			14	14
PUE-FP	EU Framework Programmes	57	143	158	14
PUE-DIV	EU Cooperation Programmes – Other	81	19		-19
SERV-NAC	R&D Services and Consulting – National	37	53	17	-36
SERV-INT	R&D Services and Consulting – International			30	30
OP	Other Funding Programmes	2			
Closed Projects		18			
	Total Funding	**216**	**224**	**218**	**-6**

Table 10.9.3 - CITE – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	16	14	16
Indexed Conferences	2	5	3
Books	0	0	0
Book Chapters	2	7	11
Concluded PhD Theses - Members	0	0	1
Concluded PhD Theses – Supervised	1	0	1

Table 10.9.4 - CITE - Summary of participation in dissemination activities

Type of Activity	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	1	1	2
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2	2	2
International events in which INESC TEC members participate in the program committees	13	6	3
Participation in events such as fairs, exhibitions or similar	14	17	0
Conferences, workshops and scientific sessions organised by the Centre	4	2	2
Participants in the conferences, workshops and scientific sessions organised by the Centre	100	144	90
Advanced training courses organised by the Centre	0	3	4

Table 10.9.5 - CITE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-COOP	SMARTHEALTH4ALL	Cristina Machado Guimarães	01/04/2020	31/03/2023
PUE-FP	DIVA	Alexandra Xavier	01/04/2018	31/03/2021
PUE-FP	INCLUDING-1	Vasco Amorim	01/08/2019	31/07/2024
PUE-FP	EENPortugal	Alexandra Xavier	01/01/2020	31/12/2021
PUE-FP	EENINNOVATION	Alexandra Xavier	01/01/2020	31/12/2021
PUE-FP	SCORPION-1	Alexandra Xavier	01/01/2021	31/12/2023
PUE-FP	MirrorLabs2-1	Alexandra Xavier	01/01/2021	31/12/2021
PUE-FP	EITJUMPSTART2021	Alexandra Xavier	21/04/2021	21/12/2021
SERV-NAC	ConsForestWise	Abílio Pereira Pacheco	01/02/2019	30/04/2022
SERV-NAC	IMSGIDI	Alexandra Xavier	15/03/2019	10/12/2021
SERV-NAC	IgniPartinsigna	Alexandra Xavier	01/02/2021	28/02/2021
SERV-NAC	audSGIDI	Alexandra Xavier	09/05/2021	21/05/2021
SERV-NAC	SGIDI_agro	Alexandra Xavier	09/08/2021	31/03/2022
SERV-INT	EurA	José Coelho Rodrigues	15/02/2021	15/02/2022
SERV-INT	CLAMTEX-1	Alexandra Xavier	22/03/2021	22/03/2022

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

10.9.2 List of publications

International Journals with Scientific Referees

1. Almeida F., Carneiro P., "Performance metrics in scrum software engineering companies", International Journal of Agile Systems and Management, vol.14, pp.205, 2021
2. Almeida, F, "Innovative response initiatives in the European Union to mitigate the effects of COVID-19", Journal of Enabling Technologies, vol.ahead-of-print, 2021
3. Almeida, F, "Open Data's Role in Social Innovation Initiatives to Fight COVID-19", Central European Management Journal, vol.29, 2021
4. Almeida, F, "Open-Innovation Practices: Diversity in Portuguese SMEs", Journal of Open Innovation: Technology, Market, and Complexity, vol.7, pp.169, 2021
5. Almeida, F, "The role of tech startups in the fight against COVID-19", World Journal of Science, Technology and Sustainable Development, vol.ahead-of-print, 2021
6. Almeida, F, Buzady, Z, Ferro, A, "Exploring the role of a serious game in developing competencies in higher tourism education", Journal of Hospitality, Leisure, Sport & Tourism Education, pp.100347, 2021
7. Almeida, F, Kovalevski, P, Sakalauskas, D, "Open source platform for big data exploration and analysis", International Journal of Business Information Systems, vol.38, pp.418-434, 2021
8. Almeida, F, Low Choy, S, "Exploring the Relationship Between Big Data and Firm Performance", Management Research And Practice, vol.13, pp.43-57, SEP, 2021
9. Almeida, F, Simoes, J, "Leadership Challenges in Agile Environments", International Journal of Information Technology Project Management, vol.12, pp.30-44, 2021
10. Almeida, FL, "Digital Skills and Their Relevance to the COVID-19 Innovative Responses in the European Union", International Journal of Innovation in the Digital Economy, vol.12, pp.45-57, 2021
11. Almeida, FL, "Management of non-technological projects by embracing agile methodologies", International Journal of Project Organisation and Management, vol.13, pp.135, 2021
12. Almeida, FL, Monteiro, JA, "Exploring the Limitations of Responsive Design Through a Case Study Approach", International Journal of Web Portals, vol.13, pp.62-73, 2021
13. Almeida, FL, Santos, JD, "Perceptions and role of university spin-offs on the employment of young graduates", International Journal of Entrepreneurship and Innovation Management, vol.25, pp.279-302, 2021
14. Pacheco, RM, Claro, J, "Prescribed burning as a cost-effective way to address climate change and forest management in Mediterranean countries", Annals of Forest Science, vol.78, DEC, 2021
15. Rocha, A, Almeida, F, "Exploring the role of organisational innovation in the time of COVID-19", International Journal of Business Environment, vol.12, pp.170, 2021
16. Silveira, S, Ramos, J, Silva, O, Almeida, F, "Sustainability Indicators For Tourism SMES: Application to Portuguese Context", Enlightening Tourism. a Pathmaking Journal, vol.11, pp.1, 2021

International Conference Proceedings with Scientific Referees

1. Gomes, N, Rego, N, Claro, J, "Supply chain flows and stocks as entry points for cyber-risks", Procedia Computer Science, vol.181, pp.261-268, 2021
2. Sá, S, Morais, J, Almeida, F, "The Identification of Emotional Intelligence Skills in Higher Education Students with WebQDA", Advances in Intelligent Systems and Computing - Computer Supported Qualitative Research, pp.45-55, 2021
3. Simoes, AC, Rodrigues, JC, Ribeiro, S, "Impacts on business models resulting from digitalization", 2021 IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2021 - Proceedings, 2021

Books

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Chapter/Paper in Books

1. Almeida, F, Adão, D, Martins, C, "Decision Support System for Assigning Members to Agile Teams", Research Anthology on Decision Support Systems and Decision Management in Healthcare, Business, and Engineering, pp.658-677, 2021
2. Almeida, F, Buzády, Z, "Learning Entrepreneurship in Higher Education Through Flow Theory and FLIGBY Game", Research Anthology on Business and Technical Education in the Information Era, pp.475-491, 2021
3. Almeida, F, Monteiro, JA, "Good Practices in E-Government Accessibility", Encyclopedia of Information Science and Technology, Fifth Edition - Advances in Information Quality and Management, pp.1513-1525, 2021
4. Almeida, F, Simões, J, "Evaluation of the Player's Performance in Entrepreneurship Serious Games", Practical Perspectives on Educational Theory and Game Development - Advances in Educational Technologies and Instructional Design, pp.148-170, 2021
5. Cunha, A, Almeida, F, "Proposal of a Technological Platform to Support the Activities of a Charity Organization", Advances in Human and Social Aspects of Technology - Ubiquitous Technologies for Human Development and Knowledge Management, pp.143-163, 2021
6. Espinheira, E, Almeida, F, "From Management 1.0 to Management 3.0 and Beyond", Effective Strategies for Communicating Insights in Business - Advances in Human Resources Management and Organizational Development, pp.32-52, 2021
7. Lourenço, J, Almeida, F, "The Impact of Emergent Technologies in the Evolutionary Path for M-Commerce", Research Anthology on E-Commerce Adoption, Models, and Applications for Modern Business, pp.824-844, 2021
8. Low-Choy, S, Almeida, F, Rose, J, "Combining study findings by using multiple literature review techniques and meta-analysis", Secondary Research Methods in the Built Environment, pp.207-220, 2021
9. Miranda, H, Almeida, F, "Municipal Solid Waste Management Using an Inclusive Technological Platform", Handbook of Research on Novel Practices and Current Successes in Achieving the Sustainable Development Goals - Practice, Progress, and Proficiency in Sustainability, pp.137-157, 2021
10. Santos, JD, Castelo, JP, Almeida, F, "Critical Success Factors in a Six-dimensional Model CRM Strategy", Encyclopedia of Organizational Knowledge, Administration, and Technology - Advances in Logistics, Operations, and Management Science, pp.2104-2117, 2021
11. Simões, AC, Rodrigues, JC, Soares, AL, "Challenges in Managing Large-Scale Collaborative R&D Projects", Contributions to Management Science, pp.237-251, 2021

Publications (Editor)

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Dissertations (PhD)

1. Pacheco, R., “Essays at the intersection of wildfire management and environmental policy: state of the art in mediterranean-climate regions, and impacts and synergies in Portugal”

10.10 CSIG - ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	13	14	11	-3
		Academic Staff	25	27	27	0
		Grant Holders and Trainees	46	42	43	1
		Total Core Researchers	**84**	**83**	**81**	**-2**
		Total Core PhD	**29**	**32**	**31**	**-1**
	Affiliated Researchers		19	17	16	-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	**104**	**101**	**98**	**-3**
		Total Integrated PhD	**48**	**49**	**47**	**-2**

Table 10.10.2 - CSIG – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes - FCT	366	294	221	-73
PN-PICT	National R&D Programmes - S&T Integrated Projects	48			
PN-COOP	National Cooperation Programmes with Industry	68	45	98	53
PUE-FP	EU Framework Programmes	371	443	786	342
PUE-DIV	EU Cooperation Programmes - Other	49	34	45	11
SERV-NAC	R&D Services and Consulting - National	273	293	354	61
SERV-INT	R&D Services and Consulting - International	16	31	26	-5
OP	Other Funding Programmes	110	55	6	-48
Closed Projects		13			
	Total Funding	**1 314**	**1 194**	**1 535**	**341**

Table 10.10.3 - CSIG - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	41	56	45
Indexed Conferences	117	78	79
Books	1	0	0
Book Chapters	3	2	6
Concluded PhD Theses - Members	1	8	2
Concluded PhD Theses – Supervised	1	20	18

Table 10.10.4 - CSIG - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	0	0	2
Software copyright registrations at IGAC	0	0	1
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	1	1	3
Granted patents	0	0	0
Commercial contracts – Licenses and Assignments	0	0	0
Spin-offs established	0	0	0
Spin-offs in development	0	0	0

Table 10.10.5 - CSIG - Summary of dissemination activities

Type of Activity	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	17	10	14
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	26	24	78
International events in which INESC TEC members participate in the program committees	70	44	24
Participation in events such as fairs, exhibitions or similar	11	9	5
Conferences, workshops and scientific sessions organised by the Centre	2	5	10
Participants in the conferences, workshops and scientific sessions organised by the Centre	410	210	989
Advanced training courses organised by the Centre	0	3	0

Table 10.10.6 – CSIG - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	WindScanner	João Correia Lopes	23/10/2017	22/10/2021
PN-FCT	MoST	Alexandre Carvalho	01/06/2018	30/11/2021
PN-FCT	PAINTER	Rui Pedro Rodrigues	01/07/2018	31/03/2022
PN-FCT	M2S	António Coelho	01/07/2018	30/06/2022
PN-FCT	PromoTourVR	Maximino Bessa	26/07/2018	25/04/2022
PN-FCT	SCReLProg	Leonel Morgado	01/10/2018	30/09/2022
PN-FCT	Wex-Atlantic	João Barroso	20/07/2018	31/10/2022
PN-FCT	EPISA	Carla Lopes	01/01/2019	31/12/2022
PN-FCT	WalkingPAD	Hugo Paredes	11/11/2019	10/11/2022
PN-FCT	FronTowns	Leonel Morgado	20/03/2021	19/03/2024
PN-COOP	FDControlo-1	Lino Oliveira	02/01/2018	30/06/2022
PN-COOP	INFRAVINI	Lino Oliveira	01/07/2019	31/12/2021
PN-COOP	NEWSAT	Susana Alexandra Barbosa	30/06/2020	30/06/2023
PN-COOP	INCAFO-1	Lino Oliveira	31/08/2020	30/06/2023
PN-COOP	SIGIPRO	Lino Oliveira	02/01/2021	02/01/2023
PN-COOP	VitalPROVID-1	Artur Rocha	31/08/2020	31/12/2021
PN-COOP	InOlive	Lino Oliveira	01/09/2021	30/06/2023
PUE-DIV	RADARONRAIA	Lino Oliveira	01/01/2018	31/07/2022
PUE-DIV	TraceRadon	Susana Alexandra Barbosa	01/06/2020	31/05/2023
PUE-DIV	LifeSkillsVR	Leonel Morgado	01/05/2021	30/04/2023
PUE-FP	RECAP	Artur Rocha	01/01/2017	30/09/2021
PUE-FP	MELOA	Artur Rocha	01/12/2017	28/02/2022
PUE-FP	InteGrid-2	António Gaspar	01/01/2017	31/10/2020
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
PUE-FP	Inno4Vac	Artur Rocha	01/09/2021	28/02/2027
PUE-FP	REDVILE-2	António Coelho	01/01/2021	31/12/2021
PUE-FP	PAFSE	Paulo Martins	01/09/2021	31/08/2024
PUE-FP	COL4INDLOG	Paulo Melo	01/05/2021	31/12/2021
SERV-NAC	VRTrainingIndustry	Leonel Morgado	13/02/2019	30/09/2021
SERV-NAC	SIGMAIA2	Ricardo Henriques	30/07/2019	30/01/2022
SERV-NAC	SIFOREST	José Correia	20/12/2019	28/10/2020
SERV-NAC	TRIMAPSTRACK	Lino Oliveira	06/01/2020	31/12/2021
SERV-NAC	DigCore	José Correia	11/05/2020	19/04/2021
SERV-NAC	Regulam2ITSUrb	José Correia	01/09/2020	31/12/2021
SERV-NAC	PGDADOS	José Correia	01/09/2020	31/10/2021
SERV-NAC	MobData4Urb	José Correia	28/02/2021	25/06/2021
SERV-NAC	FREND	Lino Oliveira	01/02/2021	30/09/2021
SERV-NAC	CholdaDigital	Lino Oliveira	17/06/2021	28/02/2022
SERV-NAC	Data4CiMob	José Correia	15/06/2021	15/12/2021
SERV-NAC	ARQNET3	José Correia	10/07/2021	10/01/2023

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	CoolBizDOC	José Correia	01/10/2021	01/03/2022
SERV-NAC	COLOGISTICS	Lino Oliveira	01/12/2021	01/07/2022
SERV-NAC	PFAI4_v2-4	António Coelho	15/05/2021	25/12/2021
SERV-INT	MBSERVMAINTENANCE	José Pedro Ornelas	20/12/2019	30/09/2021
SERV-INT	Boozebuster	José Pedro Ornelas	01/05/2021	30/06/2022
SERV-INT	PORT XXI-1	Lino Oliveira	15/11/2020	31/01/2022
OP	HDR4RTT	Maximino Bessa	30/09/2016	30/09/2020

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. Arandas, L, Gomes, JA, Penha, R, "Akson, an Audiovisual Environment for Networked Interaction and Performance", Journal of Science and Technology of the Arts, vol.13, pp.142-158, 2021
2. Barros, C, Rocio, V, Sousa, A, Paredes, H, "Task scheduling in the fog computing paradigm: Proposal of a context-aware model and evaluation of its performance [Escalonamento de pedidos no paradigma fog computing: Proposta de um modelo sensível ao contexto e avaliação do seu desempenho]", RISTI - Revista Iberica de Sistemas e Tecnologias de Informacao, vol.42, pp.93-119, 2021
3. Bastardo, R, Martins, AI, Pavao, J, Silva, AG, Rocha, NP, "Methodological Quality of User-Centered Usability Evaluation of Ambient Assisted Living Solutions: A Systematic Literature Review", International Journal of Environmental Research And Public Health, vol.18, pp.11507, NOV, 2021
4. Coelho, A, Iria, J, Soares, F, "Network-secure bidding optimization of aggregators of multi-energy systems in electricity, gas, and carbon markets", Applied Energy, vol.301, pp.117460, 2021
5. Coelho, H, Melo, M, Barbosa, L, Martins, J, Teixeira, MS, Bessa, M, "Authoring tools for creating 360 multisensory videos—Evaluation of different interfaces", Expert Systems, pp.e12418, 2021
6. Correia, L, Fuentes, D, Ribeiro, J, Costa, N, Reis, A, Rabadao, C, Barroso, J, Pereira, A, "Usability of Smartbands by the Elderly Population in the Context of Ambient Assisted Living Applications", ELECTRONICS, vol.10, pp.1617, JUL, 2021
7. Cunha, B, Madureira, A, Fonseca, B, Matos, J, "Intelligent Scheduling with Reinforcement Learning", APPLIED SCIENCES-BASEL, vol.11, pp.3710, APR, 2021
8. da Silva, DQ, dos Santos, FN, Sousa, AJ, Filipe, V, "Visible and Thermal Image-Based Trunk Detection with Deep Learning for Forestry Mobile Robotics", Journal of Imaging, vol.7, pp.176, 2021
9. da Silva, DQ, dos Santos, FN, Sousa, AJ, Filipe, V, Boaventura Cunha, J, "Unimodal and Multimodal Perception for Forest Management: Review and Dataset", COMPUTATION, vol.9, pp.127, DEC, 2021
10. Devezas, JL, Nunes, S, "Managing research the wiki way", XRDS, vol.27, pp.10-11, 2021
11. Diogo, CC, Fonseca, B, de Almeida, FSM, da Costa, LM, Pereira, JE, Filipe, V, Couto, PA, Geuna, S, Armada da Silva, PA, Mauricio, AC, Varejao, ASP, "Two-dimensional and three-dimensional techniques for determining the kinematic patterns for hindlimb obstacle avoidance during sheep locomotion", CIENCIA RURAL, vol.51, 2021

12. Fdez Arroyabe, P, Kourtidis, K, Haldoupis, C, Savoska, S, Matthews, J, Mir, LM, Kassomenos, P, Cifra, M, Barbosa, S, Chen, XM, Dragovic, S, Consoulas, C, Hunting, ER, Robert, D, van der Velde, OA, Apollonio, F, Odzimek, A, Chilingarian, A, Roye, D, Mkrtchyan, H, Price, C, Bor, J, Oikonomou, C, Birsan, MV, Crespo Facorro, B, Djordjevic, M, Salcines, C, Lopez Jimenez, A, Donner, RV, Vana, M, Pedersen, JOP, Vorenhout, M, Rycroft, M, "Glossary on atmospheric electricity and its effects on biology", International Journal of Biometeorology, 2021

13. Fuentes, D, Correia, L, Costa, N, Reis, A, Barroso, J, Pereira, A, "SAR.IoT: Secured augmented reality for IoT devices management", Sensors, vol.21, pp.6001, 2021

14. Fuentes, D, Correia, L, Costa, N, Reis, A, Ribeiro, J, Rabadao, C, Barroso, J, Pereira, A, "IndoorCare: Low-Cost Elderly Activity Monitoring System through Image Processing", SENSORS, vol.21, pp.6051, SEP, 2021

15. Garcia, KD, de Sa, CR, Poel, M, Carvalho, T, Mendes Moreira, J, Cardoso, JMP, de Carvalho, ACPLF, Kok, JN, "An Ensemble of Autonomous Auto-Encoders for Human Activity Recognition", Neurocomputing, 2021

16. Gauhar, A, Rashid, A, Hasan, O, Bispo, J, Cardoso, JMP, "Formal verification of Matrix based MATLAB models using interactive theorem proving", PeerJ Computer Science, vol.7, pp.1-21, 2021

17. Goncalves, G, Monteiro, P, Coelho, H, Melo, M, Bessa, M, "Systematic Review on Realism Research Methodologies on Immersive Virtual, Augmented and Mixed Realities", IEEE Access, vol.9, pp.89150-89161, 2021

18. Guerra, E, Dias, AD, Veras, LGDO, Aguiar, A, Choma, J, Da Silva, TS, "A Model to Enable the Reuse of Metadata-Based Frameworks in Adaptive Object Model Architectures", IEEE Access, vol.9, pp.85124-85143, 2021

19. Guo, WK, Vanhoucke, M, Coelho, J, Luo, JY, "Automatic detection of the best performing priority rule for the resource-constrained project scheduling problem", Expert Systems with Applications, pp.114116, 2021

20. Lago, AS, Dias, JP, Ferreira, HS, "Managing Non-Trivial Internet-of-Things Systems with Conversational Assistants: A Prototype and a Feasibility Experiment", Journal of Computational Science, pp.101324, 2021

21. Macedo, N, Cunha, A, Pereira, J, Carvalho, R, Silva, R, Paiva, ACR, Ramalho, MS, Silva, D, "Experiences on teaching alloy with an automated assessment platform", Science of Computer Programming, pp.102690, 2021

22. Magalhaes, M, Melo, M, Bessa, M, Coelho, AF, "The Relationship Between Cybersickness, Sense of Presence, and the Users' Expectancy and Perceived Similarity Between Virtual and Real Places", IEEE Access, vol.9, pp.79685-79694, 2021

23. Marto, A, Melo, M, Goncalves, A, Bessa, M, "Development and Evaluation of an Outdoor Multisensory AR System for Cultural Heritage", IEEE ACCESS, vol.9, pp.16419-16434, 2021

24. Monteiro, P, Goncalves, G, Coelho, H, Melo, M, Bessa, M, "GestOnHMD: Enabling Gesture-based Interaction on Low-cost VR Head-Mounted Display", IEEE Transactions on Visualization and Computer Graphics, Vol.27, Pp.2702-2713, May, 2021

25. Monteiro, P, Goncalves, G, Coelho, H, Melo, M, Bessa, M, "Hands-free interaction in immersive virtual reality: A systematic review", IEEE Transactions on Visualization and Computer Graphics, pp.1-1, 2021

26. Monteiro, P, Melo, M, Valente, A, Vasconcelos Raposo, J, Bessa, M, "Delivering Critical Stimuli for Decision Making in VR Training: Evaluation Study of a Firefighter Training Scenario", IEEE Transactions on Human-Machine Systems, pp.1-10, 2021

27. Mukherjee, R, Bessa, M, Melo Pinto, P, Chalmers, A, "Object Detection Under Challenging Lighting Conditions Using High Dynamic Range Imagery", IEEE Access, vol.9, pp.77771-77783, 2021

28. Narciso, D, Melo, M, Rodrigues, S, Cunha, JP, Vasconcelos Raposo, J, Bessa, M, "A systematic review on the use of immersive virtual reality to train professionals", MULTIMEDIA TOOLS AND APPLICATIONS, 2021

29. Paulino, N, Bispo, J, Ferreira, JC, Cardoso, JMP, "A Binary Translation Framework for Automated Hardware Generation", IEEE Micro, pp.1-1, 2021

30. Pavlovic, M, Scheffer, L, Motwani, K, Kanduri, C, Kompova, R, Vazov, N, Waagan, K, Bernal, FLM, Costa, AA, Corrie, B, Akbar, R, Al Hajj, GS, Balaban, G, Brusko, TM, Chernigovskaya, M, Christley, S, Cowell, LG, Frank, R, Grytten, I, Gundersen, S, Haff, IH, Hovig, E, Hsieh, PH, Klambauer, G, Kuijjer, ML, Lund Andersen, C, Martini, A, Minotto, T, Pensar, J, Rand, K, Riccardi, E, Robert, PA, Rocha, A, Slabodkin, A, Snapkov, I, Sollid, LM, Titov, D, Weber, CR, Widrich, M, Yaari, G, Greiff, V, Sandve, GK, "The immuneML ecosystem for machine learning analysis of adaptive immune receptor repertoires", NATURE MACHINE INTELLIGENCE, vol.3, pp.936-+, NOV, 2021

31. Peixoto, B, Pinto, R, Melo, M, Cabral, L, Bessa, M, "Immersive Virtual Reality for Foreign Language Education: A PRISMA Systematic Review", IEEE ACCESS, vol.9, pp.48952-48962, 2021

32. Pinto, RD, Peixoto, B, Melo, M, Cabral, L, Bessa, M, "Foreign Language Learning Gamification Using Virtual Reality-A Systematic Review of Empirical Research", EDUCATION SCIENCES, vol.11, pp.222, MAY, 2021

33. Ramos, J, Ribeiro, R, Safadinho, D, Barroso, J, Rabadao, C, Pereira, A, "Distributed Architecture for Unmanned Vehicle Services", Sensors, vol.21, pp.1477, 2021

34. Ribeiro, R, Ramos, J, Safadinho, D, Reis, A, Rabadao, C, Barroso, J, Pereira, A, "Web AR Solution for UAV Pilot Training and Usability Testing", Sensors, vol.21, pp.1456, 2021

35. Rocha, A, Costa, A, Oliveira, MA, Aguiar, A, "Handling Privacy Preservation in a Software Ecosystem for the Querying and Processing of Deep Sequencing Data", ERCIM NEWS, vol.2021, pp.18-19, JUL, 2021

36. Rocha, NP, Bastardo, R, Pavao, J, Santinha, G, Rodrigues, M, Rodrigues, C, Queiros, A, Dias, A, "Smart Cities' Applications to Facilitate the Mobility of Older Adults: A Systematic Review of the Literature", APPLIED SCIENCES-BASEL, vol.11, pp.6395, JUL, 2021

37. Rodrigues, R, Matos, T, de Carvalho, AV, Barbosa, JG, Assaf, R, Nóbrega, R, Coelho, A, de Sousa, AA, "Computer Graphics teaching challenges: Guidelines for balancing depth, complexity and mentoring in a confinement context", Graph. Vis. Comput., vol.4, pp.200021, 2021

38. Röttger, A, Röttger, S, Grossi, C, Vargas, A, Curcoll, R, Otáhal, P, Hernández Ceballos, MÁ, Cinelli, G, Chambers, S, Barbosa, SA, Ioan, MR, Radulescu, I, Kikaj, D, Chung, E, Arnold, T, Yver Kwok, C, Fuente, M, Mertes, F, Morosh, V, "New metrology for radon at the environmental level", Measurement Science and Technology, 2021

39. Sequeira, A, Santos, LP, Barbosa, LS, "Quantum Tree-Based Planning", IEEE Access, vol.9, pp.125416-125427, 2021

40. Silva, R, Fonseca, B, Costa, C, Martins, F, "Fostering Computational Thinking Skills: A Didactic Proposal for Elementary School Grades", EDUCATION SCIENCES, vol.11, pp.518, SEP, 2021

41. Soares, F, Madureira, A, Pages, A, Barbosa, A, Coelho, A, Cassola, F, Ribeiro, F, Viana, J, Andrade, J, Dorokhova, M, Morais, N, Wyrsch, N, Sorensen, T, "FEEdBACk: An ICT-Based Platform to Increase Energy Efficiency through Buildings' Consumer Engagement", Energies, vol.14, pp.1524, 2021

42. Vanhoucke, M, Coelho, J, "An analysis of network and resource indicators for resource-constrained project scheduling problem instances", Comput. Oper. Res., vol.132, pp.105260, 2021

43. Vasconcelos Raposo, J, Melo, M, Barbosa, L, Teixeira, C, Cabral, L, Bessa, M, "Assessing presence in virtual environments: adaptation of the psychometric properties of the Presence Questionnaire to the Portuguese populations", Behaviour & Information Technology, pp.1-11, 2021

44. Vaz, R, Freitas, D, Coelho, A, "Visiting museums from the perspective of visually impaired visitors: Experiences and accessibility resources in portuguese museums", International Journal of the Inclusive Museum, vol.14, pp.71-93, 2021

45. Vitali, E, Gadioli, D, Palermo, G, Golasowski, M, Bispo, J, Pinto, P, Martinovic, J, Slaninova, K, Cardoso, JMP, Silvano, C, "An Efficient Monte Carlo-based Probabilistic Time-Dependent Routing Calculation Targeting a Server-Side Car Navigation System", IEEE Transactions on Emerging Topics in Computing, pp.1-1, 2021

International Conference Proceedings with Scientific Referees

1. Aguiar, M, Nunes, S, Giesteirad, B, "A Survey on User Interaction with Linked Data", Proceedings of the Sixth 20th International Semantic Web Conference (ISWC 2021), Virtual Conference, 2021., vol.3023, pp.13-28, 2021
2. Alves S., Da Fonseca M.J.S., Garcia J.E., De Oliveira L.C., Teixeira A., "The omnichannel strategy in portuguese companies: an overview", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021
3. Amorim, E, Ribeiro, A, Santana, BS, Cantante, I, Jorge, A, Nunes, S, Silvano, P, Leal, A, Campos, R, "Brat2Viz: a Tool and Pipeline for Visualizing Narratives from Annotated Texts", Proceedings of Text2Story - Fourth Workshop on Narrative Extraction From Texts held in conjunction with the 43rd European Conference on Information Retrieval (ECIR 2021), Lucca, Italy, April 1, 2021 (online event due to Covid-19 outbreak)., vol.2860, pp.49-56, 2021
4. Araújo, MF, Lopes, CT, "How Can an Archive Be Characterized?", Linking Theory and Practice of Digital Libraries - 25th International Conference on Theory and Practice of Digital Libraries, TPDL 2021, Virtual Event, September 13-17, 2021, Proceedings, vol.12866, pp.118-122, 2021
5. Bastardo, R, Castro, M, Pavão, J, Ramos, L, "A timeline model for clinical events: Empowering data", Procedia Computer Science, vol.196, pp.1053-1058, 2021
6. Bastardo, R, Pavão, J, Martins, AI, Silva, AG, Rocha, NP, "A Scoping Review of Digital Solutions that Might be Used as Cognitive Screening Instruments of Community-Dwelling Older Adults", Procedia Computer Science, vol.196, pp.956-963, 2021
7. Beck, D, Morgado, L, Lee, M, Gutl, C, Dengel, A, Wang, MJ, Warren, S, Richter, J, "Towards an Immersive Learning Knowledge Tree - a Conceptual Framework for Mapping Knowledge and Tools in the Field", 2021 7th International Conference of the Immersive Learning Research Network (iLRN), 2021
8. Bernardino, I, Baptista, RJV, De Almeida, JMEB, Mamede, JHPS, "Serious Games for seniors: Learning safe behaviors on the web : Position paper", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021
9. Campaniço, AT, Khanal, S, Paredes, H, Filipe, V, "Worker Support and Training Tools to Aid in Vehicle Quality Inspection for the Automotive Industry", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.432-441, 2021
10. Campos, D, Restivo, A, Ferreira, HS, Ramos, A, "Automatic Program Repair as Semantic Suggestions: An Empirical Study", 14th IEEE Conference on Software Testing, Verification and Validation, ICST 2021, Porto de Galinhas, Brazil, April 12-16, 2021, pp.217-228, 2021
11. Campos, R, Cardoso, JMP, "On Data Parallelism Code Restructuring for HLS Targeting FPGAs", IEEE International Parallel and Distributed Processing Symposium Workshops, IPDPS Workshops 2021, Portland, OR, USA, June 17-21, 2021, pp.144-151, 2021
12. Capela, S, Silva, R, Khanal, SR, Campaniço, AT, Barroso, J, Filipe, V, "Engine labels detection for vehicle quality verification in the assembly line: A machine vision approach", Lecture Notes in Electrical Engineering, vol.695 LNEE, pp.740-751, 2021
13. Carvalho, D, Rocha, T, Martins, P, Barroso, J, "Developing an Application for Teaching Mathematics to Children with Dyscalculia: A Pilot Case Study", Innovative Technologies and Learning - 4th International Conference, ICITL 2021, Virtual Event, November 29 - December 1, 2021, Proceedings, vol.13117, pp.377-386, 2021
14. Cassola, F, Pinto, M, Mendes, D, Morgado, L, Coelho, A, Paredes, H, "A Novel Tool for Immersive Authoring of Experiential Learning in Virtual Reality", IEEE Conference on Virtual Reality and 3D User

Interfaces Abstracts and Workshops, VR Workshops 2021, Lisbon, Portugal, March 27 - April 1, 2021, pp.44-49, 2021

15. Cassola, F, Pinto, M, Mendes, D, Morgado, L, Coelho, A, Paredes, H, "Immersive Authoring of Virtual Reality Training", IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops, VR Workshops 2021, Lisbon, Portugal, March 27 - April 1, 2021, pp.633-634, 2021
16. Chaves, R, Schneider, D, Motta, C, Correia, A, Paredes, H, Caetano, B, de Souza, JM, "Crowdsourcing Urban Narratives for a Post-Pandemic World", 24th IEEE International Conference on Computer Supported Cooperative Work in Design, CSCWD 2021, Dalian, China, May 5-7, 2021, pp.894-900, 2021
17. Correia, A, Fonseca, B, Paredes, H, Chaves, R, Schneider, D, Jameel, S, "Determinants and Predictors of Intentionality and Perceived Reliability in Human-AI Interaction as a Means for Innovative Scientific Discovery", 2021 IEEE International Conference on Big Data (Big Data), Orlando, FL, USA, December 15-18, 2021, pp.3681-3684, 2021
18. Correia, A, Guimaraes, D, Paulino, D, Jameel, S, Schneider, D, Fonseca, B, Paredes, H, "AuthCrowd: Author Name Disambiguation and Entity Matching using Crowdsourcing", 24th IEEE International Conference on Computer Supported Cooperative Work in Design, CSCWD 2021, Dalian, China, May 5-7, 2021, pp.150-155, 2021
19. Correia, A, Paulino, D, Paredes, H, Fonseca, B, Jameel, S, Schneider, D, de Souza, JM, "Scientometric Research Assessment of IEEE CSCWD Conference Proceedings: An Exploratory Analysis from 2001 to 2019", 24th IEEE International Conference on Computer Supported Cooperative Work in Design, CSCWD 2021, Dalian, China, May 5-7, 2021, pp.311-316, 2021
20. Costa C.R., Garcia J.E., Da Fonseca M.J.S., Teixeira A., "Data Analysis in Content Marketing Strategies", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021
21. Costa e Silva, A, Morgado, L, Coelho, A, "Drill-Down Dashboard for Chairing of Online Master Programs in Engineering", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.203-209, 2021
22. Couto, L, Lopes, CT, "Assessing the quality of health-related Wikipedia articles with generic and specific metrics", Companion of The Web Conference 2021, Virtual Event / Ljubljana, Slovenia, April 19-23, 2021., pp.640-647, 2021
23. Couto, L, Lopes, CT, "Equal opportunities in the access to quality online health information? A multi-lingual study on Wikipedia", OpenSym 2021: 17th International Symposium on Open Collaboration, Virtual Event, Spain, September 15-17, 2021, pp.13:1-13:13, 2021
24. Cruz, A, Paredes, H, Martins, P, "A Proposal of a Classification Scheme to a Survey of Augmented Reality for Education and Training", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.519-531, 2021
25. de Almeida, MA, Correia, A, Schneider, D, de Souza, JM, "COVID-19 as Opportunity to Test Digital Nomad Lifestyle", 2021 IEEE 24th International Conference on Computer Supported Cooperative Work in Design (CSCWD), 2021
26. de Souza, JPC, Rocha, LF, Filipe, VM, Boaventura Cunha, J, Moreira, AP, "Low-Cost and Reduced-Size 3D-Cameras Metrological Evaluation Applied to Industrial Robotic Welding Operations", 2021 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), 2021
27. Dias, JP, Restivo, A, Ferreira, HS, "Empowering Visual Internet-of-Things Mashups with Self-Healing Capabilities", 3rd IEEE/ACM International Workshop on Software Engineering Research and Practices for the IoT (SERP4IoT), vol.abs/2103.07395, 2021
28. Esteves, V, Malta, P, Mamede, H, Santos, V, "Information Technologies in Social Entrepreneurship", Smart Innovation, Systems and Technologies, vol.205, pp.441-454, 2021
29. Fernandes, S, "A live environment for inspection and refactoring of software systems", ESEC/FSE 2021 - Proceedings of the 29th ACM Joint Meeting European Software Engineering Conference and Symposium on the Foundations of Software Engineering, pp.1655-1659, 2021

30. Ferreira, J, Mendes, D, Nobrega, R, Rodrigues, R, "Immersive Multimodal and Procedurally-Assisted Creation of VR Environments", IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops, VR Workshops 2021, Lisbon, Portugal, March 27 - April 1, 2021, pp.30-37, 2021

31. Ferreira, JS, Restivo, A, Ferreira, HS, "Automatically Generating Websites from Hand-drawn Mockups", Proceedings of the 16th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, 2021

32. Filipe, V, Teixeira, P, Teixeira, A, "Measuring Plantar Temperature Changes in Thermal Images Using Basic Statistical Descriptors", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12953 LNCS, pp.445-455, 2021

33. Fontes, MM, Pedrosa, D, Araujo, T, Morais, C, Costa, A, Cravino, J, Morgado, L, "Narrative-Driven Immersion and Students' Perceptions in an Online Software Programming Course", 2021 7th International Conference of the Immersive Learning Research Network (iLRN), 2021

34. Freire, M, Nunes, S, Cid, DD, "Analyzing Preconditions to Introduce Internet Voting in Portugal: Insights from the Estonian Model", Proceedings of Ongoing Research, Practitioners, Posters, Workshops, and Projects of the International Conference EGOV-CeDEM-ePart 2021, University of Granada, Spain (Hybrid) 7 - 9 September 2021, vol.3049, pp.37-45, 2021

35. Garcia, JE, Paiva, ACR, Bizoi, AM, "Test Case Generation From Web Usage Information", Procedia Computer Science, vol.181, pp.913-920, 2021

36. Garcia, JE, Pereira, JS, Cairrão, Á, "Social Media Content Marketing Strategy for Higher Education: A Case Study Approach", Marketing and Smart Technologies - Smart Innovation, Systems and Technologies, pp.493-505, 2021

37. Garrido, D, Rodrigues, R, de Sousa, AA, Jacob, J, Silva, DC, "Point Cloud Interaction and Manipulation in Virtual Reality", AIVR 2021: The 5th International Conference on Artificial Intelligence and Virtual Reality, Kumamoto, Japan, July 23 - 25, 2021, pp.15-20, 2021

38. Gomes, AC, Paiva, ACR, da Silva, AR, "Generating Test Cases from Use Cases and Structured Scenarios: Experiences with the RSL Language", Information Systems Development: Crossing Boundaries between Development and Operations (DevOps) in Information Systems (ISD2021 Proceedings), Valencia, Spain, September 8-10, 2021., 2021

39. Guimarães, D, Paulino, D, Correia, A, Trigo, L, Brazdil, P, Paredes, H, "Towards a Human-AI Hybrid Framework for Inter-Researcher Similarity Detection", 2nd IEEE International Conference on Human-Machine Systems, ICHMS 2021, Magdeburg, Germany, September 8-10, 2021, pp.1-4, 2021

40. Karimova, Y, Ribeiro, C, David, G, "Institutional Support for Data Management Plans: Five Case Studies", Metadata and Semantic Research - Communications in Computer and Information Science, pp.308-319, 2021

41. Khanal, SR, Amorim, EV, Filipe, V, "Classification of car parts using deep neural network", Lecture Notes in Electrical Engineering, vol.695 LNEE, pp.582-591, 2021

42. Lattke, S, Morgado, L, Afonso, AP, Penicheiro, F, Morgado, L, Moreira, JA, "Work-in-Progress-Immersing E-facilitators in Training: The Perspective of Project FAVILLE - Facilitators of Virtual Learning", 2021 7th International Conference of the Immersive Learning Research Network (iLRN), 2021

43. Losada, N, Jorge, F, Teixeira, MS, Melo, M, Bessa, M, "Could Virtual Reality Substitute the 'Real' Experience? Evidence from a UNESCO World Heritage Site in Northern Portugal", Smart Innovation, Systems and Technologies, vol.209, pp.153-161, 2021

44. Magalhaes, C, Ribeiro, J, Leite, A, Pires, EJS, Pavao, J, "Automatic Fall Detection Using Long Short-Term Memory Network", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12861 LNCS, pp.359-371, 2021

45. Martins, J, Moreira, F, Yong Oliveira, MA, Gonçalves, R, Branco, F, "Digitally Monitoring Thermalism Health and Wellness Effects - A Conceptual Model Proposal", Trends and Applications in Information

Systems and Technologies - Volume 4, WorldCIST 2021, Terceira Island, Azores, Portugal, 30 March - 2 April, 2021., vol.1368, pp.411-421, 2021

46. Melo, M, Gonçalves, G, Narciso, D, Bessa, M, "Impact of Different Role Types and Gender on Presence and Cybersickness in Immersive Virtual Reality Setups", International Conference on Graphics and Interaction, ICGI 2021, Porto, Portugal, November 4-5, 2021, pp.1-8, 2021
47. Miranda, P, Faria, JP, Correia, FF, Fares, A, Graça, R, Moreira, JM, "An analysis of Monte Carlo simulations for forecasting software projects", SAC '21: The 36th ACM/SIGAPP Symposium on Applied Computing, Virtual Event, Republic of Korea, March 22-26, 2021, pp.1550-1558, 2021
48. Morais, C, Pedrosa, D, Rocio, V, Cravino, J, Morgado, L, "Using BPMN to Identify Indicators for Teacher Intervention in Support of Self-regulation and Co-regulation of Learning in Asynchronous e-learning", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.210-222, 2021
49. Nunes, PS, Martins, P, Catarino, P, "The Use of Kahoot, GeoGebra and Texas Ti-Nspire Educational Software's in the Teaching of Geometry and Measurement", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.21-31, 2021
50. Nunes, RR, Cruz, G, Pedrosa, D, Maia, AM, Morgado, L, Paredes, H, Cravino, J, Martins, P, "Motivating Students to Learn Computer Programming in Higher Education: The SimProgramming Approach", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.506-518, 2021
51. Paredes, H, Paulino, D, Barroso, J, Abrantes, C, Machado, I, Silva, I, "Supervised physical exercise therapy of peripheral artery disease patients: M-health challenges and opportunities", Proceedings of the 54th Hawaii International Conference on System Sciences, 2021
52. Paulino, D, Correia, A, Barroso, J, Liberato, M, Paredes, H, "Using Expert Crowdsourcing to Annotate Extreme Weather Events", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.522-532, 2021
53. Peixoto, B, Melo, M, Cabral, L, Bessa, M, "Evaluation of Animation and Lip-Sync of Avatars, and User Interaction in Immersive Virtual Reality Learning Environments", International Conference on Graphics and Interaction, ICGI 2021, Porto, Portugal, November 4-5, 2021, pp.1-7, 2021
54. Pinheiro, CR, Guerreiro, S, Mamede, HS, "Automation of Enterprise Architecture Discovery based on Event Mining from API Gateway logs: State of the Art", 2021 IEEE 23rd Conference on Business Informatics (CBI), 2021
55. Pinho, F, Nóbrega, R, Rodrigues, R, "Immersive Adventure Games Development using 360-degree video", International Conference on Graphics and Interaction, ICGI 2021, Porto, Portugal, November 4-5, 2021, pp.1-8, 2021
56. Pintado E., de Oliveira L.C., Garcia J.E., "ENHANCING ENVIRONMENTAL SUSTAINABILITY AND E-COMMERCE DELIVERIES THROUGH THE USE OF EPP BOXES IN A DARKSTORE", Proceedings of the 16th International Symposium on Operational Research in Slovenia, SOR 2021, pp.345-350, 2021
57. Pinto, P, Cardoso, JMP, "A methodology and framework for software memoization of functions", CF '21: Computing Frontiers Conference, Virtual Event, Italy, May 11-13, 2021, pp.93-101, 2021
58. Pinto, RD, Monteiro, P, Melo, M, Cabral, L, Bessa, M, "Does gamification in virtual reality improve second language learning?", International Conference on Graphics and Interaction, ICGI 2021, Porto, Portugal, November 4-5, 2021, pp.1-8, 2021
59. Rocha, T, Barroso, J, "PLAY for LEARNING: Serious Games to Assist Learning of Basic Didactic Concepts: A Pilot Study", HCI in Games: Serious and Immersive Games - Third International Conference, HCI-Games 2021, Held as Part of the 23rd HCI International Conference, HCII 2021, Virtual Event, July 24-29, 2021, Proceedings, Part II, vol.12790, pp.62-71, 2021

60. Rudenko, R, Reis, A, Sousa, J, Barroso, J, "Visualization of Scientific Phenomena for Education", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.451-459, 2021

61. Russo, N, Reis, L, Silveira, C, Mamede, HS, "Framework for designing Business Continuity - Multidisciplinary Evaluation of Organizational Maturity", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021

62. Salgueiro, PA, Mamede, HS, "Which factors influence the adoption of online self-service technologies by B2B customers of a Telecom?", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021

63. Santos, B, Rodrigues, N, Costa, P, Coelho, A, "Integration of CAD Models into Game Engines", GRAPP: Proceedings of the 16th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications - VOL. 1: GRAPP, pp.153-160, 2021

64. Santos, T, Paulino, N, Bispo, J, Cardoso, JMP, Ferreira, JC, "On the Performance Effect of Loop Trace Window Size on Scheduling for Configurable Coarse Grain Loop Accelerators", International Conference on Field-Programmable Technology, (IC)FPT 2021, Auckland, New Zealand, December 6-10, 2021, pp.1-4, 2021

65. Santos, V, Mamede, H, Silveira, C, Reis, L, "Methodology for Introducing Creativity in Requirements Engineering", Procedia Computer Science, vol.196, pp.27-35, 2021

66. Saraiva, C, Mamede, HS, Silveira, MC, Nunes, M, "Transforming physical enterprise into a remote organisation: Transformation impact: digital tools, processes and people", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021

67. Schneider, D, Correia, A, de Souza, JM, "The Use of Social News Curation to Empower Citizens and Journalists: Findings of A Focus Group Study with Professional Curators", 2021 IEEE 24th International Conference on Computer Supported Cooperative Work in Design (CSCWD), 2021

68. Silva, B, Pires, EJS, Reis, A, de Moura Oliveira, PB, Barroso, J, "Students Drop Out Trends: A University Study", Communications in Computer and Information Science - Technology and Innovation in Learning, Teaching and Education, pp.442-450, 2021

69. Silva, M, Dias, JP, Restivo, A, Ferreira, HS, "A Review on Visual Programming for Distributed Computation in IoT", Computational Science - ICCS 2021 - 21st International Conference, Krakow, Poland, June 16-18, 2021, Proceedings, Part IV, vol.12745, pp.443-457, 2021

70. Silva, M, Dias, JP, Restivo, A, Ferreira, HS, "Visually-defined Real-Time Orchestration of IoT Systems", MobiQuitous 2020 - 17th EAI International Conference on Mobile and Ubiquitous Systems: Computing, Networking and Services, 2021

71. Silva, PF, Bispo, J, Paulino, N, "FPGAs as General-Purpose Accelerators for Non-Experts via HLS: The Graph Analysis Example", International Conference on Field-Programmable Technology, (IC)FPT 2021, Auckland, New Zealand, December 6-10, 2021, pp.1-4, 2021

72. Silveira, C, Santos, V, Reis, L, Mamede, H, "A new Approach to Sustainability and Creativity in Requirements Engineering [Uma nova Abordagem para a Sustentabilidade e Criatividade na Engenharia de Requisitos]", Iberian Conference on Information Systems and Technologies, CISTI, 2021

73. Soares, D, Dias, JP, Restivo, A, Ferreira, HS, "Programming IoT-Spaces: A User-Survey on Home Automation Rules", Computational Science - ICCS 2021 - 21st International Conference, Krakow, Poland, June 16-18, 2021, Proceedings, Part IV, vol.12745, pp.512-525, 2021

74. Sousa A., Faria J.P., Mendes-Moreira J., "An analysis of the state of the art of machine learning for risk assessment in software projects", Proceedings of the International Conference on Software Engineering and Knowledge Engineering, SEKE, vol.2021-July, pp.217-222, 2021

75. Sousa, S, Martins, P, Cravino, J, "Measuring Trust in Technology: A Survey Tool to Assess Users' Trust Experiences", Information Systems Development: Crossing Boundaries between Development and

Operations (DevOps) in Information Systems (ISD2021 Proceedings), Valencia, Spain, September 8-10, 2021., 2021

76. Statham, N, Jacob, J, Fridenfalk, M, Rodrigues, R, "Recreating a TransMedia Architectural Location In-Game via Modular Environment Assets", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.13056 LNCS, pp.377-385, 2021
77. Teixeira, G, Bispo, J, Correia, FF, "Multi-language static code analysis on the LARA framework", Proceedings of the 10th ACM SIGPLAN International Workshop on the State Of the Art in Program Analysis, 2021
78. Vicêncio, D, Silva, H, Soares, S, Filipe, V, Valente, A, "An Intelligent Predictive Maintenance Approach Based on End-of-Line Test Logfiles in the Automotive Industry", Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering - Industrial IoT Technologies and Applications, pp.121-140, 2021
79. Vieira T.D.S., Silva Â., Garcia J.E., Alves W., "Methodological Framework for Measuring Regional Logistics Performance", Proceedings of the 16th International Symposium on Operational Research in Slovenia, SOR 2021, pp.351-356, 2021

Books

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Chapter/Paper in Books

1. Cardoso, P, Peçaibes, V, Giesteira, B, Castro, LCd, "Positive Play", Advances in Medical Technologies and Clinical Practice - Handbook of Research on Solving Modern Healthcare Challenges With Gamification, pp.154-185, 2021
2. Filipe, V, Correia, M, Paredes, H, Pinto, B, Silva, I, Abrantes, C, "Characterization of walking patterns using a smartphone in patients with peripheral arterial disease", Advances and Current Trends in Biomechanics, pp.318-322, 2021
3. Giesteira, B, Silva, J, Sarmento, T, Abreu, P, Restivo, MT, "Carnival Play", Advances in Medical Technologies and Clinical Practice - Handbook of Research on Solving Modern Healthcare Challenges With Gamification, pp.206-242, 2021
4. Gomes, DA, Alves-Pimenta, MS, Ginja, M, Filipe, V, "Predicting Canine Hip Dysplasia in X-Ray Images Using Deep Learning", Communications in Computer and Information Science - Optimization, Learning Algorithms and Applications, pp.393-400, 2021
5. Oliveira Ramos, T, Morais, C, Ribeiro, C, "Evaluating the Quality of an Online Course in Information Literacy Applied to Engineering Students", Handbook of Research on Determining the Reliability of Online Assessment and Distance Learning - Advances in Mobile and Distance Learning, pp.79-117, 2021
6. Roberto Zorzal, E, Sousa, M, Mendes, D, Figueiredo Paulo, S, Rodrigues, P, Jorge, J, Lopes, DS, "A Tool for Collaborative Anatomical Dissection", Human–Computer Interaction Series - Digital Anatomy, pp.41-58, 2021

Publications (Editor)

1. Paiva, ACR, Cavalli, AR, Martins, PV, Castillo, RP, "Quality of Information and Communications Technology - 14th International Conference, QUATIC 2021, Algarve, Portugal, September 8-11, 2021, Proceedings", QUATIC, vol.1439, 2021

Dissertations (PhD)

1. Marques, F., “A mobile gamification app to promote behaviour change on energy consumption of office buildings”
2. Lima, B., “Observability and Controllability in Scenario-based Integration Testing of Time-Constrained Distributed Systems”

10.11 LIAAD – ACTIVITY RESULTS IN 2021

10.11.1 Activity indicators

The following tables present LIAADresearch team composition and evolution and the main indicators of its activity carried out in 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	3	8	8	0
		Academic Staff	22	24	22	-2
		Grant Holders and Trainees	27	25	26	1
		Total Core Researchers	**52**	**57**	**56**	**-1**
		Total Core PhD	**29**	**33**	**29**	**-4**
	Affiliated Researchers		5	7	8	1
	Administrative and Technical	Employees	0	0	1	1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**0**	**0**	**1**	**1**
		Total Integrated HR	**57**	**64**	**65**	**1**
		Total Integrated PhD	**34**	**40**	**37**	**3**

Table 10.11.2 – LIAAD - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes - FCT	229	190	196	6
PN-PICT	National R&D Programmes - S&T Integrated Projects	51			
PN-COOP	National Cooperation Programmes with Industry		38	132	93
PUE-FP	EU Framework Programmes	95	51	83	31
PUE-DIV	EU Cooperation Programmes - Other		1	15	14
SERV-NAC	R&D Services and Consulting - National	141	239	283	44
SERV-INT	R&D Services and Consulting - International		1	8	7
OP	Other Funding Programmes	2	7	22	15
Closed Projects		8			
	Total Funding	**526**	**528**	**739**	**211**

Table 10.11.3 – LIAAD - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	50	42	38
Indexed Conferences	57	32	33
Books	1	0	0
Book Chapters	2	3	5
Concluded PhD Theses - Members	2	4	2
Concluded PhD Theses - Supervised	5	6	4

Table 10.11.4 – LIAAD - Summary of IP technology transfer

Type of Result	2019	2020	2021
Invention disclosures	1	0	1
Software copyright registrations at IGAC	0	0	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	0	0	0
Granted patents	0	0	0
Commercial contracts – Licenses and Assignments	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	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	18	1	6
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	21	11	6
International events in which INESC TEC members participate in the program committees	63	40	36
Participation in events such as fairs, exhibitions or similar	4	6	2
Conferences, workshops and scientific sessions organised by the Centre	16	6	0
Participants in the conferences, workshops and scientific sessions organised by the Centre	500	200	200
Advanced training courses organised by the Centre	1	2	1

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	30/06/2022
PN-FCT	MDG	Alberto Pinto	01/10/2018	30/09/2022
PN-FCT	NITROLIMIT	Luís Torgo	01/10/2018	31/01/2022
PN-FCT	MaLPIS	Paula Brito	01/10/2018	30/09/2022
PN-FCT	FailStopper	Rita Paula Ribeiro	01/12/2018	31/08/2021
PN-FCT	Text2Story	Alípio Jorge	14/11/2019	13/11/2022
PN-COOP	SKORR-1	João Gama	01/09/2018	30/09/2021
PN-COOP	PROMESSA	João Mendes Moreira	01/08/2019	31/07/2022
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
PN-COOP	SIGIPRO-1	João Vinagre	02/01/2021	02/01/2023
PN-COOP	SADCoPQ-1	Ricardo Teixeira Sousa	22/05/2021	30/06/2023
PUE-DIV	XPM	João Gama	01/03/2021	28/02/2023
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
PUE-FP	AI_Sov-1	João Vinagre	01/01/2021	31/12/2021
SERV-NAC	RAMnet	João Gama	03/06/2019	30/09/2021
SERV-NAC	MINE4HEALTH-1	Alípio Jorge	01/01/2020	29/11/2021
SERV-NAC	SLSNA	João Gama	15/02/2020	09/02/2021
SERV-NAC	PAFML	Alípio Jorge	01/03/2020	01/03/2023
SERV-NAC	MetaFLow	Alípio Jorge	01/08/2020	30/04/2021
SERV-NAC	CloudAnalytics4Dams-1	João Vinagre	01/01/2021	15/10/2021
SERV-NAC	SIS-1	João Vinagre	12/02/2021	31/03/2022
SERV-NAC	SSPM-1	João Mendes Moreira	04/02/2021	30/10/2021
SERV-NAC	DigitalBudget_VE	João Vinagre	15/03/2021	31/12/2021
SERV-INT	PORT XXI-2	Nuno Moniz	15/11/2020	31/01/2022
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

International Journals with Scientific Referees

1. Accinelli, E, Martins, F, Muniz, H, Oliveira, BMPM, Pinto, AA, "Firms, technology, training and government fiscal policies: An evolutionary approach", Discrete & Continuous Dynamical Systems - B, vol.0, pp.0, 2021

2. Aminian, E, Ribeiro, RP, Gama, J, "Chebyshev approaches for imbalanced data streams regression models", Data Mining and Knowledge Discovery, 2021

3. Baptista, D, Ferreira, PG, Rocha, M, "Deep learning for drug response prediction in cancer", Briefings in Bioinformatics, 2021

4. Bhanu, M, Mendes Moreira, J, Chandra, J, "Embedding Traffic Network Characteristics Using Tensor for Improved Traffic Prediction", IEEE Transactions on Intelligent Transportation Systems, pp.1-13, 2021

5. Carvalho, T, Faria, P, Antunes, L, Moniz, N, "Fundamental privacy rights in a pandemic state", PLOS ONE, vol.16, 2021

6. Cavadas, B, Leite, M, Pedro, N, Magalhaes, AC, Melo, J, Correia, M, Maximo, V, Camacho, R, Fonseca, NA, Figueiredo, C, Pereira, L, "Shedding light on the african enigma: In vitro testing of homo sapiens-helicobacter pylori coevolution", Microorganisms, vol.9, pp.1-18, 2021

7. Cerveira, A, Pires, EJS, Baptista, J, "Wind Farm Cable Connection Layout Optimization with Several Substations", ENERGIES, vol.14, pp.3615, JUN, 2021

8. Corizzo, R, Ceci, M, Fanaee T, H, Gama, J, "Multi-aspect renewable energy forecasting", Information Sciences, vol.546, pp.701-722, 2021

9. Davari, N, Veloso, B, Costa, GD, Pereira, PM, Ribeiro, RP, Gama, J, "A Survey on Data-Driven Predictive Maintenance for the Railway Industry", SENSORS, vol.21, pp.5739, SEP, 2021

10. de Moraes, MM, Oliveira, B, Afonso, C, Santos, C, Torres, D, Lopes, C, de Miranda, RC, Rauber, F, Antoniazzi, L, Levy, RB, Rodrigues, S, "Dietary Patterns in Portuguese Children and Adolescent Population: The UPPER Project", Nutrients, vol.13, pp.3851, 2021

11. Dias, S, Brito, P, Amaral, P, "Discriminant analysis of distributional data via fractional programming", European Journal of Operational Research, 2021

12. Domingues, MAP, Camacho, R, Rodrigues, PP, "CMIID: A comprehensive medical information identifier for clinical search harmonization in Data Safe Havens", Journal of Biomedical Informatics, vol.114, pp.103669, 2021

13. Etemad, M, Júnior, AS, Etemad, E, Rose, J, Torgo, L, Matwin, S, "SWS: an unsupervised trajectory segmentation algorithm based on change detection with interpolation kernels", GeoInformatica, vol.25, pp.269-289, 2021

14. Garcia, KD, de Sa, CR, Poel, M, Carvalho, T, Mendes Moreira, J, Cardoso, JMP, de Carvalho, ACPLF, Kok, JN, "An Ensemble of Autonomous Auto-Encoders for Human Activity Recognition", Neurocomputing, 2021

15. Gatzioura, A, Vinagre, J, Jorge, AM, Sanchez Marre, M, "A Hybrid Recommender System for Improving Automatic Playlist Continuation", IEEE Transactions on Knowledge and Data Engineering, pp.1-1, 2021

16. Goncalves, C, Cavalcante, L, Brito, M, Bessa, RJ, Gama, J, "Forecasting conditional extreme quantiles for wind energy", Electric Power Systems Research, vol.190, 2021

17. Goncalves, CAO, Camacho, R, Goncalves, CT, Vieira, AS, Diz, LB, Iglesias, EL, "Classification of Full Text Biomedical Documents: Sections Importance Assessment", Applied Sciences, vol.11, pp.2674, 2021

18. Guimaraes, N, Figueira, A, Torgo, L, "Can Fake News Detection Models Maintain the Performance through Time? A Longitudinal Evaluation of Twitter Publications", MATHEMATICS, vol.9, pp.2988, NOV, 2021

19. Guimarães, N, Figueira, A, Torgo, L, "Towards a pragmatic detection of unreliable accounts on social networks", Online Social Networks and Media, vol.24, pp.100152, 2021

20. Homayouni, SM, Fontes, DBMM, "A MILP Model for Energy-Efficient Job Shop Scheduling Problem and Transport Resources", Advances in Production Management Systems. Artificial Intelligence for Sustainable and Resilient Production Systems - IFIP WG 5.7 International Conference, APMS 2021, Nantes, France, September 5-9, 2021, Proceedings, Part I, vol.630, pp.378-386, 2021

21. Loureiro, D, Rezaee, K, Pilehvar, MT, Camacho Collados, J, "Analysis and evaluation of language models for word sense disambiguation", Computational Linguistics, vol.47, pp.387-443, 2021

22. Maharaj, EA, Brito, P, Teles, P, "A test to compare interval time series", International Journal of Approximate Reasoning, 2021

23. Marinho, R, Pessoa, A, Lopes, M, Rosinhas, J, Pinho, J, Silveira, J, Amado, A, Silva, S, Oliveira, B, Marinho, A, Jager Wittenaar, H, "Prevalence of Nutritional Risk at Admission in Internal Medicine Wards in Portugal: The Multicentre Cross-Sectional ANUMEDI Study", ACTA MEDICA PORTUGUESA, vol.34, pp.420-427, JUN, 2021

24. Moniz, N, Cerqueira, V, "Automated Imbalanced Classification via Meta-learning", Expert Systems with Applications, pp.115011, 2021

25. Moniz, N, Monteiro, H, "No Free Lunch in imbalanced learning", Knowledge-Based Systems, vol.227, pp.107222, 2021

26. Morais, P, Ferreira, MJ, Veloso, B, "Improving Student Engagement with Project-Based Learning: A Case Study in Software Engineering", IEEE Revista Iberoamericana de Tecnologias del Aprendizaje-Ieee Rita, vol.16, pp.21-28, FEB, 2021

27. Nogueira, AR, Gama, J, Ferreira, CA, "Causal discovery in machine learning: Theories and applications", Journal of Dynamics & Games, vol.0, pp.0, 2021

28. Oliveira J.H., Renna F., Costa P., Nogueira D., Oliveira C., Ferreira C., Jorge A., Mattos S., Hatem T., Tavares T., Elola A., Rad A., Sameni R., Clifford G.D., Coimbra M.T., "The CirCor DigiScope Dataset: From Murmur Detection to Murmur Classification", CoRR, vol.abs/2108.00813, 2021

29. Oliveira, M, Moniz, N, Torgo, L, Costa, VS, "Biased resampling strategies for imbalanced spatio-temporal forecasting", International Journal of Data Science And Analytics, 2021

30. Oliveira, M, Torgo, L, Costa, VS, "Evaluation Procedures for Forecasting with Spatiotemporal Data", Mathematics, vol.9, pp.691, 2021

31. Poínhos, R, Oliveira, BMPM, Sorokina, A, Franchini, B, Afonso, C, de Almeida, MDV, "An extended version of the MNA-SF increases sensitivity in identifying malnutrition among community living older adults. Results from the PRONUTRISENIOR project", Clinical Nutrition ESPEN, 2021

32. Pratesi M., Campos P., "EMOS reloaded: Unlock the future of education in official statistics with a new partnership with Universities", Statistical Journal of the IAOS, vol.37, pp.825-833, 2021

33. Sarmento, RP, Cardoso, DO, Dearo, K, Brazdil, P, Gama, J, "Text documents streams with improved incremental similarity", Social Network Analysis and Mining, vol.11, pp.113, DEC, 2021

34. Soares, C, Figueiredo, A, Figueiredo, F, "The Subprime Crisis and Its Influence on Public, Private and Financial Sectors in European Countries", Journal of East-West Business, vol.27, pp.92-108, 2021

35. Sousa, CN, Paquete, ARC, Teles, P, Pinto, CMCB, Dias, VFF, Ribeiro, OMPL, Manzini, CSS, Nicole, AG, Souza, LH, Ozen, N, "Investigating the Effect of a Structured Intervention on the Development of Self-Care Behaviors with Arteriovenous Fistula in Hemodialysis Patients", CLINICAL NURSING RESEARCH, pp.105477382097483, 2021

36. Tisljaric, L, Fernandes, S, Caric, T, Gama, J, "Spatiotemporal Road Traffic Anomaly Detection: A Tensor-Based Approach", APPLIED SCIENCES-BASEL, vol.11, pp.12017, DEC, 2021

37. Veloso, B, Gama, J, Malheiro, B, Vinagre, J, "Hyperparameter self-tuning for data streams", Information Fusion, 2021

38. Vinagre, J, Jorge, AM, Rocha, C, Gama, J, "Statistically robust evaluation of stream-based recommender systems", IEEE Transactions on Knowledge and Data Engineering, pp.1-1, 2021

International Conference Proceedings with Scientific Referees

1. Afsar, A, Martins, F, Oliveira, BMPM, Pinto, AA, "Immune Response Model Fitting to CD4$$^+$$ T Cell Data in Lymphocytic Choriomeningitis Virus LCMV infection", Springer Proceedings in Mathematics & Statistics - Modeling, Dynamics, Optimization and Bioeconomics IV, pp.1-10, 2021
2. Amorim, E, Ribeiro, A, Santana, BS, Cantante, I, Jorge, A, Nunes, S, Silvano, P, Leal, A, Campos, R, "Brat2Viz: a Tool and Pipeline for Visualizing Narratives from Annotated Texts", Proceedings of Text2Story - Fourth Workshop on Narrative Extraction From Texts held in conjunction with the 43rd European Conference on Information Retrieval (ECIR 2021), Lucca, Italy, April 1, 2021 (online event due to Covid-19 outbreak)., vol.2860, pp.49-56, 2021
3. Bhattacharjee, M, Kambhampati, HS, Branco, P, Torgo, L, "Active Learning for Imbalanced Domains: the ALOD and ALOD-RE Algorithms", 8th IEEE International Conference on Data Science and Advanced Analytics, DSAA 2021, Porto, Portugal, October 6-9, 2021, pp.1-10, 2021
4. Campos, R, Duque, J, Cândido, T, Mendes, J, Dias, G, Jorge, A, Nunes, C, "Time-Matters: Temporal Unfolding of Texts", Lecture Notes in Computer Science - Advances in Information Retrieval, pp.492-497, 2021
5. Campos, R, Jorge, A, Jatowt, A, Bhatia, S, Finlayson, MA, "The 4th International Workshop on Narrative Extraction from Texts: Text2Story 2021", Lecture Notes in Computer Science - Advances in Information Retrieval, pp.701-704, 2021
6. Carvalho, S, Gomes, EF, "Automatic Identification of Bird Species from Audio", Intelligent Information and Database Systems - 13th Asian Conference, ACIIDS 2021, Phuket, Thailand, April 7-10, 2021, Proceedings, vol.12672, pp.41-52, 2021
7. Carvalho, T, Moniz, N, "The Compromise of Data Privacy in Predictive Performance", Advances in Intelligent Data Analysis XIX - Lecture Notes in Computer Science, pp.426-438, 2021
8. Costa, P, Nogueira, AR, Gama, J, "Modelling Voting Behaviour During a General Election Campaign Using Dynamic Bayesian Networks", Progress in Artificial Intelligence - Lecture Notes in Computer Science, pp.524-536, 2021
9. Davari, N, Veloso, B, Ribeiro, RP, Pereira, PM, Gama, J, "Predictive maintenance based on anomaly detection using deep learning for air production unit in the railway industry", 8th IEEE International Conference on Data Science and Advanced Analytics, DSAA 2021, Porto, Portugal, October 6-9, 2021, pp.1-10, 2021
10. Fares, A, Vasconcelos, F, Moreira, JM, Ferreira, CA, "Predicting Predawn Leaf Water Potential up to Seven Days Using Machine Learning", Progress in Artificial Intelligence - 20th EPIA Conference on Artificial Intelligence, EPIA 2021, Virtual Event, September 7-9, 2021, Proceedings, vol.12981, pp.39-50, 2021
11. Ferreira, P, Ladeiras, J, Camacho, R, "Assessing the Impact of Data Set Enrichment to Improve Drug Sensitivity in Cancer", Practical Applications of Computational Biology & Bioinformatics, 15th International Conference (PACBB 2021), Salamanca, Spain, 6-8 October, 2021., vol.325, pp.74-84, 2021
12. Gama, J, Veloso, B, Aminian, E, Ribeiro, RP, "Current Trends in Learning from Data Streams", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.13147 LNCS, pp.183-193, 2021
13. Gaudreault, JG, Branco, P, Gama, J, "An Analysis of Performance Metrics for Imbalanced Classification", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12986 LNAI, pp.67-77, 2021
14. Guimaraes, N, Figueira, A, Torgo, L, "Profiling Accounts Political Bias on Twitter", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021
15. Jatowt, A, Hung, IC, Färber, M, Campos, R, Yoshikawa, M, "Exploding TV Sets and Disappointing Laptops: Suggesting Interesting Content in News Archives Based on Surprise Estimation", Lecture Notes in

Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12656 LNCS, pp.254-269, 2021

16. Leal, F, Veloso, B, Malheiro, B, Burguillo, JC, "Crowdsourced Data Stream Mining for Tourism Recommendation", Advances in Intelligent Systems and Computing - Trends and Applications in Information Systems and Technologies, pp.260-269, 2021
17. Leite, B, Abdalrahman, A, Castro, J, Frade, J, Moreira, J, Soares, C, "Novelty Detection in Physical Activity", Proceedings of the 13th International Conference on Agents and Artificial Intelligence, ICAART 2021, Volume 2, Online Streaming, February 4-6, 2021., pp.859-865, 2021
18. Miranda, P, Faria, JP, Correia, FF, Fares, A, Graça, R, Moreira, JM, "An analysis of Monte Carlo simulations for forecasting software projects", SAC '21: The 36th ACM/SIGAPP Symposium on Applied Computing, Virtual Event, Republic of Korea, March 22-26, 2021, pp.1550-1558, 2021
19. Muhammad, AR, Aguiar, A, Moreira, JM, "Transportation Mode Detection from GPS data: A Data Science Benchmark study", 24th IEEE International Intelligent Transportation Systems Conference, ITSC 2021, Indianapolis, IN, USA, September 19-22, 2021, vol.2021-September, pp.3726-3731, 2021
20. Neves, TM, Moreira, JM, Rossetti, RJF, "A Data-Driven Simulator for Assessing Decision-Making in Soccer", Progress in Artificial Intelligence - 20th EPIA Conference on Artificial Intelligence, EPIA 2021, Virtual Event, September 7-9, 2021, Proceedings, vol.12981, pp.687-698, 2021
21. Nogueira, AR, Ferreira, CA, Gama, J, Pinto, A, "Generalised Partial Association in Causal Rules Discovery", Progress in Artificial Intelligence - 20th EPIA Conference on Artificial Intelligence, EPIA 2021, Virtual Event, September 7-9, 2021, Proceedings, vol.12981, pp.485-497, 2021
22. Oliveira, J, Nogueira, DM, Renna, F, Ferreira, CA, Jorge, AM, Coimbra, MT, "Do we really need a segmentation step in heart sound classification algorithms?", 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2021, Mexico, November 1-5, 2021, pp.286-289, 2021
23. Oliveira, M, Oliveira, J, Camacho, R, Ferreira, C, "A Multi-spot Murmur Sound Detection Algorithm and Its Application to a Pediatric and Neonate Population", Proceedings of the 14th International Joint Conference on Biomedical Engineering Systems and Technologies, 2021
24. Oliveira, S, Loureiro, D, Jorge, A, "Improving Portuguese Semantic Role Labeling with Transformers and Transfer Learning", 8th IEEE International Conference on Data Science and Advanced Analytics, DSAA 2021, Porto, Portugal, October 6-9, 2021, pp.1-9, 2021
25. Pasquali, A, Campos, R, Ribeiro, A, Santana, BS, Jorge, A, Jatowt, A, "TLS-Covid19: A New Annotated Corpus for Timeline Summarization", Lecture Notes in Computer Science - Advances in Information Retrieval, pp.497-512, 2021
26. Pereira, CS, Veloso, B, Durão, N, Moreira, F, "The influence of technological innovations on international business strategy before and during COVID-19 pandemic", Procedia Computer Science, vol.196, pp.44-51, 2021
27. Seca, D, Moreira, JM, "Benchmark of Encoders of Nominal Features for Regression", Trends and Applications in Information Systems and Technologies - Volume 1, WorldCIST 2021, Terceira Island, Azores, Portugal, 30 March - 2 April, 2021., vol.1365, pp.146-155, 2021
28. Silva, C, da Silva, MF, Rodrigues, A, Silva, J, Costa, VS, Jorge, A, Dutra, I, "Predictive Maintenance for Sensor Enhancement in Industry 4.0", Recent Challenges in Intelligent Information and Database Systems - Communications in Computer and Information Science, pp.403-415, 2021
29. Sousa A., Faria J.P., Mendes-Moreira J., "An analysis of the state of the art of machine learning for risk assessment in software projects", Proceedings of the International Conference on Software Engineering and Knowledge Engineering, SEKE, vol.2021-July, pp.217-222, 2021
30. Tabassum, S, Gama, J, Azevedo, P, Teixeira, L, Martins, C, Martins, A, "Dynamic Topic Modeling Using Social Network Analytics", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12981 LNAI, pp.498-509, 2021

31. Trindade, J, Vinagre, J, Fernandes, K, Paiva, N, Jorge, A, "Partially Monotonic Learning for Neural Networks", Advances in Intelligent Data Analysis XIX - 19th International Symposium on Intelligent Data Analysis, IDA 2021, Porto, Portugal, April 26-28, 2021, Proceedings, vol.12695, pp.12-23, 2021

32. Veloso, B, Caroprese, L, Konig, M, Teixeira, S, Manco, G, Hoos, HH, Gama, J, "Hyper-parameter Optimization for Latent Spaces", Machine Learning And Knowledge Discovery In Databases, ECML PKDD 2021: RESEARCH TRACK, PT III, vol.12977, pp.249-264, 2021

33. Vinagre, J, Jorge, AM, Ghossein, MA, Bifet, A, "ORSUM 2021 - 4th Workshop on Online Recommender Systems and User Modeling", RecSys '21: Fifteenth ACM Conference on Recommender Systems, Amsterdam, The Netherlands, 27 September 2021 - 1 October 2021, pp.792-793, 2021

Books

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Chapter/Paper in Books

1. Baptista, J, Lima, F, Cerveira, A, "Optimization of Wind Turbines Placement in Offshore Wind Farms: Wake Effects Concerns", Communications in Computer and Information Science - Optimization, Learning Algorithms and Applications, pp.102-109, 2021

2. Barros, P, Cerveira, A, Baptista, J, "An Optimization Model for Scheduling of Households Load Profiles Incorporating Electric Vehicles Charging", Advances in Intelligent Systems and Computing - Intelligent Systems Design and Applications, pp.753-763, 2021

3. Campos, R, Pasquali, A, Jatowt, A, Mangaravite, V, Jorge, AM, "Automatic Generation of Timelines for Past-Web Events", The Past Web, pp.225-242, 2021

4. Gonçalves, PCT, Moura, AS, Cordeiro, MNDS, Campos, P, "Medical Social Networks, Epidemiology and Health Systems", Encyclopedia of Information Science and Technology, Fifth Edition - Advances in Information Quality and Management, pp.1827-1838, 2021

5. Veloso, B, Gama, J, Malheiro, B, "Classification and Recommendation With Data Streams", Encyclopedia of Information Science and Technology, Fifth Edition - Advances in Information Quality and Management, pp.675-684, 2021

Publications (Editor)

1. Campos, R, Jorge, AM, Jatowt, A, Bhatia, S, Finlayson, MA, "Proceedings of Text2Story - Fourth Workshop on Narrative Extraction from Texts held in conjunction with the 43rd European Conference on Information Retrieval (ECIR 2021), Lucca, Italy, April 1, 2021 (online event due to Covid-19 outbreak)", Text2Story@ECIR, vol.2860, 2021

2. Soares, C, Torgo, L, "Discovery Science - 24th International Conference, DS 2021, Halifax, NS, Canada, October 11-13, 2021, Proceedings", DS, vol.12986, 2021

Dissertations (PhD)

1. Esteves, F., “O Impacto dos Jogos Digitais na Atratividade de Destinos Turísticos”
2. Nejad, E., “Regime Detection in Sensor Data”

10.12 CRACS – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	1	1	1	0
		Academic Staff	15	17	16	-1
		Grant Holders and Trainees	21	16	19	3
		Total Core Researchers	**37**	**34**	**36**	**2**
		Total Core PhD	**18**	**19**	**17**	**-2**
	Affiliated Researchers		2	1	1	0
	Administrative and Technical	Employees	1	1	0	-1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**1**	**1**	**0**	**-1**
		Total Integrated HR	**40**	**36**	**37**	**1**
		Total Integrated PhD	**19**	**19**	**18**	**-1**

Table 10.12.2 - CRACS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes - FCT	65	16	2	-14
PN-PICT	National R&D Programmes - S&T Integrated Projects	25			
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	70	1		-1
PUE-DIV	EU Cooperation Programmes - Other	15	50	60	10
SERV-NAC	R&D Services and Consulting - National	49	94	35	-59
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes		11	8	-3
Closed Projects		4			
	Total Funding	**229**	**173**	**106**	**-68**

Table 10.12.3 - CRACS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	17	16	38
Indexed Conferences	28	35	21
Books	0	0	0
Book Chapters	2	0	0
Concluded PhD Theses - Members	1	1	5
Concluded PhD Theses - Supervised	1	1	6

Table 10.12.4 – CRACS - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	1	0	0
Software copyright registrations at IGAC	0	0	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	1	3	1
Granted patents	0	0	0
Commercial contracts – Licenses and Assignments	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	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	3	5	18
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2	7	6
International events in which INESC TEC members participate in the program committees	32	43	41
Participation in events such as fairs, exhibitions or similar	1	0	7
Conferences, workshops and scientific sessions organised by the Centre	0	3	2
Participants in the conferences, workshops and scientific sessions organised by the Centre	0	2200	300
Advanced training courses organised by the Centre	0	1	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	14/12/2021
PUE-DIV	FGPE	Ricardo Queirós	01/09/2018	31/05/2021
PUE-DIV	PANDORA	António Pinto	01/12/2020	30/11/2022
PUE-DIV	JuezLTI	Ricardo Queirós	01/05/2021	30/04/2023
PUE-DIV	FGPEPlus	Ricardo Queirós	01/06/2021	31/05/2023
SERV-NAC	EFA-Cloud	Luís Filipe Antunes	01/01/2019	12/02/2021
SERV-NAC	AI4DM	Vítor Santos Costa	01/09/2021	01/05/2022
OP	SBACPAD2020	Miguel Gonçalves Areias	08/09/2020	31/12/2021
OP	ICLP2021	Ricardo Rocha	30/03/2021	31/12/2021

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

10.12.2 List of publications

International Journals with Scientific Referees

1. Alves, S, Wassermann, R, "Preface to special issue: LSFA 2017 and 2018", Mathematical Structures in Computer Science, vol.31, pp.255-256, 2021
2. Andrade, E, Granjal, J, Vilela, JP, Arantes, C, "A Security Gateway for power distribution systems in open networks", Computers & Security, vol.111, pp.102492, DEC, 2021
3. Antunes, M, Silva, C, Marques, F, "An Integrated Cybernetic Awareness Strategy to Assess Cybersecurity Attitudes and Behaviours in School Context", Applied Sciences-Basel, vol.11, pp.11269, DEC, 2021
4. Areias, M, Rocha, R, "On the correctness and efficiency of a novel lock-free hash trie map design", J. Parallel Distributed Comput., vol.150, pp.184-195, 2021
5. Baptista, S, Teixeira, A, Castro, L, Cunha, M, Serrao, C, Rodrigues, A, Duarte, I, "Physician Burnout in Primary Care during the COVID-19 Pandemic: A Cross-Sectional Study in Portugal", Journal of Primary Care and Community Health, vol.12, APR, 2021
6. Brandao, A, Resende, JS, Martins, R, "Hardening cryptographic operations through the use of secure enclaves", Computers and Security, vol.108, 2021
7. Carnaz, G, Nogueira, VB, Antunes, M, "A Graph Database Representation of Portuguese Criminal-Related Documents", INFORMATICS-BASEL, vol.8, pp.37, JUN, 2021
8. Carvalho, T, Faria, P, Antunes, L, Moniz, N, "Fundamental privacy rights in a pandemic state", PLOS ONE, vol.16, 2021
9. Castro, L, Loureiro, M, Henriques, TS, Nunes, I, "Systematic Review of Intrapartum Fetal Heart Rate Spectral Analysis and an Application in the Detection of Fetal Acidemia", Frontiers in Pediatrics, vol.9, 2021
10. Castro, L, Rodrigues, A, "Torus-Breakdown Near a Heteroclinic Attractor: A Case Study", International Journal of Bifurcation And Chaos, vol.31, AUG, 2021

11. Cohen, A, Esfahanizadeh, H, Sousa, B, Vilela, JP, Luis, M, Raposo, D, Michel, F, Sargento, S, Medard, M, "Bringing Network Coding into SDN: Architectural Study for Meshed Heterogeneous Communications", IEEE Communications Magazine, vol.59, pp.37-43, APR, 2021

12. Corte Real, J, Dutra, I, Rocha, R, "Pruning strategies for the efficient traversal of the search space in PILP environments", Knowledge and Information Systems, vol.63, pp.3183-3215, DEC, 2021

13. Cunha, M, Mendes, R, Vilela, JP, "A survey of privacy-preserving mechanisms for heterogeneous data types", Computer Science Review, vol.41, pp.100403, 2021

14. Farhat, J, Brante, G, Souza, RD, Vilela, JP, "On the Secure Spectral Efficiency of URLLC With Randomly Located Colluding Eavesdroppers", IEEE Internet Of Things Journal, vol.8, pp.14672-14682, 2021

15. Ferreira, S, Antunes, M, Correia, ME, "A Dataset of Photos and Videos for Digital Forensics Analysis Using Machine Learning Processing", Data, vol.6, pp.87, 2021

16. Ferreira, S, Antunes, M, Correia, ME, "Exposing Manipulated Photos and Videos in Digital Forensics Analysis", Journal of Imaging, vol.7, pp.102, 2021

17. Filho, T, Fernando, L, Rabelo, M, Silva, S, Santos, C, Ribeiro, M, Grout, IA, Moreira, W, Oliveira, A, "A Standard-Based Internet of Things Platform and Data Flow Modeling for Smart Environmental Monitoring", Sensors, vol.21, pp.4228, 2021

18. Goncalves, JV, Castro, L, Rego, G, Nunes, R, "Burnout Determinants among Nurses Working in Palliative Care during the Coronavirus Disease 2019 Pandemic", International Journal of Environmental Research And Public Health, vol.18, APR, 2021

19. Guimaraes, N, Figueira, A, Torgo, L, "Can Fake News Detection Models Maintain the Performance through Time? A Longitudinal Evaluation of Twitter Publications", MATHEMATICS, vol.9, pp.2988, NOV, 2021

20. Guimarães, N, Figueira, A, Torgo, L, "Towards a pragmatic detection of unreliable accounts on social networks", Online Social Networks and Media, vol.24, pp.100152, 2021

21. Miguel, C, Castro, L, dos Santos, JPM, Serrao, C, Duarte, I, "Impact of COVID-19 on Medicine Lecturers' Mental Health and Emergency Remote Teaching Challenges", International Journal of Environmental Research And Public Health, vol.18, JUL, 2021

22. Moreno, P, Areias, M, Rocha, R, "On the Implementation of Memory Reclamation Methods in a Lock-Free Hash Trie Design", Journal of Parallel and Distributed Computing, 2021

23. Oliveira, M, Moniz, N, Torgo, L, Costa, VS, "Biased resampling strategies for imbalanced spatio-temporal forecasting", International Journal of Data Science and Analytics, 2021

24. Oliveira, M, Torgo, L, Costa, VS, "Evaluation Procedures for Forecasting with Spatiotemporal Data", Mathematics, vol.9, pp.691, 2021

25. Pinto, E, Goncalves, F, Sacarlal, J, Castro, L, Rego, G, "Pain management in cancer patients in the main hospitals in Mozambique", Annals of Palliative Medicine, vol.10, pp.4069-4079, 2021

26. Resende, JS, Magalhaes, L, Brandao, A, Martins, R, Antunes, L, "Towards a Modular On-Premise Approach for Data Sharing", Sensors, vol.21, pp.5805, 2021

27. Ribeiro, M, Henriques, T, Castro, L, Souto, A, Antunes, L, Costa Santos, C, Teixeira, A, "The Entropy Universe", Entropy, vol.23, pp.222, 2021

28. Ribeiro, M, Monteiro Santos, J, Castro, L, Antunes, L, Costa Santos, C, Teixeira, A, Henriques, TS, "Non-linear Methods Predominant in Fetal Heart Rate Analysis: A Systematic Review", FRONTIERS IN MEDICINE, Vol.8, 2021

29. Ribeiro, P, Paredes, P, Silva, MEP, Aparicio, D, Silva, F, "A Survey on Subgraph Counting: Concepts, Algorithms, and Applications to Network Motifs and Graphlets", ACM Computing Surveys, vol.54, pp.28:1-28:36, APR, 2021

30. Rodrigues, L, Riker, A, Ribeiro, M, Both, C, Sousa, F, Moreira, W, Cardoso, K, Oliveira, A, "Flight Planning Optimization of Multiple UAVs for Internet of Things", SENSORS, vol.21, pp.7735, NOV, 2021
31. Rosario Ferreira, N, Guimaraes, V, Costa, VS, Moreira, IS, "SicknessMiner: a deep-learning-driven text-mining tool to abridge disease-disease associations", BMC BIOINFORMATICS, vol.22, pp.482, 2021
32. Serrao, C, Castro, L, Teixeira, A, Rodrigues, AR, Duarte, I, "Resilience in Physicians: Contributions to the Validation of the European Portuguese Version of the Resilience Scale", Acta Medica Portuguesa, vol.34, pp.523-532, 2021
33. Serrao, C, Duarte, I, Castro, L, Teixeira, A, "Burnout and Depression in Portuguese Healthcare Workers during the COVID-19 Pandemic-The Mediating Role of Psychological Resilience", International Journal Of Environmental Research And Public Health, vol.18, pp.1-13, JAN, 2021
34. Silva, A, Gomes, M, Vilela, JP, Harrison, WK, "SDR Proof-of-Concept of Full-Duplex Jamming for Enhanced Physical Layer Security", SENSORS, vol.21, pp.1-15, FEB, 2021
35. Silva, J, Marques, ERB, Lopes, LMB, Silva, F, "Energy-Aware Adaptive Offloading of Soft Real-Time Jobs in Mobile Edge Clouds", Journal of Cloud Computing-Advances Systems and Applications, vol.abs/2102.05504, 2021
36. Silva, VF, Silva, ME, Ribeiro, P, Silva, F, "Time series analysis via network science: Concepts and algorithms", WIREs Data Mining and Knowledge Discovery, 2021
37. Sousa, P, Magalhaes, L, Resende, J, Martins, R, Antunes, L, "Provisioning, authentication and secure communications for iot devices on fiware", Sensors, vol.21, pp.5898, 2021
38. Teixeira, A, Souto, A, Antunes, L, "On Conditional Tsallis Entropy", ENTROPY, vol.23, pp.1427, NOV, 2021

International Conference Proceedings with Scientific Referees

1. Alves, S, Ramos, M, "An ML-style record calculus with extensible records", 37th International Conference on Mathematical Foundations of Programming Semantics, vol.abs/2108.06296, 2021
2. Areias, M, Rocha, R, "Towards an Elastic Lock-Free Hash Trie Design", 20th International Symposium on Parallel and Distributed Computing, ISPDC 2021, Cluj-Napoca, Romania, July 28-30, 2021, pp.9-16, 2021
3. Brandao, A, Mendes, R, Vilela, JP, "Efficient Privacy Preserving Distributed K-Means for Non-IID Data", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol.12695 LNCS, pp.439-451, 2021
4. Coelho, T, Figueira, A, "Covid-19 Impact on Higher Education Institution's Social Media Content Strategy", Lecture Notes in Computer Science, pp.657-665, 2021
5. dos Santos, AF, Leal, JP, "Derzis: A Path Aware Linked Data Crawler", 10th Symposium on Languages, Applications and Technologies, SLATE 2021, July 1-2, 2021, Vila do Conde/Póvoa de Varzim, Portugal., vol.94, pp.2:1-2:12, 2021
6. Ferreira, S, Antunes, M, Correia, ME, "Forensic Analysis of Tampered Digital Photos", Progress in Pattern Recognition, Image Analysis, Computer Vision, and Applications - 25th Iberoamerican Congress, CIARP 2021, Porto, Portugal, May 10-13, 2021, Revised Selected Papers, vol.12702, pp.461-470, 2021
7. Giddens, S, Gomes, MAC, Vilela, JP, Santos, JL, Harrison, WK, "Enumeration of the Degree Distribution Space for Finite Block Length LDPC Codes", IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC 2021), 2021
8. Guimaraes, N, Figueira, A, Torgo, L, "Profiling Accounts Political Bias on Twitter", 2021 16th Iberian Conference on Information Systems and Technologies (CISTI), 2021
9. Hirahara, S, Ilango, R, Loff, B, "Hardness of Constant-round Communication Complexity", Electron. Colloquium Comput. Complex., vol.28, pp.30, 2021
10. Nunes, P, Antunes, M, Silva, C, "Evaluating cybersecurity attitudes and behaviors in Portuguese healthcare institutions", Procedia Computer Science, vol.181, pp.173-181, 2021

11. Paiva, JC, Haraszczuk, A, Queirós, R, Leal, JP, Swacha, J, Kosta, S, "FGPE Gamification Service: A GraphQL Service to Gamify Online Education", Trends and Applications in Information Systems and Technologies - Volume 4, WorldCIST 2021, Terceira Island, Azores, Portugal, 30 March - 2 April, 2021., vol.1368, pp.480-489, 2021
12. Paiva, JC, Queirós, R, Leal, JP, "Mooshak's Diet Update: Introducing YAPExIL Format to Mooshak (Short Paper)", 10th Symposium on Languages, Applications and Technologies, SLATE 2021, July 1-2, 2021, Vila do Conde/Póvoa de Varzim, Portugal., vol.94, pp.9:1-9:7, 2021
13. Paiva, JC, Queirós, R, Leal, JP, Swacha, J, Miernik, F, "An Open-Source Gamified Programming Learning Environment (Short Paper)", Second International Computer Programming Education Conference, ICPEC 2021, May 27-28, 2021, University of Minho, Braga, Portugal., vol.91, pp.5:1-5:8, 2021
14. Pinto, TMS, Vilela, JP, Gomes, MAC, Harrison, WK, "Keyed Polar Coding for Physical-Layer Security without Channel State Information", IEEE International Conference on Communications (ICC 2021), 2021
15. Primo, M, Leal, JP, "Matching User Interfaces to Assess Simple Web Applications (Short Paper)", Second International Computer Programming Education Conference, ICPEC 2021, May 27-28, 2021, University of Minho, Braga, Portugal., vol.91, pp.7:1-7:6, 2021
16. Queirós, R, Paiva, JC, Leal, JP, "Programming Exercises Interoperability: The Case of a Non-Picky Consumer", 10th Symposium on Languages, Applications and Technologies, SLATE 2021, July 1-2, 2021, Vila do Conde/Póvoa de Varzim, Portugal., vol.94, pp.5:1-5:9, 2021
17. Queirós, R, Pinto, M, Terroso, T, "User Experience Evaluation in a Code Playground (Short Paper)", Second International Computer Programming Education Conference, ICPEC 2021, May 27-28, 2021, University of Minho, Braga, Portugal., vol.91, pp.17:1-17:9, 2021
18. Silva, C, da Silva, MF, Rodrigues, A, Silva, J, Costa, VS, Jorge, A, Dutra, I, "Predictive Maintenance for Sensor Enhancement in Industry 4.0", Recent Challenges in Intelligent Information and Database Systems - Communications in Computer and Information Science, pp.403-415, 2021
19. Silva, C, Sousa, B, Vilela, JP, "CROCUS: An Objective Approach for SDN Controllers Security Assessment", Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST, vol.398 LNICST, pp.438-455, 2021
20. Simões, A, Queirós, R, "Experiments on PR-Based Gamification (Short Paper)", Second International Computer Programming Education Conference, ICPEC 2021, May 27-28, 2021, University of Minho, Braga, Portugal., vol.91, pp.16:1-16:10, 2021
21. Soares, J, Fernandez, R, Silva, M, Freitas, T, Martins, R, "ZERMIA - A Fault Injector Framework for Testing Byzantine Fault Tolerant Protocols", Network and System Security - Lecture Notes in Computer Science, pp.38-60, 2021

Books

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Chapter/Paper in Books

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Publications (Editor)

1. Gruschka, N, Coelho Antunes, LF, Rannenberg, K, Drogkaris, P, "Privacy Technologies and Policy - 9th Annual Privacy Forum, APF 2021, Oslo, Norway, June 17-18, 2021, Proceedings", APF, vol.12703, 2021
2. Henriques, PR, Portela, F, Queirós, R, Simões, A, "Second International Computer Programming Education Conference, ICPEC 2021, May 27-28, 2021, University of Minho, Braga, Portugal", ICPEC, vol.91, 2021

3. Queirós, R, Pinto, M, Simões, A, Portela, F, Pereira, MJ, "10th Symposium on Languages, Applications and Technologies, SLATE 2021, July 1-2, 2021, Vila do Conde/Póvoa de Varzim, Portugal", SLATE, vol.94, 2021

Dissertations (PhD)

1. Silva, J., “Adaptive Computation Offloading in Mobile Edge Clouds”
2. Oliveira, M., “Predictive Analytics for Spatio-Temporal Data”
3. Sousa, P., “Privacy Preserving Middleware Platform for IoT”
4. Resende, J., “Security Enhancing Technologies for Cloud-of-Clouds”
5. Silva, J., “Towards Measuring Scientific Impact Using Network Science”

10.13 HASLAB – ACTIVITY RESULTS IN 2021

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 2021 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2021 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			2019	2020	2021	Δ 2020-21
Integrated HR	Core Research Team	Employees	7	9	8	-1
		Academic Staff	16	19	21	2
		Grant Holders and Trainees	30	28	32	4
		Total Core Researchers	**53**	**56**	**61**	**5**
		Total Core PhD	**27**	**26**	**26**	**0**
	Affiliated Researchers		6	6	6	0
	Administrative and Technical	Employees	1	2	2	0
		Grant Holders and Trainees	1	0	0	0
		Total Admin and Tech	**2**	**2**	**2**	**0**
		Total Integrated HR	**61**	**64**	**69**	**5**
		Total Integrated PhD	**33**	**32**	**32**	**0**

Table 10.13.2 - HASLab - Project funding Table

Funding Source		Total Income (k€)			Δ (k€)
		2019	2020	2021	2020-21
PN-FCT	National R&D Programmes - FCT	228	206	252	45
PN-PICT	National R&D Programmes - S&T Integrated Projects	34			
PN-COOP	National Cooperation Programmes with Industry	2	122	217	95
PUE-FP	EU Framework Programmes	452	148	130	-18
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	72	353	459	106
SERV-INT	R&D Services and Consulting - International	113	30	85	55
OP	Other Funding Programmes	249	137	29	-108
Closed Projects		6			
	Total Funding	**1 158**	**997**	**1 173**	**176**

10.13.3 - HASLab - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2019	2020	2021
Indexed Journals	12	14	15
Indexed Conferences	51	40	37
Books	1	0	0
Book Chapters	3	0	1
Concluded PhD Theses - Members	1	2	2
Concluded PhD Theses - Supervised	1	3	2

Table 10.13.4 - HASLab - Summary of technology transfer

Type of Result	2019	2020	2021
Invention disclosures	0	0	3
Software copyright registrations at IGAC	0	0	0
Patent first priority filings (New inventions)	0	0	0
Patent applications (Internationalisation)	0	0	0
Granted patents	0	1	0
Commercial contracts – Licenses and Assignments	0	0	0
Spin-offs established	1	0	0
Spin-offs in development	0	0	0

Table 10.13.5 - HASLab - Summary of participation in dissemination activities

Type of Activity	2019	2020	2021
Participation as principal editor, editor or associated editor in journals	1	3	6
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	6	6	8
International events in which INESC TEC members participate in the program committees	33	32	23
Participation in events such as fairs, exhibitions or similar	8	2	5
Conferences, workshops and scientific sessions organised by the Centre	3	5	4
Participants in the conferences, workshops and scientific sessions organised by the Centre	687	50	125
Advanced training courses organised by the Centre	5	1	2

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	15/10/2021
PN-FCT	DaVinci	Guillermina Cledou	26/07/2018	31/03/2022
PN-FCT	HADES	Manuel Barbosa	01/10/2018	31/03/2022
PN-FCT	MaLPIS-1	Ricardo Morla	01/10/2018	30/09/2022
PN-FCT	PAStor	João Tiago Paulo	01/10/2020	31/12/2021
PN-FCT	ACTPM	João Tiago Paulo	01/10/2020	30/09/2021
PN-FCT	StayAway	José Orlando Pereira	01/04/2020	31/12/2021
PN-FCT	PassCert	José Bacelar Almeida	01/02/2021	30/04/2022
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	InterConnect-2	Fábio André Coelho	01/10/2019	30/09/2023
PUE-FP	CircThread-1	Ana Nunes Alonso	01/06/2021	31/05/2025
PUE-FP	RISC2	António Luís Sousa	01/01/2021	30/06/2023
SERV-NAC	MobileID	Vítor Francisco Fonte	01/10/2019	31/01/2022
SERV-NAC	AppOwl	Ricardo Morla	12/02/2020	25/06/2021
SERV-NAC	IoT4Distribuicao-1	Fábio André Coelho	04/01/2021	31/01/2022
SERV-NAC	ENSCOMP	José Nuno Oliveira	01/09/2020	31/03/2022
SERV-NAC	DigiLightRail	Alcino Cunha	26/10/2020	25/03/2022
SERV-NAC	CloudAnalytics4Dams	Fábio André Coelho	01/01/2021	15/10/2021
SERV-NAC	SIS	Ana Nunes Alonso	12/02/2021	31/03/2022
SERV-NAC	IDigitalEIDPT	Vítor Francisco Fonte	01/12/2020	31/12/2021
SERV-NAC	IDINA	João Marco	20/10/2021	01/09/2024
SERV-INT	ECZK	Manuel Barbosa	21/08/2020	31/12/2021
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

International Journals with Scientific Referees

1. Alam, MI, Halder, R, Pinto, JS, "A deductive reasoning approach for database applications using verification conditions", Journal of Systems and Software, vol.175, MAY, 2021
2. Allahdadi, A, Pernes, D, Cardoso, JS, Morla, R, "Hidden Markov models on a self-organizing map for anomaly detection in 802.11 wireless networks", Neural Computing and Applications, 2021
3. Baquero, C, Casari, P, Anta, AF, Garcia Garcia, A, Frey, D, Garcia Agundez, A, Georgiou, C, Girault, B, Ortega, A, Goessens, M, Hernandez Roig, HA, Nicolaou, N, Stavrakis, E, Ojo, O, Roberts, JC, Sanchez, I,

"The CoronaSurveys System for COVID-19 Incidence Data Collection and Processing", Frontiers In Computer Science, vol.3, pp.641237, 2021

4. Cledou, G, Proenca, J, Sputh, BHC, Verhulst, E, "Hubs for VirtuosoNext: Online verification of real-time coordinators", Science of Computer Programming, pp.102566, 2021
5. Cogo, V, Paulo, J, Bessani, A, "GenoDedup: Similarity-Based Deduplication and Delta-Encoding for Genome Sequencing Data", IEEE Transactions on Computers, pp.1-1, 2021
6. Couto, M, Fernandes, JP, Saraiva, J, "Statically analyzing the energy efficiency of software product lines", Journal of Low Power Electronics and Applications, vol.11, pp.13, 2021
7. Harrison, MD, Masci, P, Campos, JC, "Balancing the formal and the informal in user-centred design", Interact. Comput., vol.33, pp.55-72, 2021
8. Liu, A, Wang, S, Barbosa, LS, Sun, M, "Fuzzy Automata as Coalgebras", Mathematics, vol.9, pp.1-21, FEB, 2021
9. Macedo, N, Cunha, A, Pereira, J, Carvalho, R, Silva, R, Paiva, ACR, Ramalho, MS, Silva, D, "Experiences on teaching alloy with an automated assessment platform", Science of Computer Programming, pp.102690, 2021
10. Menci, SP, Bessa, RJ, Herndler, B, Korner, C, Rao, BV, Leimgruber, F, Madureira, AA, Rua, D, Coelho, F, Silva, JV, Andrade, JR, Sampaio, G, Teixeira, H, Simoes, M, Viana, J, Oliveira, L, Castro, D, Krisper, U, Andre, R, "Functional Scalability and Replicability Analysis for Smart Grid Functions: The InteGrid Project Approach", Energies, vol.14, pp.5685, 2021
11. Neves, F, Vilaca, R, Pereira, J, "Detailed Black-Box Monitoring of Distributed Systems", Applied Computing Review, vol.21, pp.24-36, MAR, 2021
12. Pereira, R, Couto, M, Ribeiro, F, Rua, R, Cunha, J, Fernandes, JP, Saraiva, J, "Ranking programming languages by energy efficiency", Science of Computer Programming, vol.205, pp.102609, 2021
13. Santos, LC, Santos, A, Santos, FN, Valente, A, "A Case Study on Improving the Software Dependability of a ROS Path Planner for Steep Slope Vineyards", Robotics, vol.10, pp.103, 2021
14. Sequeira, A, Santos, LP, Barbosa, LS, "Quantum Tree-Based Planning", IEEE Access, vol.9, pp.125416-125427, 2021
15. Silva, C, Vieira, J, Campos, JC, Couto, R, Ribeiro, AN, "Development and Validation of a Descriptive Cognitive Model for Predicting Usability Issues in a Low-Code Development Platform", Human Factors, 2021

International Conference Proceedings with Scientific Referees

1. Abdalla, M, Barbosa, M, Katz, J, Loss, J, Xu, J, "Algebraic Adversaries in the Universal Composability Framework", Advances in Cryptology - ASIACRYPT 2021 - 27th International Conference on the Theory and Application of Cryptology and Information Security, Singapore, December 6-10, 2021, Proceedings, Part III, vol.13092, pp.311-341, 2021
2. Almeida, JB, Barbosa, M, Correia, ML, Eldefrawy, K, Lengrand, SG, Pacheco, H, Pereira, V, "Machine-checked ZKP for NP relations: Formally Verified Security Proofs and Implementations of MPC-in-the-Head", CCS '21: 2021 ACM SIGSAC Conference on Computer and Communications Security, Virtual Event, Republic of Korea, November 15 - 19, 2021, pp.2587-2600, 2021
3. Barbosa, M, Barthe, G, Bhargavan, K, Blanchet, B, Cremers, C, Liao, K, Parno, B, "SoK: Computer-Aided Cryptography", 42nd IEEE Symposium on Security and Privacy, SP 2021, San Francisco, CA, USA, 24-27 May 2021, pp.777-795, 2021
4. Barbosa, M, Barthe, G, Fan, X, Grégoire, B, Hung, SH, Katz, J, Strub, PY, Wu, X, Zhou, L, "EasyPQC: Verifying Post-Quantum Cryptography", CCS '21: 2021 ACM SIGSAC Conference on Computer and Communications Security, Virtual Event, Republic of Korea, November 15 - 19, 2021, pp.2564-2586, 2021

5. Barbosa, M, Barthe, G, Grégoire, B, Koutsos, A, Strub, PY, "Mechanized Proofs of Adversarial Complexity and Application to Universal Composability", CCS '21: 2021 ACM SIGSAC Conference on Computer and Communications Security, Virtual Event, Republic of Korea, November 15 - 19, 2021, pp.2541-2563, 2021

6. Barbosa, M, Boldyreva, A, Chen, S, Warinschi, B, "Provable Security Analysis of FIDO2", ADVANCES IN CRYPTOLOGY - CRYPTO 2021, PT III, vol.12827, pp.125-156, 2021

7. Barbosa, M, Ferreira, B, Marques, J, Portela, B, Preguica, N, "Secure Conflict-free Replicated Data Types", ICDCN '21: International Conference on Distributed Computing and Networking, Virtual Event, Nara, Japan, January 5-8, 2021., pp.6-15, 2021

8. Baumann, K, Campos, JC, Dix, A, Nigay, L, Palanque, P, Vanderdonckt, J, van der Veer, G, Weyers, B, "HCI-E^{2}: HCI Engineering Education", Human-Computer-Interaction – INTERACT 2021 - Lecture Notes in Computer Science, pp.542-547, 2021

9. Brito, M, Cunha, J, Saraiva, J, "Identification of microservices from monolithic applications through topic modelling", SAC '21: The 36th ACM/SIGAPP Symposium on Applied Computing, Virtual Event, Republic of Korea, March 22-26, 2021, pp.1409-1418, 2021

10. Caldas, R, Novo, C, Morla, R, Cruz, L, Carvalho, A, Campelo, D, "Inferring Legacy IoT Device Behavior over a Layer 2 TLS Tunnel", 5th Cyber Security in Networking Conference, CSNet 2021, Abu Dhabi, United Arab Emirates, October 12-14, 2021, pp.23-30, 2021

11. Campos, JC, Nicholas Graham, TC, Spano, LD, den Bergh, JV, "The Management of Risks and Benefits when Engineering Interactive Digital Systems", EICS '21: ACM SIGCHI Symposium on Engineering Interactive Computing Systems, Virtual Event, The Netherlands, 8-11 June 2021, pp.81-83, 2021

12. Carreira, C, Ferreira, JF, Mendes, A, Christin, N, "Exploring Usable Security to Improve the Impact of Formal Verification: A Research Agenda", Proceedings First Workshop on Applicable Formal Methods, AppFM@FM 2021, virtual, 23rd November 2021., vol.349, pp.77-84, 2021

13. Dantas, M, Leitao, D, Correia, C, Macedo, R, Xu, WJ, Paulo, J, "MONARCH: Hierarchical Storage Management for Deep Learning Frameworks", 2021 IEEE International Conference on Cluster Computing (CLUSTER), 2021

14. Enes, V, Baquero, C, Gotsman, A, Sutra, P, "Efficient replication via timestamp stability", EuroSys '21: Sixteenth European Conference on Computer Systems, Online Event, United Kingdom, April 26-28, 2021, pp.178-193, 2021

15. Faria, A, Macedo, R, Pereira, J, Paulo, J, "BDUS: implementing block devices in user space", SYSTOR '21: The 14th ACM International Systems and Storage Conference, Haifa, Israel, June 14-16, 2021., pp.8:1-8:11, 2021

16. Faria, N, Pereira, J, "Totally-Ordered Prefix Parallel Snapshot Isolation", PaPoC@EuroSys 2021, 8th Workshop on Principles and Practice of Consistency for Distributed Data, Online Event, United Kingdom, April 26, 2021, pp.6:1-6:7, 2021

17. Faria, N, Pereira, J, Alonso, AN, Vilaça, R, "Towards Generic Fine-Grained Transaction Isolation in Polystores", Heterogeneous Data Management, Polystores, and Analytics for Healthcare - VLDB Workshops, Poly 2021 and DMAH 2021, Virtual Event, August 20, 2021, Revised Selected Papers, vol.12921, pp.29-42, 2021

18. Ferreira, D, Paulo, J, Matos, M, "ATOCS: Automatic Configuration of Encryption Schemes for Secure NoSQL Databases", 17th European Dependable Computing Conference, EDCC 2021, Munich, Germany, September 13-16, 2021, pp.67-74, 2021

19. Freitas, F, Ferreira, A, Cunha, J, "Refactoring Java Monoliths into Executable Microservice-Based Applications", SBLP'21: 25th Brazilian Symposium on Programming Languages, Joinville, Brazil, 27 September 2021 - 1 October 2021, pp.100-107, 2021

20. Gião, HD, Cunha, J, Pereira, R, "Linear Programming Meets Block-based Languages", IEEE Symposium on Visual Languages and Human-Centric Computing, VL/HCC 2021, St Louis, MO, USA, October 10-13, 2021, pp.1-3, 2021

21. Hristoskova, A, Deleito, NG, Klein, S, Sousa, J, Martins, N, Tagaio, J, Serra, J, Silva, C, Ferreira, J, Santos, PM, Morla, R, Almeida, L, Bulut, B, Sultanoglu, S, "An Initial Analysis of the Shortcomings of Conventional AI and the Benefits of Distributed AI Approaches in Industrial Use Cases", Artificial Intelligence Applications and Innovations. AIAI 2021 IFIP WG 12.5 International Workshops - 5G-PINE 2021, AI-BIO 2021, DAAI 2021, DARE 2021, EEAI 2021, and MHDW 2021, Hersonissos, Crete, Greece, June 25-27, 2021, Proceedings, vol.628, pp.281-292, 2021

22. Jain, M, Gomes, L, Madeira, A, Barbosa, LS, "Towards a specification theory for fuzzy modal logic", 2021 International Symposium on Theoretical Aspects of Software Engineering (TASE), 2021

23. Jain, M, Gomes, L, Madeira, A, Barbosa, LS, "Towards a specification theory for fuzzy modal logic", International Symposium on Theoretical Aspects of Software Engineering, TASE 2021, Shanghai, China, August 25-27, 2021, pp.175-182, 2021

24. Lima, R, Ferreira, JF, Mendes, A, "Automatic Repair of Java Code with Timing Side-Channel Vulnerabilities", 2021 36th IEEE/ACM International Conference on Automated Software Engineering Workshops (ASEW), 2021

25. Macedo, Jd, Abreu, R, Pereira, R, Saraiva, J, "On the Runtime and Energy Performance of WebAssembly: Is WebAssembly superior to JavaScript yet?", 36th IEEE/ACM International Conference on Automated Software Engineering, ASE 2021 - Workshops, Melbourne, Australia, November 15-19, 2021, pp.255-262, 2021

26. Macedo, R, Correia, C, Dantas, M, Brito, C, Xu, WJ, Tanimura, Y, Haga, J, Paulo, J, "The Case for Storage Optimization Decoupling in Deep Learning Frameworks", 2021 IEEE International Conference on Cluster Computing (CLUSTER), 2021

27. Machado, C, Campos, JC, "Towards the integration of user interface prototyping and model-based development", International Conference on Graphics and Interaction, ICGI 2021, Porto, Portugal, November 4-5, 2021, pp.1-8, 2021

28. Miranda, M, Esteves, T, Portela, B, Paulo, J, "S2Dedup", Proceedings of the 14th ACM International Conference on Systems and Storage, 2021

29. Neves, F, Machado, N, Vilaca, R, Pereira, J, "Horus: Non-Intrusive Causal Analysis of Distributed Systems Logs", 51st Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN 2021), pp.212-223, 2021

30. Novo, C, Silva, JMC, Morla, R, "An Outlook on using Packet Sampling in Flow-based C2 TLS Malware Traffic Detection", 12th International Conference on Network of the Future, NoF 2021, Coimbra, Portugal, October 6-8, 2021, pp.1-5, 2021

31. Pontes, R, Portela, B, Barbosa, M, Vilaca, R, "CODBS: A cascading oblivious search protocol optimized for real-world relational database indexes", 40th International Symposium on Reliable Distributed Systems, SRDS 2021, Chicago, IL, USA, September 20-23, 2021, pp.176-186, 2021

32. Santos, A, Cunha, A, Macedo, N, "The High-Assurance ROS Framework", 3rd IEEE/ACM International Workshop on Robotics Software Engineering, RoSE 2021, vol.abs/2103.01603, 2021

33. Santos, PM, Sousa, J, Morla, R, Martins, N, Tagaio, J, Serra, J, Silva, C, Sousa, M, Souto, PF, Ferreira, LL, Ferreira, J, Almeida, L, "Towards a Distributed Learning Architecture for Securing ISP Home Customers", Artificial Intelligence Applications and Innovations. AIAI 2021 IFIP WG 12.5 International Workshops - 5G-PINE 2021, AI-BIO 2021, DAAI 2021, DARE 2021, EEAI 2021, and MHDW 2021, Hersonissos, Crete, Greece, June 25-27, 2021, Proceedings, vol.628, pp.311-322, 2021

34. Saraiva, J, Zong, Z, Pereira, R, "Bringing Green Software to Computer Science Curriculum: Perspectives from Researchers and Educators", ITiCSE 2021: 26th ACM Conference on Innovation and Technology in Computer Science Education, Virtual Event, Germany, June 26 - July 1, 2021., pp.498-504, 2021

35. Sequeira, A, Santos, LP, Barbosa, LS, "Generalised Quantum Tree Search", 2nd IEEE/ACM International Workshop on Quantum Software Engineering, Q-SE@ICSE 2021, Madrid, Spain, June 1-2, 2021, pp.39-40, 2021
36. Silva, JM, Fonte, V, Sousa, A, "Towards a bottom-up approach to inclusive digital identity systems", ACM International Conference Proceeding Series, pp.523-525, 2021
37. ter Beek, MH, Cledou, G, Hennicker, R, Proença, J, "Featured Team Automata", Formal Methods - 24th International Symposium, FM 2021, Virtual Event, November 20-26, 2021, Proceedings, vol.13047, pp.483-502, 2021

Books

Blank

Chapter/Paper in Books

1. Shoker, A, Yactine, H, "On the feasibility of byzantine agreement to secure fog/edge data management", Advances in Information Security, vol.83, pp.121-143, 2021

Publications (Editor)

1. Ferreira, JF, Mendes, A, Menghi, C, "Formal Methods Teaching – 4th International Workshop and Tutorial, FMTea 2021, Virtual Event, November 21, 2021, Proceedings", FMTea, vol.13122, 2021
2. Harms, KJ, Cunha, J, Oney, S, Kelleher, C, "IEEE Symposium on Visual Languages and Human-Centric Computing, VL/HCC 2021, St Louis, MO, USA, October 10-13, 2021", VL/HCC, 2021

Dissertations (PhD)

1. Neves, F., “Holistic performance and scalability analysis for large-scale distributed systems”
2. Pontes, R., “Trade-offs between privacy and efficiency on databases”