INSTITUTE FOR SYSTEMS
AND COMPUTER ENGINEERING,
TECHNOLOGY AND SCIENCE

INESCTEC

ACTIVITY REPORT // 2022

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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 2022

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EXECUTIVE SUMMARY

With the long tail of the pandemic, the conflict in Ukraine, the acceleration of digital transformation, the growing global competition for highly qualified professionals, an increasing inflation, especially in food and energy, around the world, the last three years have been some of the most challenging in recent memory.

In such a tumultuous year, the worst thing to do would have been to lose heart and retreat from making a difference. On the contrary, our drive did not change, and as the context got more challenging, our community stuck together and sought to embrace all opportunities to explore, grow and bring value to the economy and society at large.

In 2022, the INESC TEC community grew, and so did its activity and its scientific production, while it maintained its track-record in knowledge valorisation and technology transfer, and in scientific dissemination to society.

Jointly with this external commitment, we also endeavoured to look at our organisation and initiate or continue long-term reforms. The in-depth work in our human resources management model proceeded, our Ethics Committee inaugurated its operation, we reformulated our Business Advisory Board and we launched a transversal and purposeful process of elaboration of a strategic plan towards 2030.

Thus, notwithstanding the activities being conditioned by adversities, 2022 was a year of very good results and institutional accomplishments. Overall, INESC TEC implemented the main initiatives planned for 2022, with more or less extensive adaptations depending on the nature of each initiative, and significant new additions, leading to a meaningful increase of 14% in the size of the activity.

At the end of 2022, INESC TEC hosted more than 800 integrated researchers, 360+ with a PhD. The most noticeable evolution in Human Resources was the increase in R&D employees (19%), and the reversal of the decrease in the number of grant holders that had been happening since 2018 because of the new grant holders statute and the Portuguese Government policy for scientific employment.

In scientific terms, we advanced the definition of our managed science model as a means to strengthen the Institution's scientific strategy. The fourth call for Internal Seed Projects, aiming at supporting internal exploratory R&D activity led to the support of four new projects, two in the inter-centre research category and two in junior researcher development. The scientific areas covered extreme learning machines, optical and quantum computing, deep neural networks and biometrics and explainable artificial intelligence.

INESC TEC improved the number of publications in indexed journals, with 465 articles, the institute's main overall publication priority, 68% of which in first quartile journals. The number of INESC TEC researchers that concluded their PhD theses was maitained when compared with the previous year.

INESC TEC reached 23 M€ of income (a 14% increase when compared to the previous year), extending a period of more than a decade of continuous and sustainable growth. In 2022, 45% of its total project funding (95 projects) came from European programmes (37% increase). A most noticeable increase in project activity was also observed in the National Cooperation Programmes with Industry (70%), while the R&D contracts with industry reduced 10%.

Another significant highlight was the launch of the first call of the INESC TEC International Visiting Researcher Programme, which provided the opportunity to 10 researchers from institutions abroad to conduct research activities at INESC TEC for up to three months while maintaining their affiliation with their home institutions. In turn, INESC TEC researchers also participated in international exchange mobility programs, namely with American and Japanese institutions.

As for its contribution to public policies, INESC TEC provided contributions to draft legislation and funding programmes in preparation, participated in twelve Collaborative Laboratories (CoLABs) and it is actively preparing the creation of a new organisational structure to coordinate INESC TEC's contributions to public policy.

Despite these intense research and innovative activities, our initiatives to reach society and promote science did not falter. Our Annual Autumn Forum was dedicated to the issues of climate change and decarbonisation of the economy, in particular those related to energy. The 4th and 5th issues of the magazine "INESC TEC Science & Society", aimed at citizens interested in general knowledge about research, focused on "(R)Evolution in Agro-Food and Forestry" and on "The Energy Transition", respectively.

INESC TEC also became the main shareholder of the company CEO – Companhia da Energia Oceânica, owner of an offshore energy test zone in Aguçadoura, with grid connection (4 MW of power) and capable of supporting the development and testing of marine renewable energy technologies (TRL ~5-8), as well as other multi-purpose marine structures, marine robotics, telecommunications, advanced sensing, collection of ocean and environmental data for model development, among others.

INESC TEC researchers broke the world depth record in the exploration of flooded caves by exploring the world's deepest natural cave, the "Hranice Abyss" (Czech Republic), sending an autonomous underwater vehicle down to 450 metres. The UX-1Neo is one of the most technologically advanced underwater robots in the world, and it was developed by INESC TEC, within the scope of the UNEXUP project, and counted with the collaboration of UNEXMIN Georobotics, one of our spin-offs.

Eventually, the year 2022 will be remembered for its turbulent context and our year's track-record will sum up to our history already three decades long, but the most important contribution will be the teams of researchers and devoted professionals who developed knowledge, ideas, partnerships and innovations to solve the problems of the present and the future.

As we reflect on the past and look at the future, we deeply thank our community, researchers and staff, for making the most of the opportunities created in 2022, and for their unwavering energy and commitment to our purpose.

We remain firm in our conviction that, with science and innovation, we can continue to contribute to improve society, facing all headwinds. Success is a long-term prospect, measured in years and decades, but it starts with actions we take now.

1 INTRODUCTION

This document presents the scientific and technological activities, as well as the results of INESC TEC during 2022.

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 2022, 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 2022.

Section 5 focuses on the TEC4 initiatives, platforms that articulate the activity towards economic and societal impacts, presenting their main achievements in 2022 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 2022, INESC TEC hosted 801 integrated researchers (364 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 and Innovation 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 2022 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).

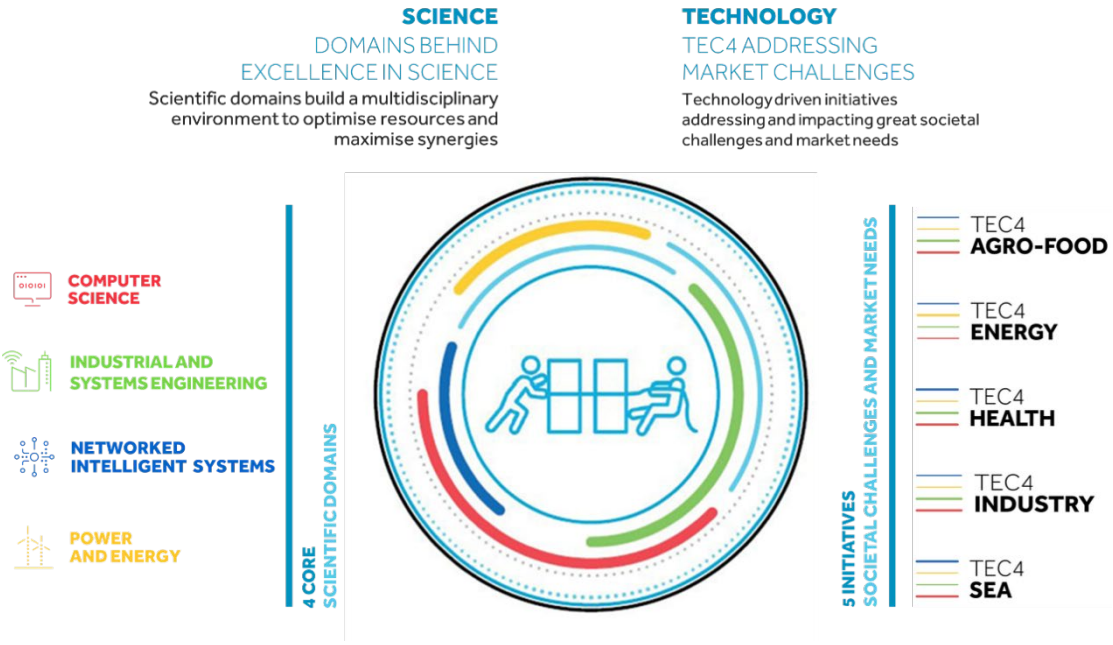


Figure 2.2.2 - Putting pervasive intelligence to work

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.

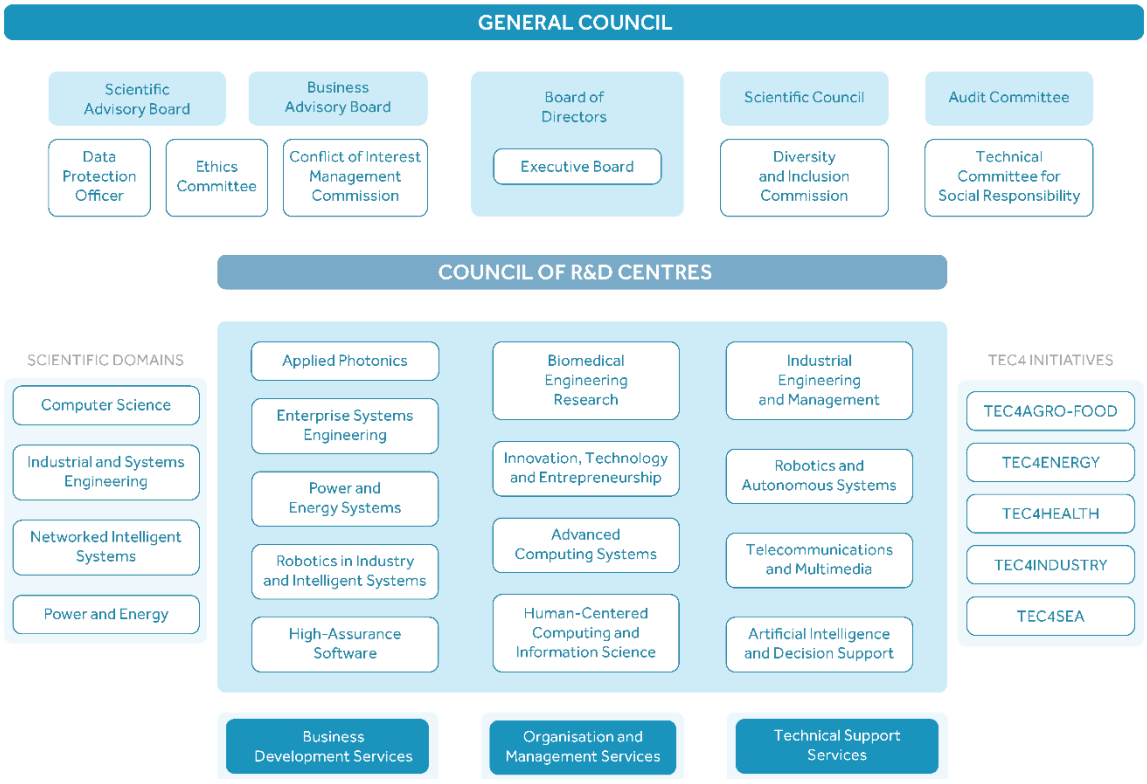


Figure 2.3.1 - Organisational Structure

The Centres are INESC TEC's R&D organisational base 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, currently under strategic redefinition, are meant to structure the institute's research competences and challenges, facilitating strategic thinking, trajectory monitoring, and science communication.

The TEC4 initiatives articulate INESC TEC's activity towards major 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.

The Scientific Advisory Board is since December, composed of twelve internationally recognised scientists that support the institution in its search for continuous improvement and 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 Audit Committee includes a ROC and oversees and validates the financial behaviour of the Institute.

Five non-statutory bodies are in charge of aspects that INESC TEC particularly values. The Ethics Committee ensures the observance and promotion of standards of integrity, honesty and responsibility in research activities carried out by INESC TEC's members, through the implementation of the institution's Code of Ethics. The Conflict of Interest Management Commission (CGCI) 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 Compliance Officer will be responsible for the implementation of the Compliance Programme for the prevention of corruption, in articulation with other relevant organisational units. The Technical Committee for Social Responsibility has as its mission the incorporation of social responsibility in the institution's organisational culture and practices. The Diversity and Inclusion Commission thrives 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 gender balance as a major priority. In this regard, the approval and implementation of the Gender Equality Plan recently approved deserves a special highlight. A new office is being set up 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 – Chairman of the Board of Directors, Strategic leadership, institutional relations, public policies, articulation with the General Council, Public Policies Office, and strategic plan.

João Claro – Vice-president, Chief Executive officer, 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, HumanISE, LIAAD and HASLab, and overseeing of the Services AG, SAS, SIG and SRC. (Co-responsibility with João Claro: coordination of operational management.)

Graça Barbosa - Conflicts of interest management, 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.

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.

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, thus provides an ideal environment for innovators.

The reinforcement of its global dynamics of excellence is a permanent priority for the institution, whose expansion in recent years has required a renewed attention to some of its fundamentals, in particular to human resources management, research careers, and 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 the structures where the diverse activities and personal contributions are balanced under an agreed 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 encounter of different scientific disciplines, certainly a key enabler of its actual impact 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 in this purpose.

2.5.4 Scale, density, and critical mass

INESC TEC's ambitious vision and mission require both scale and density, these being nurtured by its multi-institutional base model anchored in four major high-education institutions. 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 as 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 challenge the research teams, 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 common interest in protecting its research, education, and innovation environments, this being reinforced by its Code of Ethics 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.

As a whole institution, INESC TEC exists and operates on an implicit social contract with its community at large. As such, in addition to the desired outcomes for its associates and research and innovation partners, the institute's strategy and activity must also be aligned with its stakeholders' 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 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, universal access having in mind people with disabilities inclusion, ethnic and cultural diversity are the key priorities to be addressed by the Diversity and Inclusion Commission, in line with the results of the D&I Survey.

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 concept translates into the commitment to foster pervasive intelligence through the creation of new computer intelligence paradigms, their development and application. This is favoured by the institute's size and diversity, as well as by its managed science model, creating fertile ground for multidisciplinary cooperation.

Current computer systems pervading society, in areas such as public administration, industry, earth observation, and large-scale critical systems, including utilities, healthcare, transportation, and finance, among others, 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 in four broad scientific domains and cooperate towards meeting sixteen major short- to medium-term research challenges. Examples include challenges such as achieving machine perception, making communication systems context-aware, creating a diversity of forms of human-empowering computing, improving the quality and key non-functional properties of information and industrial systems, increasing the autonomy of robotic systems, achieving fully and resilient renewable energy systems, and incorporating responsibility and sustainability in technology-driven innovation.

Research and development are complemented by knowledge valorisation and technology transfer activities, conducted with a sizeable and ever-expanding portfolio of partners and customers. Currently, through the TEC4 initiatives, business development at INESC TEC has its major focus on five socioeconomic/market areas: agriculture and food, energy, healthcare, industry and sea.

3 RESULTS ACHIEVED IN 2022

This section presents a short summary of the results INESC TEC achieved during 2022, 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 The year 2022 in review

Times have become harder. With the long tail of the pandemic, the conflict in Ukraine, the acceleration of digital transformation, the growing global competition for highly qualified professionals, an increasing inflation, especially in food and energy, around the world, the last three years have been some of the most challenging in recent memory. During this time, many people and communities have faced loss, may it be of loved ones, financial security, or ways of life.

Undoubtedly, the world had been doing more, and this was visible. However, recent events have slowed or perhaps even reversed this progress, namely in topics such as climate change or eradication of poverty. Inflation has been rising and economic growth has been slowing. Geopolitics have become increasingly polarised.

In such a tumultuous year, the worst thing to do would have been to lose heart and retreat from making a difference. On the contrary, our drive did not change, and as the context got more challenging, our community stuck together and sought to embrace all opportunities to explore, grow and bring value to the economy and society at large.

In 2022, the INESC TEC community grew, and so did its activity and its scientific production, while it maintained its track-record in knowledge valorisation and technology transfer, and in scientific dissemination to society.

Jointly with this external commitment, we also endeavoured to look at our organisation and initiate or continue long-term reforms. The in-depth work in our human resources management model proceeded, our Ethics Committee inaugurated its operation, we reformulated our Business Advisory Board and we launched a transversal and purposeful process of elaboration of a strategic plan towards 2030.

Eventually, the year 2022 will be remembered for its turbulent context, and the year's results will become part of our already three decades long history, but our most important contribution will be the devoted teams of researchers and professionals who created knowledge, ideas, partnerships, and innovations to address the problems of the present and the future.

As we reflect on the past and look at the future, we deeply thank our community, researchers and staff, for making the most of the opportunities created in 2022, and for their unwavering energy and commitment to our purpose. We remain firm in our conviction that, with science and innovation, we can continue to contribute to improve society, facing all headwinds. Success is a long-term prospect, measured in years and decades, but it starts with actions we take now.

3.2 Highlights in 2022

As mentioned, notwithstanding having its activity conditioned by the external context, the year of 2022 was yet again a year of growth, with very good results and institutional accomplishments for INESC TEC.

Overall, INESC TEC carried out the steps foreseen for the main initiatives planned for 2022, with natural adaptations arising from the nature of each initiative. INESC TEC's income has grown 14%, while at the same time, it strived to strengthen its fundamentals, and reinforce 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 2022 are summarised next, broadly under the same categories that were adopted for the 2022 plan: excellence in research, managed science model, partnership with HEI, structural initiatives, internationalisation, contributions to public policy, openness to society, and support structure.

- MANAGED SCIENCE MODEL

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

  - Ongoing process of improvement of INESC TEC’s managed science model, by proceeding with the implementation of the new organisation of Scientific Domains and by fostering their closer strategic integration with the other two key internal organisational units – R&D Centres and TEC4s;
  - Restructuring of the Business Advisory Board for the new mandate beginning in 2023;
  - Ongoing process of the preparation of INESC TEC’s Strategic Plan for 2023-2030, with a cross-organisational involvement of INESC TEC’s Community. Based on the reflection and contributions of a theme-specific workgroup, a shared and global discussion held in the 2022 INESC TEC Strategic Gathering allowed the community to discuss the foundational pillars of INESC TEC strategy: Purpose, Vision, Mission and Values.

- EXCELLENCE IN RESEARCH

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

  - Preparation of the coming FCT R&D Unit Evaluation process, to be held in 2023, taking into account the review and discussion of the institute’s scientific strategy and goals undertaken with the Scientific Advisory Board;
  - The results of the fourth call for Internal Seed Projects, aiming at supporting internal exploratory R&D activity were known in 2022. The Evaluation Committee (composed by Anibal Matos (chair), Bernardo Silva, Daniel Vasconcelos, Luís Lopes, Manuel Ricardo, Maria Antónia Carravilla, and Susana Barbosa) selected two inter-centre research projects and two junior researcher development projects. The scientific areas covered extreme learning machines, optical and quantum computing, deep learning explainability, deep neural networks and biometrics and explainable artificial intelligence;
  - 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 250 PhD students and 650 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;
  - Reinforcement of the research team with the recruitment of researchers for key strategic areas (19% overall 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”)

  - Continued collaboration in the Advanced Studies Programmes running in several Associate HEI, to offer post-graduate training within the scope of R&D projects, both through a structured introduction to transferrable skills (innovation, entrepreneurship, leadership, and time management, among others) as well as through the 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;

- Ongoing expansion of 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 located in a P. Porto campus building;
- A new general agreement on joint IP was signed with the University of Porto, which defined the rules on the management of the current and future joint patents and boosts the collaboration between the TLOs of both institutions.

- STRUCTURAL INITIATIVES

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

  - In 2022, 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 subsections 3.3 and 3.4. Likewise, the creation of the Ethics Committee and the full beginning of its activity in 2022 are presented in more detail in subsection 3.4.

- INTERNATIONALISATION

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

  - First call of the INESC TEC International Visiting Researcher Programme, which provided the opportunity to 10 researchers from institutions abroad to conduct research activities at INESC TEC for up to three months while maintaining their affiliation with their home institutions;
  - Participation of INESC TEC researchers in international exchange mobility programs, namely with USA (Texas Advanced Computing Center) and Japan (National Institute of Informatics);
  - 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 2022 marked the exit of a prolonged state of uncertainty due to the pandemic containment measures. The HUB, in representation of the 5 INESC institutes (INESC Coimbra, INESC ID, INOV, INESC MN and INESC TEC) transitioned from a period focused in internal capacity building and external visibility through online means to a period of full scope operation focused on strategic initiatives in the areas of communication, representation and visibility, organisational development and targeted lobbying, positioning of INESC researchers in key EU networks, infrastructures, public private partnerships and other relevant platforms. It has also initiated an ambitious process to build its own capacity as a think tank in EU R&I related themes, through direct participation and mobilisation of INESC researchers to participate in strategic projects supporting the European Commission and other multinational EU networks and platforms in defining governance, funding and agenda-setting processes;
  - Consolidation of INESC P&D Brasil's operation, as the association celebrated its 10th anniversary. In 2022, INESC TEC and INESC P&D Brasil signed a new agreement for scientific and technological cooperation to frame several projects and exchange activities running under distinct programmes and frameworks, and in both directions;

- 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 20+ international organisations. In 2022, INESC TEC joined the following organisations: 6G-IA - 6G Smart Networks and Services Industry Association, EASTRO - European Association of Space Technology Research Organisations, EBRAINS AISBL, and Stichting Sprint Robotics Collaborative - The Sprint Robotics Collaborative Foundation.

- CONTRIBUTIONS TO PUBLIC POLICY

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

  - Ongoing work towards the creation of a new organisational structure to coordinate INESC TEC's contributions to public policy and follow-up on public policies in its areas of expertise;
  - Active participation in the Associated Laboratories Council and contribution to draft legislation and funding programmes in preparation;
  - Strong contribution to the CoLABs (Collaborative Laboratories) public policy objective through the participation in twelve 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")

  - Intense participation in the calls of Horizon Europe programme, with 107 proposals submitted; 10 proposals submitted in the Digital Europe Programme (9 of which in the scope of the European Digital Innovation Hubs) and 27 proposals presented in European calls to EIT Manufacturing;
  - Submission of 25 applications to the Green Mobilisation Agendas and Innovation Pacts (PRR); 3 applications to the Bioeconomy Mobilisation Agendas (PRR); 5 submitted to the IFAP Research and Innovation Agendas (PRR); 1 application submitted to the Hub Azul, Infrastructure Network for the Blue Economy (PRR). It is worth mentioning the approval of 22 Mobilising Agendas, with an overall budget for INESC TEC of 39 M€, for 3 years and the approval of the application submitted to the Blue Hub, Infrastructure Network for the Blue Economy, with a funding of 6 M€;
  - Approval of ATTRACT DIH - Digital Innovation Hub for Artificial Intelligence and High Performance Computing, coordinated by INESC TEC;
  - Preparation and submission of expressions of interest regarding the National Roadmap for Research Infrastructures (RNIE) with a focus on its update, modernisation and strengthening for the period 2022-2027;
  - Application submitted to the Institutional Call to Scientific Employment Stimulus – Associate Laboratory;
  - Application for the recognition of INESC TEC as a Technology and Innovation Centre and to the Interface programme, a multi-annual base funding for three years, which will allow the capacity-building and promotion of activities close to the market.

- 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 issues of climate change and decarbonisation of the economy, in particular those related to energy. This event, which is already an INESC TEC hallmark, 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 4th and 5th 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 fourth edition's special topic was focused on "(R)Evolution in Agro-Food and Forestry" and the fifth one's on "The Energy Transition". 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;
- Promotion of open days and seminars, 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 2022 - the annual meeting of science, technology and innovation in Portugal, Mostra UPorto 2022, and acting as a host institution of the Programme "Summer with Science", 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 2022. 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.
  - INESC TEC became the main shareholder of the company CEO – Companhia da Energia Oceânica, owner of an offshore energy test zone in Aguçadoura, with grid connection (4 MW of power) and capable of supporting the development and testing of marine renewable energy technologies (TRL ~5-8), as well as other multi-purpose marine structures, marine robotics, telecommunications, advanced sensing, collection of ocean and environmental data for model development, among others. The test site, which is about 45 m deep, has an area of 4 km2, at a distance of about 5 km from the coast, which makes it a site with unique characteristics for a platform of this nature.

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

- Bruno Loff, professor at the Faculty of Sciences of the University of Porto (FCUP) and researcher at INESC TEC, was awarded with a European Research Council 5 years grant of 1.5M€ to support research in the field of Computational Complexity;
- INESC TEC researchers broke the world depth record in the exploration of flooded caves by exploring the world's deepest natural cave, the "Hranice Abyss" (Czech Republic), sending an autonomous underwater vehicle down to 450 metres. The UX-1Neo is one of the most technologically evolved underwater robots in the world, and it was developed by INESC TEC, within the scope of the UNEXUP project.
- INESC TEC's Weta Robot that aims to address the question of movement in mountain vineyards won the international annual iF Design award, for the best design for agricultural robots (design by Everythink, a start-up incubated in UPTEC – Parque de Ciência e Tecnologia of U. Porto).

Furthermore, several INESC TEC researchers received individual awards, prizes and recognitions for their research work or scientific contributions in international conferences or challenges. Some of them are presented in more detail in Chapter 6, contextualised in the activity of their respective R&D Centres.

3.3 Compliance Officers

3.3.1 Data Protection Officer

Data Protection Officer: Vasco Rosa Dias

Presentation

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

Highlights in 2022

- Monitoring of the implementation, updates and awareness raising of the approved data protection internal procedures.
- Preparation and introduction of a new tool for the assessment and monitoring of Data Protection Agreements and updated inventory of DPAs in force.
- Development and monitoring of the implementation of a new Data Transfers Impact Assessment tool.
- Continued implementation of the cooperation agreement established with ISPUP in the field of Data Protection. Design and adaptation of new procedures for the ISPUP environment. Contributions to improvements in the information system of ISPUP and associated policies.
- 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 general internal operations. Presence in several data protection and ethics governance bodies in H2020 projects coordinated by INESC TEC. 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.
- Strengthening of the training plan for staff members and researchers, including the launching of an online Moodle course and several contents covering important data protection aspects of INESC TEC's activity.
- Continuation of the awareness-raising initiatives, including live sessions and meetings with services addressing specific topics and publics within the organisation as well as the issuing and dissemination of guidelines and Policies, e.g. on hybrid and remote events and the use of videoconferencing platforms. Issuing of DPO's opinions and recommendations in English version for wider dissemination at INESC TEC community.
- A large number of data processing and joint controllership agreements was negotiated and implemented.
- 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.
- Active participation of Metared data protection Working Group's activities.

3.4 Internal Commissions and Committees

3.4.1 Conflicts of Interest Management Commission

Chairperson: José Carlos Marques dos Santos

Presentation

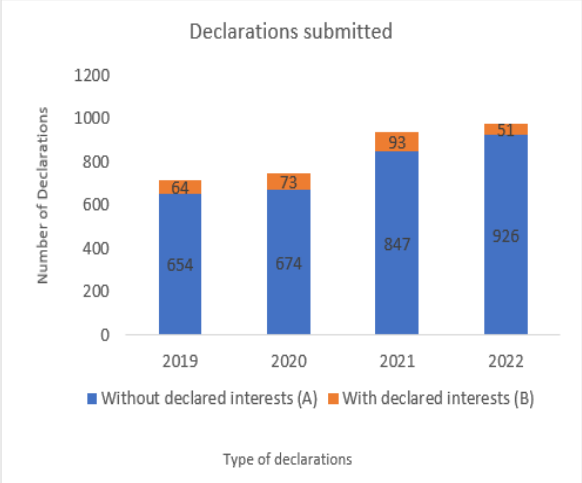
INESC TEC has a Conflict of Interest Management Policy, which applies to all integrated human resources. The Commission for Conflicts of Interest Management has the responsibility to ensure compliance throughout the institution, namely by:

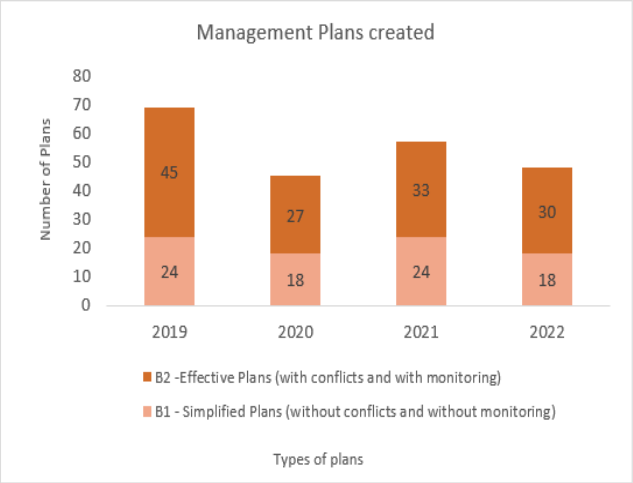
- Assessing the declarations of interests and identifying the conflicts of interest;
- Agreeing with the collaborator on the terms and proposing to the Board of Directors management plans for identified conflicts of interest, in order to reduce or eliminate those conflicts;
- Informing the collaborators 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 2022

During 2022, 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 Conflict of Interest Management Policy;
- Parameterisation and implementation of more improvements in the IT platform, in particular those aimed at enhancing the process of managing and controlling conflicts of interest, as well as the implementation of the monitoring report;
- Submission to the Board of Directors, and subsequent approval, of the documents related to the monitoring role of the Conflict 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, before 2022, there were declarations classified by the author as having interests, which CGCI detected not to be the case, therefore not giving rise to any plan, that have been statistically considered as declaration with interests.

3.4.2 Diversity and Inclusion Commission

Chairperson: Beatriz Brito Oliveira

Presentation

The Board of Directors of INESC TEC established the Diversity & Inclusion (D&I) Commission in September 2021. Its main mission is to propose and implement a D&I program.

The D&I Commission is composed of INESC TEC collaborators, from different structures/services: Ana Lopes, Beatriz Oliveira, Tiago Silva, Tiago Gonçalves (since May 2022), and Rita Costa (since October 2022). Nuno Moniz was part of the Commission up to May 2022, as well as Sheila Habib, up to July 2022.

Two Advisory Groups support the Commission's work. The Internal Advisory Group is composed by a representative set of collaborators and supports the Commission through brainstorming, discussion and validation, whereas the External Advisory Group is composed by key players in the D&I field and provides strategic counselling.

Highlights in 2022

Definition of D&I priorities: In 2022, the D&I priorities for the following years were established, based on the reality of INESC TEC collaborators, the institution's vision and mission, and the broader current context of R&D organisations in Europe. The three main priorities for INESC TEC are:

- **Gender equality:** INESC TEC should pave solid paths in matters of gender balance and representation (especially in higher-ranking positions) and promote equal opportunities for all its collaborators to pursue their professional ambitions, well-being, and work-life balance;
- **Interculturality:** Addressing interculturality will allow INESC TEC to develop a long-term commitment to be mindful and foster the inclusion of different cultural backgrounds, languages and religions, as well as attract and retain international talent;
- **Accessibility:** INESC TEC needs to raise awareness regarding accessibility issues and ensure anyone can conduct their work (access a place, document, process or do a task) freely and independently, rather than adapting processes and infrastructure on an as-needed basis.

Launch of the Gender Equality Plan 2022-2026: In 2022, the Board of Directors formally approved the Gender Equality Plan (GEP) and the D&I Commission presented it to the INESC TEC community in an online session, including an open discussion. This document is also publicly available since July 2022.

Report, presentation and discussion of the D&I Survey results: In November 16, 2022, the D&I Commission shared the main findings of the D&I Survey launched in the end of 2021 in an online session, with an open discussion with the INESC TEC community. The results were analysed in detail and made available in the intranet.

Awareness-raising and competence-building actions: The D&I Commission organised several trainings, events and communications with this objective.

- Trainings: Intercultural Dialogue Training (two editions: May, 25; December, 2), Social Diversity Training (May, 31), dissemination of online courses, such as Literacy on Racism and Racial Discrimination;
- Events: White Cane Awareness Day Event (October, 18), Women in STEM Event (July, 6);
- Communications: About relevant observed dates: International Day of Women and Girls in Science (February, 11), International Women's Day (March, 8), International Day for the Elimination of Racial Discrimination (March, 21), Equal Pay Day (November, 15), International Day of Persons with Disabilities (December, 3). About cultural celebrations: Ramadan (April, 1), Diwali (October, 25), Hanukkah (December, 18-26).

3.4.3 Technical Committee for Social Responsibility

Chairperson: Joana Coelho

Presentation

Corporate Social Responsibility (CRS) was defined by the European Commission (in 2011) as “the responsibility of enterprises for their impacts on society and outlines what an enterprise should do to meet that responsibility”.

In November 2018, a work group composed of co-workers of INESC TEC from different centres and services was established to perform a diagnosis of the social responsibility status in the institution. Following the results of that diagnosis, in October 2019, a Social Responsibility Committee was formally established; the main mission is to incorporate social responsibility into INESC TEC's organisational practices and culture. The Technical Committee for Social Responsibility, which focuses on two dimensions – internal (comprising organisational principles, employees and the work environment) and external (focusing on society and the market) -, has a renewed mandate every two years.

Even though the pandemic situation had a huge impact on the activities that were previously foreseen by the Committee, the conditions verified in the second semester of 2022 allowed picking up some of the foreseen activities.

Highlights in 2022

INTERNAL DIMENSION:

- Actions were focused on environmental area, namely:
  - Collection of Nespresso capsules to be recycled, thus contributing to the donation of rice that Nespresso makes to the Food Bank, as part of the "Recycling is Feeding" project;
  - Maintenance of the containers for placing plastic caps in the institution's headquarters and at Braga’s pole. The collected quantity allowed, in 2022, to help a young girl, from Braga, with a rare disease.

EXTERNAL DIMENSION:

- Regarding the activities conducted focusing on the societal area, the Committee:
  - Supported an association in the city of Porto, by donating a washing machine that was no longer used for research purposes;
  - Appealed to the INESC TEC community for blood and bone marrow donation;
  - Asked the community to identify institutions where they would like to volunteer and to whom they would like to donate goods during Christmas season;
  - Organised a volunteer afternoon – on 5 December 2022 to celebrate the International Volunteering Day – with effective work done by INESC TEC co-workers in five different institutions, in the city of Porto;
  - Arranged a goods collection among INESC TEC community that were delivered to the Support Centre for the Homeless, in Porto.
- In what concerns the market area, the Commission tried to give visibility of every action:
  - Internally: by making e-mail announcements or by publishing information in the chat’s platforms used by INESC TEC community;
  - Externally: by publishing four news pieces through the social responsibility section on BIP INESC TEC Magazine, with a total of 97 visualisations, and by promoting through 10 publications on INESC TEC social media channels, reaching more than 6680 people.

3.4.4 Ethics Committee

Chairperson: Pedro Guedes de Oliveira

Presentation

In 2022, after the approval of the Ethics Code, the Board of INESC TEC appointed the Ethics Committee, after consulting the Scientific Board.

The Board is chaired by Pedro Guedes de Oliveira, Professor Emeritus at the University of Porto and Senior Consultant to the President of the Board of INESC TEC, and integrates Susana Magalhães, who holds PhD in Bioethics and is the Coordinator of the Unit for Responsible Conduct in Research at I3S and Assistant Professor at the Fernando Pessoa University, Vasco Rosa Dias, Data Protection Officer at INESC TEC and ISPUP, Lia Patrício and Alípio Jorge, professors, respectively at the Faculty of Engineering and Faculty of Sciences of the University of Porto and researchers of INESC TEC.

Highlights in 2022

In March 2022 the Ethics Committee of INESC TEC had its first meeting, and started to organise and implement the necessary procedures and information platforms so that the project leaders could submit their ethics questionnaires of ethics self-assessment, online. Those questionnaires are regularly analysed by the Ethics Committee which may result in further analysis and interactions with the project leaders.

Also, as a result of issues raised by researchers, either through the presentation of simple questions, frequently in the design stage of research projects, or by requesting the Ethics Committee formal opinion with relation to specific R&D projects or in the context of the papers submission procedure, a direct contact is established in order to be able to provide the required answers and suggest the adequate measures, whenever necessary, and to counselling the researchers concerning any ethic issues, mainly when their projects involve human beings or personal data, or artificial intelligence or autonomous systems. Other meetings were organised among the Ethics Committee members to discuss operational issues of the Committee.

To sum up, the main highlights in 2022 were:

- Appointment of the Ethics Committee;
- Presentation of the Code of Ethics and the Ethics Committee to the INESC TEC Community;
- Definition and implementation of main procedures and IT supporting tools, in particular as regards the ethics self-assessment online questionnaire designed for highlighting relevant dimensions in projects which involve human beings or personal data or AI;
- Start of the Ethics Committee meetings;
- First Ethics Committee's preliminary assessments, following the submission of self-assessment online questionnaires;
- Issuing of the first formal opinions by the Ethics Committee;
- Regular contacts with the INESC TEC community.

3.5 Human Resources

3.5.1 Global Indicators

Table 3.5.1 and Figure 3.5.1 show the breakdown of Human Resources by type of contractual relation with INESC TEC and its evolution since 2020. The number of researchers with PhDs is also shown (364 at the end of 2022).

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 3.5.1 - Evolution of Human Resources

Type of Human Resources			2020	2021	2022	Δ 2021-22	
Integrated HR	Core Research Team	Employees	152	159	189	30	19%
		Academic Staff	169	174	185	11	6%
		Grant Holders and Trainees	334	324	354	30	9%
		Total Core Researchers	**655**	**657**	**728**	**71**	**11%**
		Total Core PhD	**264**	**255**	**272**	**17**	**7%**
	Affiliated Researchers		77	67	73	6	9%
	Administrative and Technical	Employees	94	102	115	13	13%
		Academic Staff	11	11	10	-1	-9%
		Grant Holders and Trainees	9	6	6		0%
		Total Mgmt, Admin and Tech	**114**	**119**	**131**	**12**	**10%**
		Total Integrated HR	**846**	**843**	**932**	**89**	**11%**
		Total Integrated PhD	**354**	**342**	**364**	**22**	**6%**
Curricular Trainees			38	35	16	-19	-54%
External Research Collaborators			237	247	241	-6	-2%
External Administrative and Technical Staff			7	8	9	1	13%
External Students			141	169	239	70	41%
Total			**1269**	**1302**	**1437**	**135**	**10%**

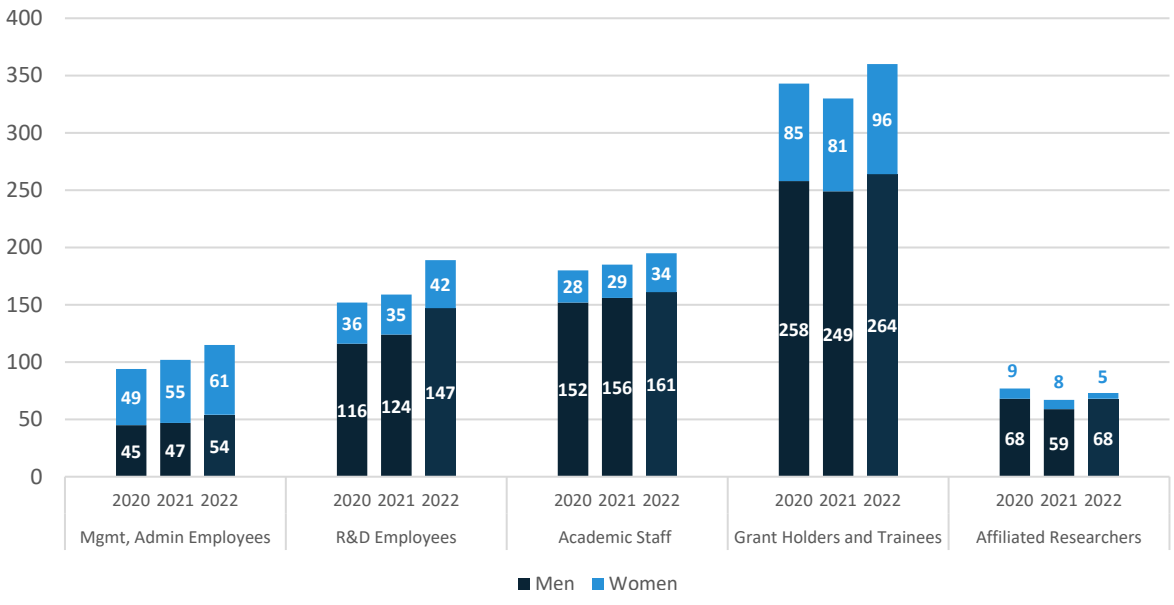


Figure 3.5.1 - Evolution of Human Resources

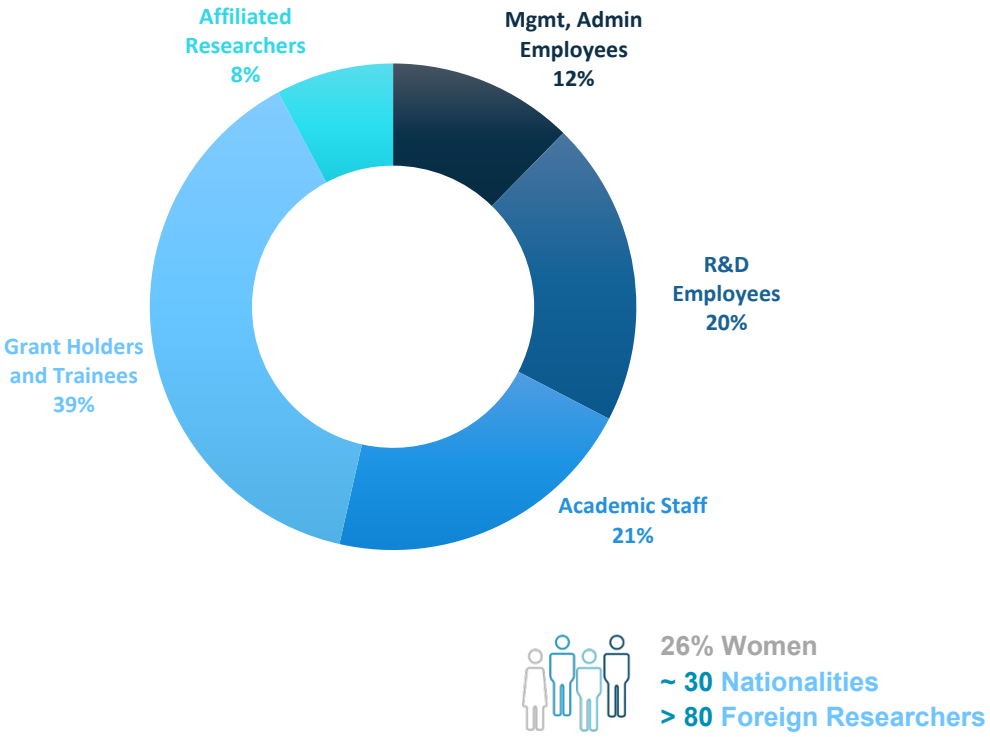


Figure 3.5.2 - Distribution of Human Resources

As seen in Figure 3.5.2, grant holders and trainees are the largest group of human resources (39%) at INESC TEC, featuring an increase in 2022 (Figure 3.5.1). This growth finally reverses a downward trend that had been occurring since 2018, mostly in result of the national regulations for grants and the continued implementation of the Portuguese Government's policy for scientific employment stimulus. These also explain the steady rise in the number of R&D employees (19% in 2022), 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 strategic objectives, such as the reinforcement of human resources management and of the networks technical support, or the creation of an organisational structure for public policy.

The team profile followed very closely the profile included in the 2022 plan, while the total numbers were slightly below 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 years, the percentages of women have remained almost unchanged (25% for Integrated HR and 22% for Integrated Researchers), though in 2022, we reached 26% for Integrated HR, due to a slight increase in the core research team. This and other dimensions have been analysed by the Diversity and Inclusion Commission and are being addressed in the Gender Equality Plan implemented since 2022.

3.5.2 R&D Centres Indicators

The number and structure of Human Resources in each R&D Centre is detailed in Table 3.5.2.

Table 3.5.2 - Human Resources by type and R&D Centre

Type of Human Resources			Total R&D Centres	R&D Centres													Special Projects
				CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	HUMANISE	LIAAD	CRACS	HASLAB	
Integrated HR	Core Research Team	Employees	**189**	9	15	24	4	50	27	19	7	5	14	7	1	7	
		Academic Staff	**185**	14	8	12	6	10	6	13	19	2	33	23	16	23	
		Grant Holders and Trainees	**354**	49	19	35	15	39	11	33	24	1	45	27	14	42	
		Total Core Researchers	**728**	**72**	**42**	**71**	**25**	**99**	**44**	**65**	**50**	**8**	**92**	**57**	**31**	**72**	
		Total Core PhD	**272**	**22**	**19**	**17**	**8**	**29**	**16**	**20**	**26**	**5**	**38**	**28**	**16**	**28**	
	Affiliated Researchers		**73**	10	3	1	1	5	9	3	5	2	18	7	2	7	
	Administrative and Technical	Employees	**19**	1	1	3	1	3	2	2	1		1	1		3	2
		Total Admin and Tech	**19**	1	1	3	1	3	2	2	1		1	1		3	2
	Total Integrated HR		**820**	**83**	**46**	**75**	**27**	**107**	**55**	**70**	**56**	**10**	**111**	**65**	**33**	**82**	**2**
	Total Integrated PhD		**321**	**29**	**20**	**16**	**9**	**29**	**22**	**24**	**32**	**6**	**47**	**37**	**18**	**32**	
Curricular Trainees			**16**				**1**		**6**	**2**		**4**	**3**				
External Researchers			**212**	**26**	**4**	**4**	**16**	**17**	**18**	**18**	**26**	**11**	**20**	**31**	**6**	**15**	**3**
External Administrative and Technical Staff			**6**				**1**	**1**		**1**	**2**					**1**	
External Students			**237**	**54**	**14**	**5**	**13**	**24**	**7**	**15**	**8**		**26**	**27**	**3**	**41**	
Total			**1 291**	**163**	**64**	**84**	**58**	**149**	**86**	**106**	**92**	**25**	**160**	**123**	**42**	**139**	**5**

R&D Centres:

CTM	Centre for Telecommunications and Multimedia
CAP	Centre for Applied Photonics
CRAS	Centre for Robotics and Autonomous Systems
CBER	Centre for Biomedical Engineering Research
CPES	Centre for Power and Energy Systems
CESE	Centre for Enterprise Systems Engineering
CRIIS	Centre for Robotics in Industry and Intelligent Systems
CEGI	Centre for Industrial Engineering and Management
CITE	Centre for Innovation, Technology and Entrepreneurship
HUMANISE	Centre for Human-Centered Computing and Information Science
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

3.5.3 Support Services Indicators

The Human Resources figures by the end of 2022 for the Board of Directors, the TEC4 teams, and the Support Services are provided in Table 3.5.3.

Table 3.5.3 - Human Resources by type and Service

Type of Human Resources		Total	Support Services																
			Board and Advisors	TEC4	DPO	Organisation and Management Services					Business Development Services				Technical Support Services			
						AG	AJ	CF	CG	RH	SAAF	SAL	SRI	SCOM	SRC	SIG	SAS	SGI
Integrated HR	Employees	94	13	7	2	2	3	9	12	9	2	3	5	7	5	5	4	6
	Academic Staff	10	7	3														
	Grant Holders and Trainees	6		1								1				4		
	Affiliated Researchers																	
	Total Integrated HR	**110**	**20**	**11**	**2**	**2**	**3**	**9**	**12**	**9**	**2**	**4**	**5**	**7**	**5**	**9**	**4**	**6**
	Total Integrated PhD	**22**	**11**	**6**		**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*

3.6 Activity in Projects

3.6.1 Global Indicators

Table 3.6.1 shows the breakdown of INESC TEC's funding sources and the evolution from 2018 to 2022.

Table 3.6.1 - Funding sources and evolution

Sources			Value (k€)					Δ (k€ | %)	
			2018	2019	2020	2021	2022	2021-22	
Projects	PN-FCT	National R&D Programmes - FCT	2 279	3 677	3 524	2 295	1 522	-773	-34%
	PN-PICT	National R&D Programmes - S&T Integrated Projects	2 428	468	22	49	154	105	214%
	PN-COOP	National Cooperation Programmes with Industry	1 251	928	1 250	2 189	3 720	1 531	70%
	PUE-FP	EU Framework Programmes	3 628	3 910	4 903	5 529	7 642	2 113	38%
	PUE-DIV	EU Cooperation Programmes - Other	707	713	300	449	534	84	19%
	SERV-NAC	R&D Services and Consulting - National	2 525	2 527	2 899	3 519	3 527	7	0%
	SERV-INT	R&D Services and Consulting - International	509	410	547	678	326	-352	-52%
	OP	Other Funding Programmes	841	1 067	955	560	713	152	27%
	Closed Projects		309	185					
		Total Projects	**14 477**	**13 884**	**14 399**	**15 270**	**18 137**	**2 868**	**19%**
National Strategic Programme - Pluriannual			2 485	2 307	2 396	2 257	3 062	805	36%
National Strategic Programme - RHAQ			0	0	289	520	507	-13	-3%
National Strategic Programme - EEC			0	368	460	484	509	25	5%
National Strategic Programme - CIT			0	368	599	836	28	-809	-97%
National Strategic Programmes - Other			13	961	10	241	350	110	46%
Other Revenues			170	73	102	520	443	-77	-15%
		Total Revenues	**17 145**	**17 960**	**18 255**	**20 127**	**23 036**	**2 909**	**14%**

Figure 3.6.1 illustrates the distribution of funding for the projects carried out in 2022, and its evolution since 2018. The activity level has grown steadily, with oscillations in the relative importance of the different funding sources, typically reflecting the cyclic nature of national and international funding programs.

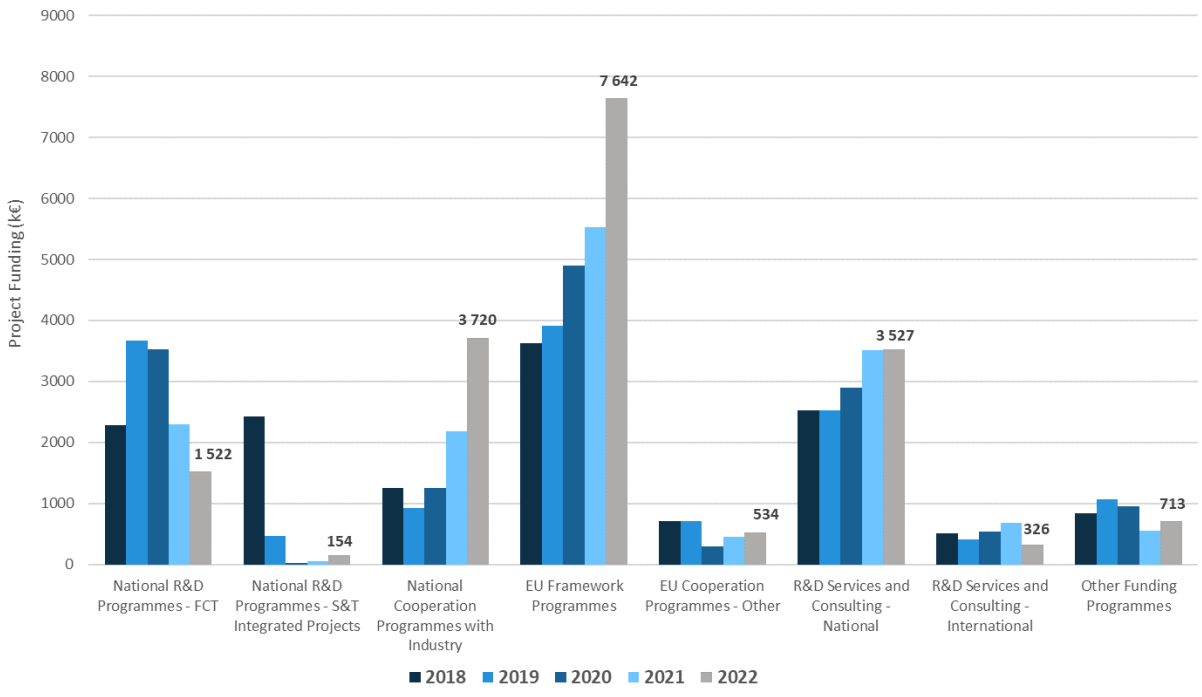


Figure 3.6.1 - Evolution of project funding by source (k€)

Figure 3.6.2 shows the project funding distribution by source, in comparison with the previous year.

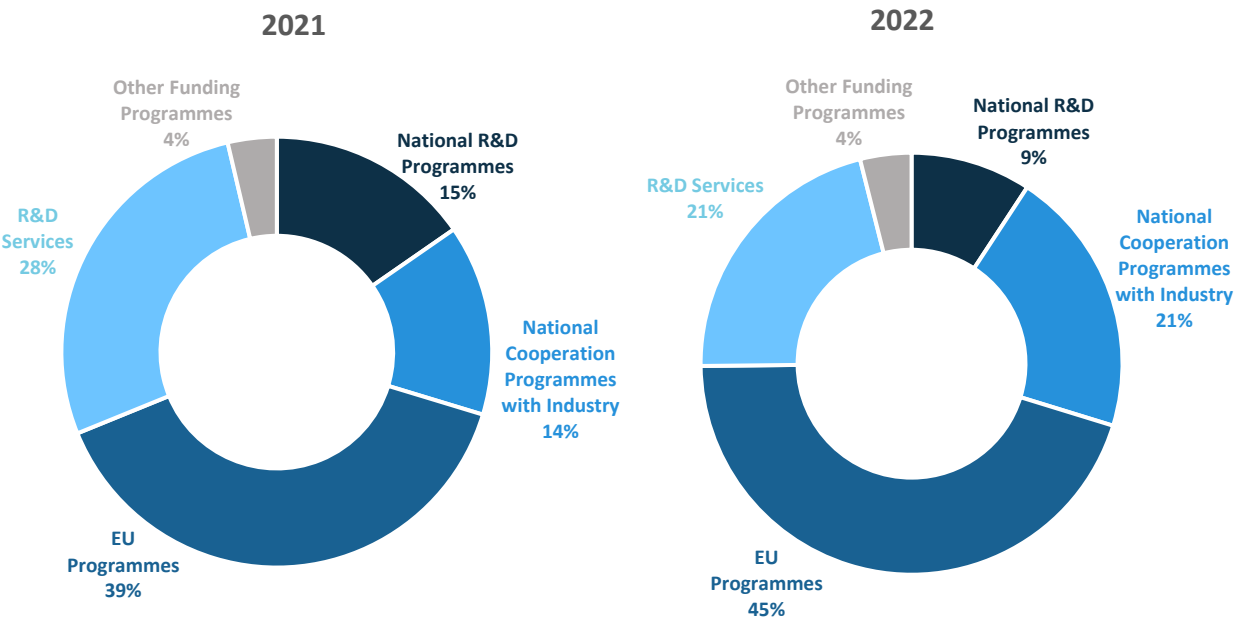


Figure 3.6.2 - Distribution of project funding by source – 2021 and 2022

The number of active projects and the average funding per project by source are also of interest and are shown in Table 3.6.2.

Table 3.6.2 - Number of active projects and average funding by source

Type of Project		Number of Active Projects					Δ (%)	Average Funding (k€)	
		2018	2019	2020	2021	2022	2021-22	2021	2022
PN-FCT	National R&D Programmes - FCT	66	74	68	61	48	-13	38	32
PN-PICT	National R&D Programmes - S&T Integrated Projects	10	10	0	1	1	0	49	154
PN-COOP	National Cooperation Programmes with Industry	23	21	33	46	58	12	48	64
PUE-FP	EU Framework Programmes	30	48	72	67	75	8	83	102
PUE-DIV	EU Cooperation Programmes - Other	18	20	18	15	20	5	30	27
SERV-NAC	R&D Services and Consulting - National	87	121	126	125	121	-4	28	29
SERV-INT	R&D Services and Consulting - International	19	13	20	20	15	-5	34	22
OP	Other Funding Programmes	30	31	40	27	18	-9	21	40
	Total	**283**	**338**	**377**	**362**	**356**	**-6**	**42**	**51**

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 a total funding of 23 M€, consolidating the continuous growth observed in previous years;
- Despite a tumultuous context, INESC TEC was able to increase its level of activity in about 14%, with 356 active R&D projects during the year, and 37% of its funding from international sources;

- The balance between the different sources of funding has changed, with an increase in the level of funding from European projects, as well as from National Cooperation Programmes with Industry, compensating for the reduction in funding for FCT projects and R&D Services;
- The noteworthy increase in the National Cooperation Programmes with Industry (70%) was mainly related with the intense activity in P2020 projects (co-promoted R&D and Mobilisers).
- The decrease in FCT project funding is related with the completion of several projects and a smaller number of FCT projects started in 2022, since the funding available for the latest calls was considerably lower;
- The National Strategic Programme – "Pluriannual" – amounted to 13% 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", was in its final phasing out in 2022, being of significant importance for technology transfer capabilities and activities. An application to the Interface programme, the continuing multi-annual base funding for these activities was submitted in 2022;
- 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.

3.6.2 R&D Centres Indicators

A detailed view of the total funding by source per R&D Centre is given in Table 3.6.3 and Figure 3.6.3.

Table 3.6.3 - Project Funding (k€) per R&D Centre

Funding Source		Total (k€)	R&D Centres														
			CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	HUMANISE	LIAAD	CRACS	HASLAB	Special Projects
Projects	PN-FCT	**1 522**	113	120	543	76	117	130	5	107	0	109	122	0	84	-4
	PN-PICT	**154**	77	0	0	0	77	0	0	0	0	0	0	0	0	0
	PN-COOP	**3 720**	277	201	469	80	527	918	510	98	7	226	173	0	234	0
	PUE-FP	**7 642**	244	206	1 791	38	2 034	533	780	478	331	943	69	0	195	0
	PUE-DIV	**534**	11	5	149	0	60	1	19	11	45	76	61	96	0	0
	SERV-NAC	**3 527**	625	43	89	23	956	347	236	137	23	450	73	85	431	8
	SERV-INT	**326**	21	64	128	21	27	37	0	0	0	12	0	0	15	0
	OP	**713**	74	21	0	6	180	0	4	0	0	1	0	5	25	397
Total Funding		**18 137**	**1 443**	**659**	**3 169**	**244**	**3 978**	**1 967**	**1 554**	**832**	**406**	**1 816**	**498**	**186**	**984**	**400**

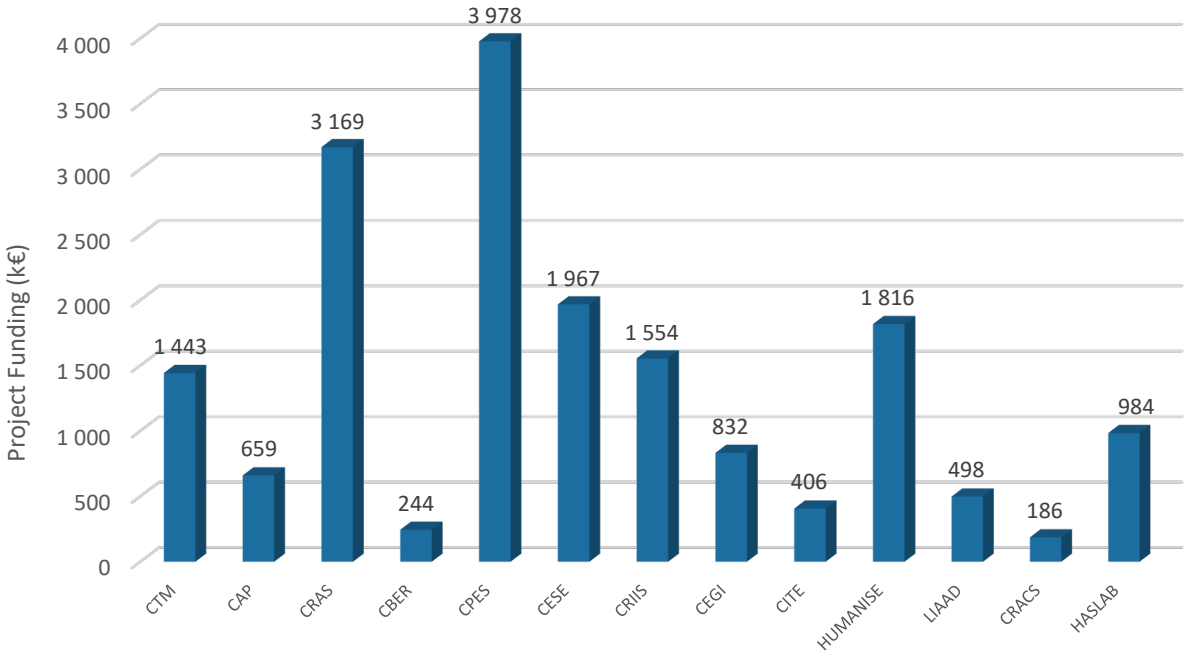


Figure 3.6.3 - Total Project Funding per R&D Centre (k€)

3.7 Publications

3.7.1 Global Indicators

Tables 3.7.1 and 3.7.2 and Figures 3.7.1 and 3.7.2 show the number of INESC TEC publications and their evolution between 2018 and 2022.

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.

The calculation of the publication indicators has the particularity that the records continue to evolve after the closing of a reference year, being a process with some time lag. INESC TEC has established two moments of calculation of its publications data: three months after the end of year *n* for the elaboration of the respective activity report. These indicators are called consolidated. The second moment occurs 11 months after the end of year *n*, when the *n+2* Plan is being elaborated. These indicators are referred to as closed.

To allow a more accurate analysis of the evolution of INESC TEC's publications data, two different views will be presented. Table 3.7.1 and Figure 3.7.1 compare consolidated data for the various years to allow a more accurate perception of INESC TEC's publication performance in 2022. In turn, Table 3.7.2 and Figure 3.7.2 present the consolidated data for 2022 compared with the closed data from previous years, in order to yield the best information available at the time of elaboration of this document.

Table 3.7.1 – Evolution of Publications (Consolidated)

Publication Type	2018 (Consolidated)	2019 (Consolidated)	2020 (Consolidated)	2021 (Consolidated)	2022 (Consolidated)
Indexed Journals	303	369	398	440	465
Indexed Conferences	438	410	317	362	349
Books	5	4	2	3	3
Book Chapters	38	29	25	34	45
PhD Theses - Members	38	19	28	30	31
PhD Theses - Supervised	56	33	46	58	43

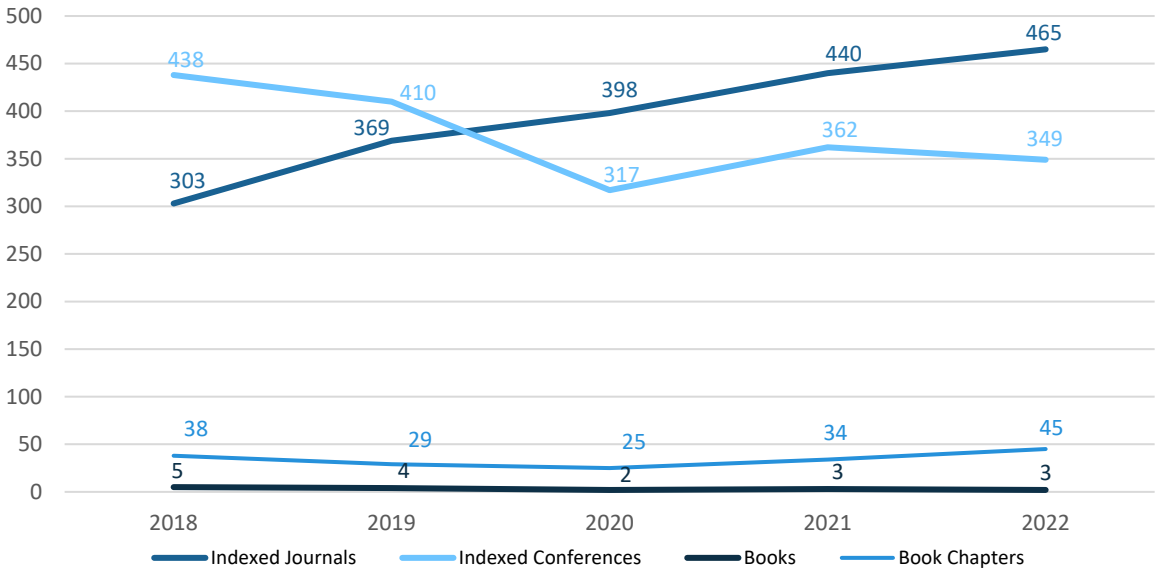


Figure 3.7.1 - Evolution of Publications (Consolidated)

Table 3.7.2 – Evolution of Publications (2022 Consolidated vs Previous years' Closed)

Publication Type	2018 (Closed)	2019 (Closed)	2020 (Closed)	2021 (Closed)	2022 (Consolidated)
Indexed Journals	312	381	426	451	465
Indexed Conferences	494	570	411	471	349
Books	7	6	2	4	3
Book Chapters	40	29	31	33	45
PhD Theses - Members	38	19	28	30	31
PhD Theses – Supervised	56	33	46	58	43

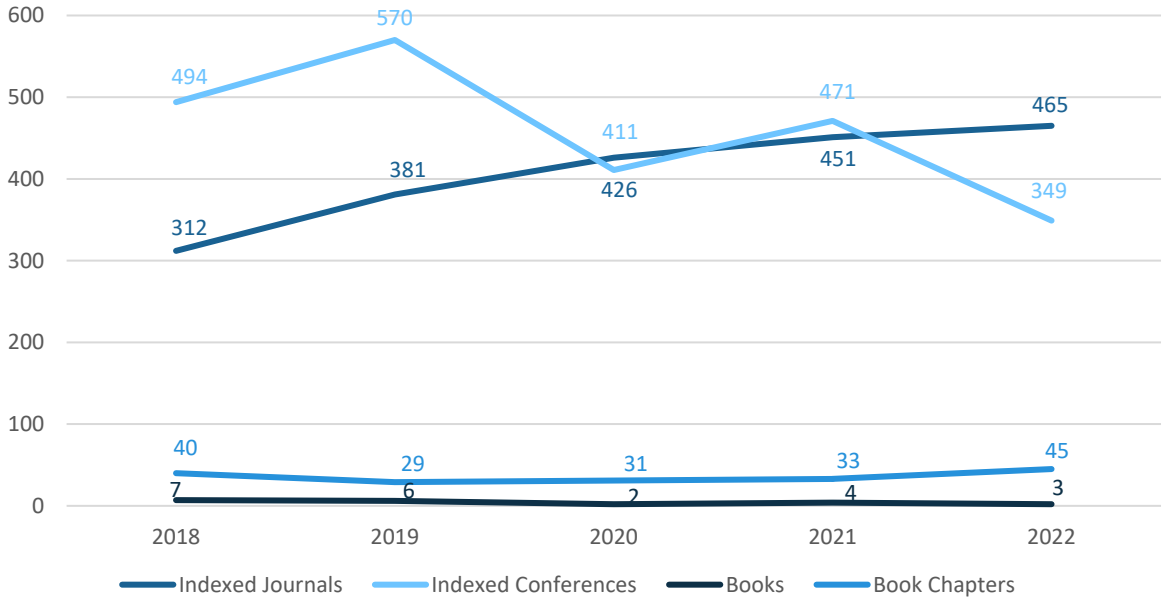


Figure 3.7.2 - Evolution of Publications (2022 Consolidated vs Previous years' Closed)

Surpassing the estimates included in the 2022 plan that estimated 390 papers in journals, INESC TEC steadily increased the number of publications in indexed journals, the institute's main overall publication priority.

The number of publications in indexed conferences decreased in 2022 when compared with the previous year. However, as it can be observed when comparing Figures 3.7.1 and 3.7.2, this indicator tends to evolve significantly during the following year as the indexing sources keep updating their data, being confidently expected that it will evolve very positively until its calculation is closed.

When looking at the evolution of publications per capita (Figure 3.7.3), considering only consolidated data, we can see that the number of articles in indexed journals per Core PhD remains stable compared to the previous year, as presented in Figure 3.7.3.

As for the number of articles in indexed conferences per Core PhD, there is greater variability, with the 2022 figure only slightly above the 2020 indicator, the lower performance in analysis and deeply affected by the lockdown due to the impact of COVID.

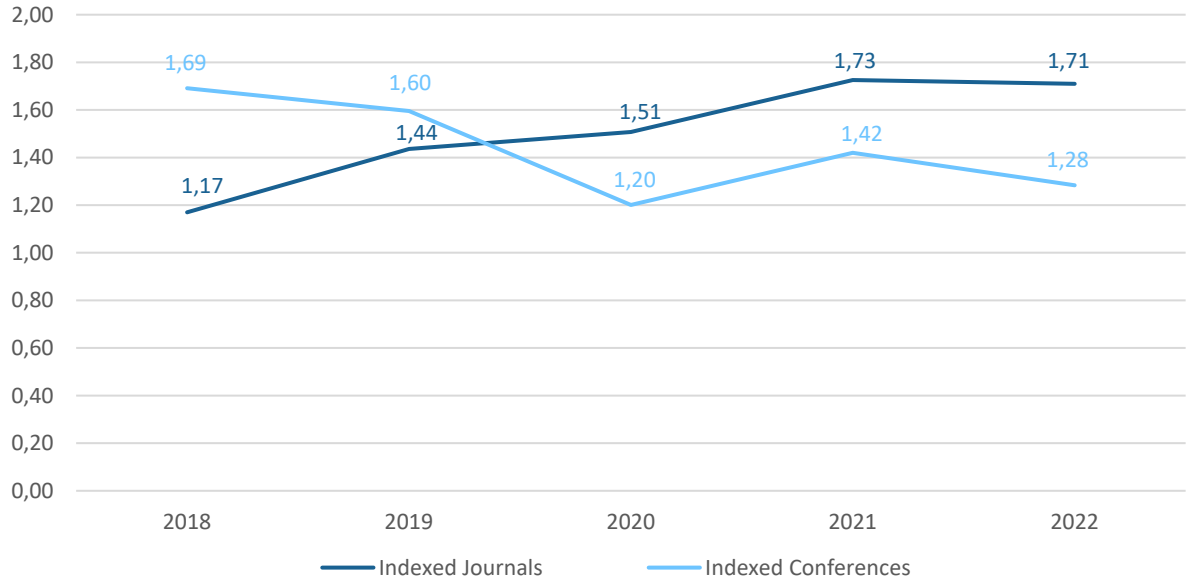


Figure 3.7.3 - Evolution of Publications per Core PhD (Consolidated)

As for the publications in journals indexed by Scopus, Figure 3.7.4 shows their distribution per impact factor quartile: 315 of them were in First Quartile journals (compared to 292 articles in 2021 (consolidated)) which correspond to 68% of the articles in indexed journals, corresponding to yet another improvement in terms of relevance of the publications when compared with the previous year (66% in 2021).

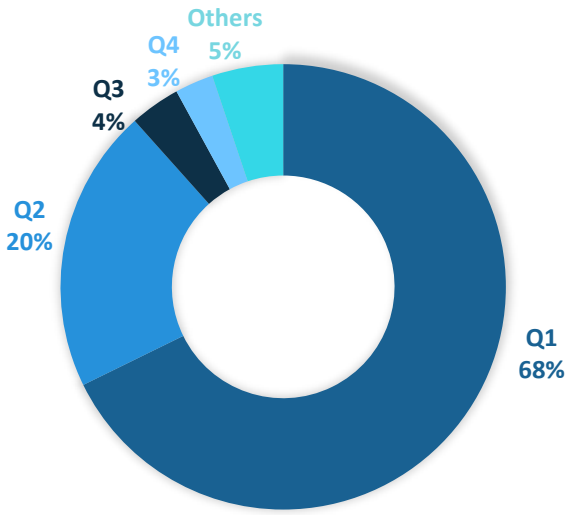


Figure 3.7.4 – Indexed Journal impact factor Quartile distribution (Scopus)

3.7.2 R&D Centres Indicators

Figure 3.7.5 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.

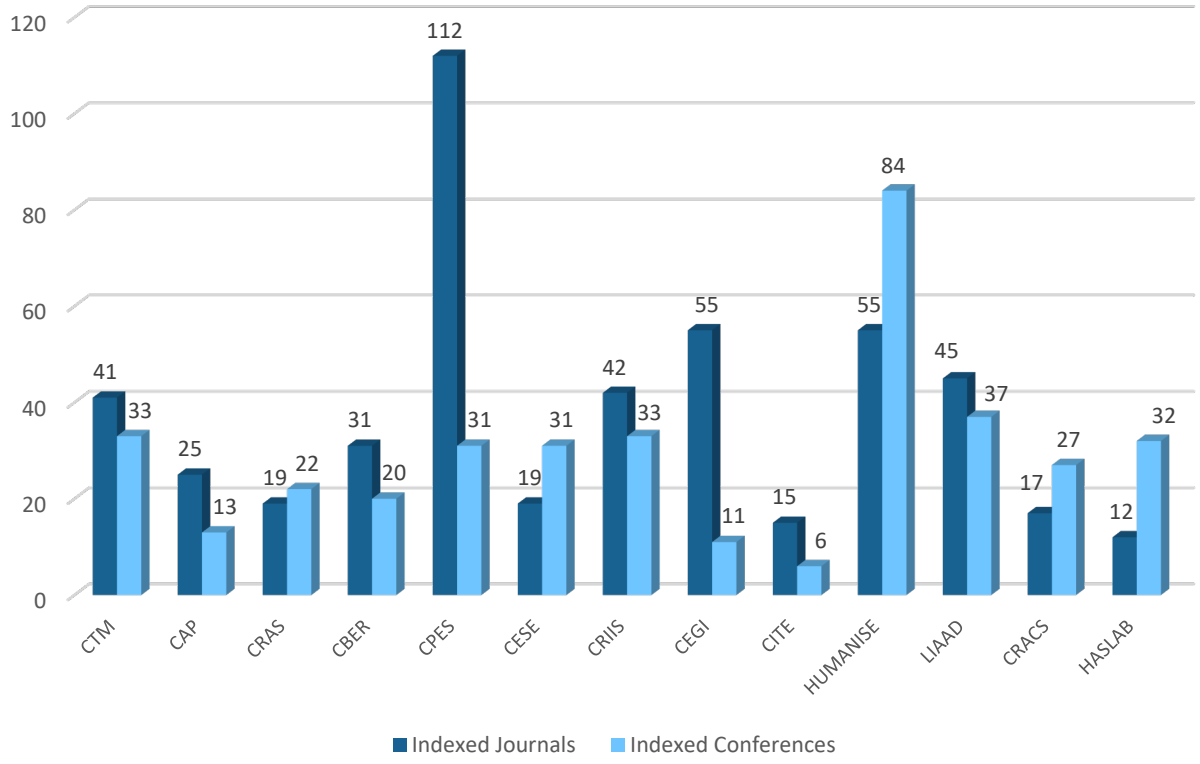


Figure 3.7.5 - Indexed Publications in Journals and Conferences by Centre

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

3.8 Technology Transfer

Overall, transfer results (Table 3.8.1.) were above or in line with the estimates included in the 2022 plan. This was the result of the strategic commitment of the R&D Centres in addition to the scouting activities of the Technology Licensing Office (SAL).

Table 3.8.1 - Results related with IP Protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)	_	30	24
Technology Disclosures (TDF)	26	8	21
First Priority Patent Applications (New inventions)	7	5	5
First Patents Internationalisation	4	3	2
First Patents Granted	2	6	2
Commercial Contracts (Licences, Options, Assignments)	5	3	1
Spin-offs		1	
Spin-offs in development	3	2	2

In 2022, a revision of the technology transfer indicators took place, considering best practices and international benchmarks. The resulting scoreboard of indicators is more rigorous, limiting, for example, the counting of patents to first applications or first patent grants.

As planned, the number of invention disclosures remained high, in part due to the simplification of the initial communication phase by introducing short disclosure forms but articulated with a selection funnel prone to a high-quality and lean IP portfolio management.

The number of new patented inventions/technologies stabilised at a few units per year, after a policy-driven earlier peak enabled by the combination of patent-related project performance criteria and the availability of public funding for international patenting. In 2022, the IP strategy focused on quality over quantity and will continue to do so in the forthcoming years.

As for commercial contracts, the anticipated increase was not yet achieved in 2022 but continued efforts in active scouting of both new technologies and business opportunities and exploitation of the IP portfolio will remain and surely come to fruition as the result of the current set of commercial leads.

As for pre-incubation activity, two spin-offs remain in a development phase, iLoF and WeSenss. More information on INESC TEC's spin-offs is presented in the next section.

3.8.1 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 2022.

Table 3.8.2 - Overview on INESC TEC's most recent established spin-offs

Name and description	Main developments in 2022
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. **Year of incorporation:** 2019 **Sector:** Software security / Fintech **Employees (FTE):** < 5	Development of a strategic partnership to study the application of Keyruptive's IP in a different product. Successful conclusion of the logistics project that was underway.
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. **Year of incorporation:** 2019 **Sector:** Medtech **Employees (FTE):** < 5	The new prototype was released together with a first version of the Application of iHandU that will be used in clinical appointments, remote monitoring, and patient self-assessment. The multi-centre clinical study to validate iHandU technology now includes Complejo Universitario de Santiago de Compostela, which joined as a partner for the validation of the technology. InSignals got the chance to receive valuable feedback from neurologists and industry key players from Europe and North America. The team participated in international conferences and was invited to speak at the annual meeting of the Parkinson Study Group in Phoenix (US), and at BIAL Moving ON series.
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. **Year of incorporation:** 2018 **Sector:** Digital mobility **Employees (FTE):** 10-20	First installation of the platform Pick completed at Trevo, the municipal public bus operator of the city of Évora, that, through it, is the first city in Portugal with a system of public transit managed fully with smartphones and cloud services and which accepts the payment of fares onboard with contactless bank cards. Ubrider signed a global sales partnership with Mastercard. Both companies aim to foster the acceptance of contactless and digital payments at public transit, reducing the payments' friction.
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. **Year of incorporation:** 2015 **Sector:** IT for transport and logistics **Employees (FTE):** < 5	Implementation projects using the core technology developed by MITMYNID and diversification for other industries on consulting and technology development. New products in the market, as the result of research and innovation processes, for health and e-democracy and citizenship.
UNEXMIN Georobotics Underwater mine exploration robotic system for commercial mine surveying, exploration and geoscientific purposes. **Year of incorporation:** 2018 **Sector:** Geological consulting **Employees (FTE):** < 5	In 2022 UGR, continued the up-scaling and exploitation of the UX1neo robotics explorer robot. A total of 5 pilots and one service contract were done in different sites during 2022, 3 of them commercial jobs, that are: South Crofty (UK), Danube mission (Hungary), and in Käfersteige mine in Pforzheim, Germany.

Table 3.8.3 - Overview on INESC TEC's spin-offs in development

Spin-offs in Development	
Name and description	**Main developments in 2022**
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. **Sector:** Medtech, Digital health **Employees (FTE):** 10-20	Applied a new technological core to prognosis ovarian cancer and initiated clinical studies with eight 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. **Sector:** Medtech **Employees (FTE):** N/A	WeSENSS is still being pre-incubated at C-BER's BRAINlab, and does not yet have employees. This is planned to change during 2023 due to the "Tech2Market" prize awarded by the EIT accelerator program. With this prize, it will aim to increase its visibility in the search of closing a paid proof-of-concept deployment, endorse its relation with existing and new early costumer and look for more funding to create a strong development team. Besides the prize, the WeSENSS technology is being evolved at INESC TEC in the scope of two EU-funded projects and one National-funded project (FIRE-RES, iProcureSecurity, AgWearCare). These projects are allowing: 1) to evolve the wearable devices into more robust MVP; 2) to improve the cloud server communications protocol; 3) to deploy proof-of-concept applications with three potential future clients through its cloud API, showing its scalability and easy adaptability.

3.9 Dissemination activities

Table 3.9.1 illustrates the evolution of the participation of INESC TEC members and R&D Centres in a variety of categories of dissemination activities.

Table 3.9.1 - Results related with dissemination activity

Type of Activity	2020	2021	2022
Participation as principal editor, editor or associated editor in journals	90	118	151
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	74	77	63
International events in which INESC TEC members participate in the program committees	273	259	228
Participation in events such as fairs, exhibitions or similar	63	82	43
Conferences, workshops and scientific sessions organised by the R&D Centres	41	75	76
Participants in the conferences, workshops and scientific sessions organised by the R&D Centres	5 488	7 239	3 549
Advanced training courses organised by the R&D Centres	20	15	10

Despite a significant growth in science and innovation projects, INESC TEC's researchers were able to maintain a dynamic activity in scientific dissemination events and other formats.

Most results related with dissemination activities exceeded the estimates included in the 2022 plan, with the participation in editorial roles increasing greatly in importance, when compared to the participation in the program committees of international events, and the number of conferences and workshops and scientific sessions organised by the R&D Centres.

Besides the INESC TEC Autumn Forum, not considered in the above numbers since those are limited to activities of the R&D Centres, several summer schools and advanced training courses were also organised. A special mention is due to the 10th Summer School VISUM - VISion Understanding and Machine Intelligence, held in July 2022, that gathered 75 participants from 18 countries.

The virtual alternative provided in many events, as hybrid format or full remote participation, had the virtuous consequence to reach world-wide participants who otherwise would not have participated.

3.10 Participation in other entities

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. In addition to the regular engagement in their activities, INESC TEC also actively participates in several Boards, Committees, and Working Groups, thus enhancing the gathering and sharing of knowledge with other leading experts in its fields of activity.

In 2022, INESC TEC joined 6 associations: 6G-IA, ATE, EASTRO, EBRAINS, RAIL CoLAB and STICHTING SPRINT ROBOTICS COLLABORATIVE. Furthermore, INESC TEC became the main shareholder of the company CEO - Companhia da Energia Oceânica.

Table 3.10.1 - INESC TEC's participation in other entities

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 3.10.1)*		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), RAIL CoLAB (railway).
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
Specific fields of knowledge	Energy	CIGRÉ, DERLab, EFFRA, EERA, EES-UETP, IEA Wind, WA4ES, ATE
	Industrial and Systems Engineering	EuRobotics, CERVIM, EtherCAT Technology Group, IDSA, ROS-INDUSTRIAL CONSORTIUM EUROPE
	Networked Intelligent Systems	EPIC, AIOTI, ETSI, 6G-IA, EBRAINS STICHTING SPRINT ROBOTICS COLLABORATIVE (Robotics)
	Computer Science	ERCIM, CENTRA
	Strategic Benchmark/network	INESC P&D Brasil, EARTO, ASTP Proton, EASTRO (Space)
COMPANIES		
CEO - Companhia da Energia Oceânica		In May 2022, INESC TEC became the main shareholder of the company CEO – Companhia da Energia Oceânica, owner of an Aguçadoura's test zone with grid connection (4 MW of power), capable of supporting the development and testing of marine renewable energy technologies (TRL ~5-8), as well as other multi-purpose marine structures, marine robotics, telecommunications, advanced sensing, collection of ocean and environmental data for model development, among others. Besides its strategic relevance in the domains of the Sea and Energy, it will enhance synergies with structuring initiatives in progress in terms of infrastructures, ongoing projects and R&D lines in various Centres.

3.10.1 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 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 2022

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 2022, INESC TEC was associated with twelve 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 2022 and the main developments in these fruitful relationships.

Table 3.10.2 - 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 2022	16
HR hired	30 HR hired by the CoLAB by the end of 2022
Base funding planned	1 804 M€
Competitive funding – submitted and approved proposals	Involved in more than thirty proposals raising many R&D services and consulting projects, as well as collaborative research and innovation projects both national and international. In addition to acquiring a financial volume of 7 507 M€ for the CoLAB, those projects represent a financial volume of 187 500 M€ for the forestry sector, fully demonstrating the exceptional mobilising capacity of this CoLAB (more than 100 partners have been involved) and the leadership in creating value and impact on the sector.
Main activities and achievements in 2022	2022 was the third year of activity of ForestWISE, which has now hired 100% of the 22 elements provided for in the RHAQ Plan. An enormous effort was made to attract projects and consolidate the CoLAB's position in the national and international arena. The activity recorded a sharp growth in the volume of projects, highlighting the procurement of services for companies associated with CoLAB and other public entities, as well as participation in European projects. There was a strong involvement in large-scale national projects that emerged under the PRR, namely in Components C12 (Sustainable Bioeconomy), C5 (Capitalisation and Business Innovation) and 6 (Qualifications and Skills). ForestWISE also participated in dozens of national and international events. Significant advances were made in strengthening contacts with associates, in the operationalisation of infrastructures, in the management model and in the internal organisation focused on four lines of work.
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. 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 three 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, many of them successful.

Table 3.10.3 - 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 2022	16 / 0
HR hired	10
Base funding planned	
Competitive funding – submitted and approved proposals	Submitted: 13 | Approved: 6
Main activities and achievements in 2022	National mapping of 30 entities and 182 infrastructures (associates + industry) related to R&D services. National mapping of 58 marine by-products from 137 entities. Provided Services to e.g., support the development of new products, the management of PRR applications and customised Funding Watch. Signed MOUs with international stakeholders. Active presence in media, social networks and engagement in Ocean Literacy actions. Development and participation in events e.g., B2E's events with local authorities with the presence of important stakeholders in the Blue and Bluebio Economy. Presence in relevant fair and expositions (Aquaculture Europe 2022) involving the associates.
Activities to foster Associates' involvement	Development of R&I projects with associates and tasks supporting the development of products and services. Support of the implementation of associates R&I priorities, providing new national and international funding opportunities and technology surveillance mechanisms. Promoting the associates' competences and technologies through internationalisation, supporting their integration in international networks and platforms (incl. representation).
Fulfilment of INESC TEC's strategic objectives related to this participation	Boost the Blue Bioeconomy sector, mainly aquaculture 4.0, by providing services to support the development of R&D projects (e.g., PRR, direct contracts, among others) and sharing funding opportunities.

Table 3.10.4 - CoLAB AQUAVALOR

CoLAB AQUAVALOR	
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 2022	28 / 1
HR hired	13
Base funding planned	
Competitive funding – submitted and approved proposals	631.908€
Main activities and achievements in 2022	Development of an intelligent and autonomous system for monitoring the environmental quality of Barroso GIAHS territory and a Digital Ecosystem for allowing access to environmental data that will support decision-making. Preparation of proposals for several competitive funding calls (FCT/BPI La Caixa Promove 2022). Provisioning of services related to the digital transition of the Agrifood sector. Development of new and innovative food products based on the endogenous resources of the Alto Tamega region (ex: natural mineral water); The organisation of international scientific and technical events (ex: AQUAFORUM'22).
Activities to foster Associates' involvement	Proposals to competitive funding calls (ex: FCT/BPI La Caixa Promove 2022); The 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 competencies 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 retaining highly qualified human resources and developing higher added value economic activities. So far, the COLAB's development aligns 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), from which we can highlight the provisioning of specialised services to the regional economy.

Table 3.10.5 - BUILT CoLAB

BUILT CoLAB	
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 2022	20 / 0
HR hired	27 HR were hired by the CoLAB by the end of 2022
Base funding planned	1 038 557,81€
Competitive funding – submitted and approved proposals	10 proposals for competitive were submitted (6 Horizon Europe, 1 “FCT – todos os domínios científicos”, 2 Agendas Mobilizadoras (PRR), 1 ERASMUS+). Participation in several others (decarbonisation namely) via future subcontracting of the submitting companies/entities.
Main activities and achievements in 2022	This year was marked by several successful milestones in the short history of BUILT CoLAB: the approval of the “Missão Interface” project (the base funding project until 2027), the approval of DIGITALbuilt (the EDIH), the first FCT project approved, a “agenda mobilizadora” approved (PRR), the presentation of the “National Construction Circularity Plan” (BUILT CoLAB’s authorship), the development of several business proposals with large potential of acceptance, and the conclusion of the “Future of Construction” SIAC project with a very successful and impactful event.
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; involvement in DIGITALbuilt (the EDIH); and the development of several bilateral projects that will support activities in the twin transition of partners.
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. Participation in several large national and European project proposals.

Table 3.10.6 - 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 2022	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 2022	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 3.10.7 - 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 2022	7 / -
HR hired	Fifteen (15) new HR have been hired in 2022 adding to existing 18 in 2021, with a total of 33 people at 31st December 2022
Base funding planned	Subsidies (state and other public entities): 1 178 372 € Donations: 536 175€
Competitive funding – submitted and approved proposals	**Horizon Europe**: Submitted proposals: 8 / Approved proposals: 2 (with a total budget: 332 k€). **PRR Agendas Mobilizadoras Fase 3**: Submitted proposals: 3 / Approved proposals: 3 (with a total budget: 16,2 M€). **Digital Innovation Hubs EU**: Submitted proposals: 1 / Approved proposals: 0
Main activities and achievements in 2022	SEL continued developing the main projects started in 2020 related with SEL continued developing the several projects started in the years before related with EV charging solutions, batteries for homes, 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 2022 leading to a considerable activity in this forefront.
Activities to foster Associates' involvement	Ideation 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 2023 through collaborative projects, EU funded projects and sub-contracting of advanced consulting and development projects.

Table 3.10.8 - 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 2022	10 / 2
HR hired	Transversal: 1 HRs | Pillar 1 (Redox Flow Batteries): 6 HRs | Pillar 2 (Supercapacitors): 5 HRs | Pillar 3 (Power Electronics and Energy Management): 8 HRs)
Base funding planned	709 k€
Competitive funding – submitted and approved proposals	• Cadeia de Valor das Baterias em Portugal - PRR Agenda focused on the development of sodium ion batteries and associated advances. • New Generation Storage - PRR Agenda focused on the development of energy storage solutions, namely using batteries. • i-STENTORE - Horizon Europe project, where the focus of VG CoLAB is on the implementation of a RFB demonstration prototype in the grid of EDM, in Madeira Island. IronFLOW - FCT
Main activities and achievements in 2022	Execution and completion of service contract for Simoldes Plásticos, with the development of the first sodium-ion coin cell in Portugal. Initiation of a service project for Efacec in the area of future trends in battery technologies, which resulted in interesting interactions with key players in batteries in Europe. Service contract for Litricity, GmbH, for the development of custom fuel additives. Signature of a second service contract with Efacec, to develop a high-flexibility modular DC/DC power converter prototype. This service contract is just starting and will be delivered in the first half of 2023.
Activities to foster Associates' involvement	VG CoLAB organised Scientific internal training programs oriented to all the Associates and presented the ongoing projects.
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 3.10.9 - CoLAB HYLAB

CoLAB HYLAB	
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 2022	12 / 0
HR hired	0
Base funding planned	N/A
Competitive funding – submitted and approved proposals	In 2022 no execution from funds related with the base financing took place. However, in December 2022 the first payment of the strategic funding in the amount of 442 k€ was received.
Main activities and achievements in 2022	HyLab hasn't started its scientific activities.
Activities to foster Associates' involvement	Several meetings, at the management level, took place with the associates to prepare common projects and identify human resources needed by HyLab.
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 3.10.10 - 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 2022	195/18
HR hired	46 (33 from Associates + 13 from staff)
Base funding planned	370 k€
Competitive funding – submitted and approved proposals	18 proposals submitted | 8 proposals approved
Main activities and achievements in 2022	Ongoing activities: - Development and implementation of new technologies, products and strategies to reduce copper application (Project COPPEREPLACE); - WICA - Wine Innovation Collaboration Alliance, from the project EPAWI, which aims to provide response to the challenges presented by grape and wine producers through intersectoral innovation, with the participation of auxiliary companies and the collaboration of Business Support Organisations (BSO); - Development of an automated platform to explore the metabolic pathways of the grapevine in order to understand in situ the physiology and metabolism of the vine (Project OmicBots); - Development of a low-cost sensor network that allows spatial evaluation of water stress in the vineyard in real time; - Collection of viticultural, climatic and biological information, in order to support the decision making of the economic agents in the sector's economic agents, as well as to contribute to the development of models, namely of phenology, diseases and pests.
Activities to foster Associates' involvement	- Frequent communications with the Associates related with results/databases compiled by the CoLAB; - Workshops / Seminars; - Technology/machinery demonstration sessions in the vineyard; - Activities related to the ongoing projects; - Collaboration for partnerships in project applications.
Fulfilment of INESC TEC's strategic objectives related to this participation	ADVID is definitely a valuable partner as the participation in the CoLAB allows to easily put in place the "innovation triangle" in the wine sector, consequently increasing the chances for collaborative R&I projects in the sector, with countless examples of this fruitful collaboration.

Table 3.10.11 - 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 2022	18 / 1
HR hired	5 assigned by the associates and 8 hired by the CoLAB, in March 2023 a total of 14 HR's from the CoLAB
Base funding planned	1.2M€ from October 2020 to October 2023; 1,1M€ approved from the Interface mission starting in October 2023 until March 2026
Competitive funding – submitted and approved proposals	In 2022: 10 competitive proposals submitted (~1,2M€ applied budget), 2 approved (1HEurope, 1 Mobilizing Agenda in an aprox. Total budget for the CoLAB of 600k); successful application to the Interface Mission ensuring for the CoLAB a total of 1.1M€ base funding approved to start in 2023.
Main activities and achievements in 2022	Main activities: - Establishment of steady national and international networks that allow FeedInov CoLAB to position as the main reference interface structure in the livestock sector, and as a privileged partner. - Publication of MSc thesis in collaboration with IST on foresight scenarios on consumption of animal products. - Publication of 3 good practices manuals for the compound feed industry in collaboration with IACA. Main achievements in 2022: - Approval of the first competitive proposals, one of them a European CSA action, marking after 1,5 years of starting its activity, the start of the 1/3 competitive funding. - Start of collaborative research services, with two signed contracts, contributing to the 1/3 private funding.
Activities to foster Associates' involvement	All associates have a place in the General Assembly. 1st Collaborative meeting for associates held presential in EZN for brainstorm and engagement. Regular B2B meetings with Associates. BSc, MSc theses is collaboration with Associates
Fulfilment of INESC TEC's strategic objectives related to this participation	FeedInov CoLab continues to reveal itself as a very promising partnership as until INESC TEC had joined the CoLAB, there wasn't a relevant activity regarding Zootechny in a broad sense but the situation is changing and results of the collaboration are appearing.

Table 3.10.12 - 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 2022	17
HR hired	8
Base funding planned	1.1 M€ (3 years base funding *Missão Interface*)
Competitive funding – submitted and approved proposals	22 proposals submitted (17 national proposals and 5 international) |4 national proposals approved (1.7M€ raise funding)
Main activities and achievements in 2022	Redefinition of the SFCOLAB's innovation agenda for the next three years (2023-2026), based on 4 major strategic lines of action: i) innovation, ii) training, iii) digital technologies awareness and iv) services and products for the agro-sector. Strong approximation with the agro-sector through project proposals and dynamisation of events. Development of specific projects with Associates such as i) development of the chill hours prediction model for the orchards (ImpactWave), ii) installation of SOFIS demonstrator in Aquaponics system (CMTorres Vedras), iii) pedagogical actions with the students from the Escola Profissional Agrícola Fernando Barros Leal (AVA), project management support (Adega Cooperativa de São Mamede da Ventosa, AVA, Quinta do Pinto), among others. Workshops & Training: Sprayer Calibration Workshop (ISA), internship program host, Precision Agriculture Workshop (Brasil and Portugal). Low-cost technological solutions for the agro-sector: validation of the low-cost hardware (sensors, micro-processors, communication devices), software, transmission communication protocols and database platforms. Diagnostics for the installation of low-cost technological pilots for crop monitoring at national level, under on-going projects. Signed collaboration protocol with ESRI, APAS, AIHO, CR-INOVE. Awards: honorable mention by COTEC, in the Innovation in Ecosystem Xperience 4.0 contest, Innovation Summit 2022. Other participations: participation in different interviews highlighting the participation in the TV program "Sociedade Civil" da RTP.
Activities to foster Associates' involvement	SFCoLAB organised: two sessions of "Espaços de Dialogo" for the fruticulture and viticulture in Óbidos and Torres Vedras, respectively; IV Fórum Agriculture 4.0 (70 participants); in collaboration with CONFAGRI the Precision Farming Workshop; SFCOLAB vai à Escola in which received students from the Escola Profissional Agrícola Fernando Barros de Leal; Dia Aberto under the Tech@Week (ANI) and in which technological roadmap for the Agriculture 4.0 was presented. Other participations of SFCOLAB to foster and advertise it's Associates: Presence at the Feira de São Pedro in Torres Vedras (stand); Presence at the 1st Feira de Inovação do Fundão (stand and dynamisation of some conference sessions); Publication of technical papers; Participation in Portuguese and international networking.
Fulfilment of INESC TEC's strategic objectives related to this participation	Due to its nature (digital innovation in agriculture), there are obviously overlaps, not being clear how the participation in the CoLAB may add real value to INESC TEC activities and therefore a continuous monitoring and evaluation of the membership should be performed to ensure 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 2022.

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 2022

Novel perception tools

The main scientific outcomes produced during 2022 were the following:

- Characterisation of laser direct writing in Ultra Low Expansion (ULE) glass; this includes direct writing of waveguides plus the possibility of glass micromachining;
- Fabrication of reference cavities which are insensitive to temperature variations. These cavities were employed in the fabrication of high-resolution temperature sensors for applications in space (tens of microKelvin);
- Fabrication of long, uniform and glass embedded 3D metallic electrodes glass, using micromachining capabilities, for optical signal processing applications;

- Large area microfluidic devices for biomedical research were produced having in mind vesicle separation. These devices find use in liquid biopsy applications;
- Development of Fabry-Perot cavity sensors with a sensitivity of 100 micrometers at 50 Kelvin, and with a dimension of 80 mm;
- Development of a White-light interrogation system for absolute temperature measurement and with the ability to read at 1kHz;
- Fabrication of a high-power laser at 1550 nm for micro-thermoelectric generators arrays. The laser was manufactured in erbium-doped fibre using a multimode fibre;
- 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;
- 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;
- Implementation of a processing pipeline for LIBS analysis of complex mineral samples. These tools enable decision making in real operational scenarios in the raw material sector;
- Development and deployment of an experimental setup for the realisation of quantum light fluid analogues;
- Discovery of quantitative early gait alterations in Hereditary Amyloidosis neurodegenerative disease patients.

Beyond human vision

The main scientific outcomes produced during 2022 were the following:

- Novel deep-learning approach to Lung CT image processing;
- A novel end-to-end lung cancer characterisation, using CT images, using a semi-supervised approach;
- Near-real-time pathological motion detection for clinical neurology use;
- Novel algorithm that achieves state of the art results in unsupervised multi-source domain adaptation;
- A more rigorous privacy-preserving methodology capable of anonymising case-based explanations without compromising their explanatory value;
- Definition of a challenging, realistic, and diverse, publicly available occluded face recognition benchmark.

Context-aware communication systems

The main scientific outcomes produced during 2022 were the following:

- Novel antenna array design method demonstrated at 12.5 GHz enabling the reduction by 25% of the number of phase shifters of a beam-scanning reflect-array;
- Simple and fast method for calculating broadband spectral optical properties of biological tissues, which can be used to develop light propagation models for diagnostic and treatment procedures;
- Traffic- and energy-aware placement algorithms for slicing-aware aerial networks that enable significant gains in network performance and resource efficiency against state-of-the-art counterparts;
- Machine Learning based path loss modules enabling digital twins of wireless networks in ns-3;
- Simulation platform for multimodal underwater communications enabling faster evaluation of underwater data muling communications solutions and the reproduction of past experiments;

- World first demonstration of successful integration of Thin-Film-Transistor (TFT) and memristor, resulting in proof-of-concept for cost-effective, flexible artificial neural networks hardware.

Autonomy of robotic systems

The main scientific outcomes produced during 2022 were the following:

- Design and validation of a varying buoyancy module for use in autonomous underwater vehicles;
- Algorithm for the optimal sensor placement for underwater vehicle localisation;
- Algorithm for processing hyperspectral images for the remote detection and classification of marine litter, based on zero-shot learning;
- Definition of multicriteria metrics for the evaluation of motion planners for underwater intervention;
- Algorithm for the detection of multiple vessels in harsh maritime environments;
- Design and deployment of a modular multi-domain aware autonomous surface vessel for inspection activities;
- Development and testing of the first underwater system in the world for the capture of deep-sea species and their transport to the surface ensuring the same pressure and temperature condition.

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 builds (Figure 4.2.1) 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.

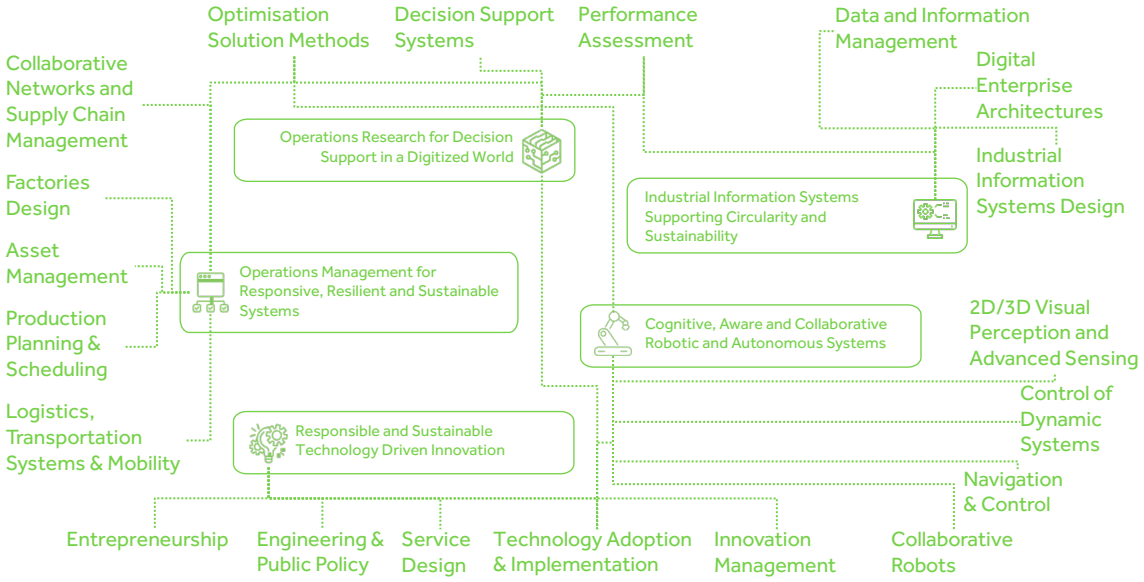


Figure 4.2.1 - Interaction between research lines and areas of competence in the ISE domain

4.2.2 Scientific outcomes in 2022

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).

Among the 2022 scientific outcomes associated with this challenge, the following are highlighted: advances in the integration of pricing and fleet management for shared mobility systems; development of policies to tackle perishable products waste in grocery retailing; advanced optimisation algorithms for pallet loading, aiming at integration into intelligent systems controlling intralogistics flows and robotic palletization; simulation-optimisation to manage disruptions in biomass supply chains; new approach to WIP management in Assembly Manufacturing Systems based on reinforcement learning; application of Digital Twins to Complex Infrastructures and Environments; reference architecture and simulation model to support strategic decision-making in the design of more efficient, flexible, resilient, and sustainable pharmaceutical supply-chains; examination of the main trends and vulnerabilities faced by European supply chains; exploration of the development of circular supply chain models in different sectors; studies of the role of visibility and trust in information sharing between supply chains partners, and buyer-seller power relationships in digital transformation of SMEs; decision support tool for design and assessment of innovative services in “last mile” urban logistics, focusing on environmental impact; design of use cases and modelling of physical and data flows for smart green ports.

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.

From INESC TEC’s activity in 2022, the following scientific outcomes in the scope of this challenge are worthy of highlight: new models and algorithms incorporating uncertainty in cutting and packing problems; availability of the first version of the TRUST-AI framework, allowing users to run any algorithm, and integrating interfaces to interact with genetic programming, while managing computing resources.

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.

Among the 2022 scientific outcomes associated with this challenge, the following are worthy of note: a multi-robot coordination system, considering communication failures; AgRobPP and VineSlam modules upgraded with new features for agricultural contexts; configurable, modular, portable, and unified architecture for a robotic grasping planner; object detection pipeline with deep learning, complemented by blender-based tool to speed up AI model training; two variants of Variable Rate Technologies with advanced perception systems for precision

spraying robots; portable solution for projected spatial augmented reality, using short throw projectors and smaller sensing devices; augmented reality-based system to improve human-robot interaction and safety in collaborative workspaces; development of the FollowMe module for robots following individuals performing agricultural tasks, using time-of-flight based sensors and a visual camera; advanced but intuitive Human-Robot-interfaces for the smartphone and Android ecosystem; exploration of tethered drones and quadruped robots for application on industrial and agricultural robots; AI-based solution for the Digital Twin component of the Open Scalable Production System (OSPS), benefiting from the integration of cloud-based services; enhancement of the OSPS framework with support for ROS2, and integration with the Robotics and Automation MarketPlace (RAMP); expansion of the AgIoT module features.

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.

The following scientific outcomes in the scope of the challenge are worthy of highlight: qualitative and quantitative studies to understand citizen engagement behaviours and drivers, cocreation workshops, and development of new approach and tools to build engagement strategies, in the scope of sustainable energy transitions; reviews of human-robot collaboration; study on manufacturing industry in the North of Portugal; study of the value of operations analysis for digital transformation using digital twins; an “Open Innovation Campaign Handbook”, to support international campaign implementations.

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 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 2022 scientific outcomes in the scope of this challenge are worthy of note: advances in interoperability architectures for inter-organisational data and information management; abstract digital solutions for vertical and horizontal integration of value chains exploring International Data Spaces; study of the role of Industry 4.0 reference architectures in digital transformation, based on boundary objects; review of the Cognitive Digital Twin concept as enabler of Product-Service Systems.

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 organisations 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.

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 2022

An overarching objective for the domain in 2022 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 Data Streams track at ACM SAC 2022; the IoT Stream for Predictive Maintenance and SoGood workshops at ECML/PKDD; the KDBI stream at EPIA 2022; the ORSUM workshop at RecSys; the International Conference of Innovative Technologies and Learning; the Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion; the International Conference on Technology and Innovation in Learning, Teaching and Education; the LinkedArchives'22 workshop in TPDL'22; the 15th IEEE International Conference on Software Testing, Verification and Validation; the International Conference on the Art, Science, and Engineering of Programming; the 22nd IEEE International Conference on Software Quality, Security, and Reliability; the 22nd International Conference on Agile Software Development; and the International School and Conference on Network Science. João Gama was program chair of PAKDD 2022 and published a special issue of the Machine Learning journal. Sandra Alves was elected Executive Officer of ACM SIGLOG. Other events included: MUG 2022, to promote the adoption of advanced computing techniques and engagement with its operational team and a Spring School on formal methods for reactive and quantum systems.

A MoU has been signed with DITTO - Digital Twins of The Ocean, a program endorsed by the UN Decade of Ocean Science for Sustainable Development (2021-2030). Participation in the European **Network of Excellence on Artificial Intelligence** is ongoing.

The RISC2 European project won the HPCwire Editor's Choice Award for Best HPC Collaboration. The SIS^1 project was a finalist in the Portugal Digital Awards, for "Best Insurance Project". Bruno Loff won an ERC Starting Grant with a project on meta-complexity entitled "The hardness of finding good algorithms". Ricardo Campos won 3rd place at this year's edition of the Arquivo.pt award.

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 2022, researchers in this domain produced 75 (down from 88) Q1 journal papers, 18 (up from 16) CORE A and 5 (up from 4) CORE A* conference papers. As a whole, in 2022, researchers in this domain published 126 (down from

136) papers in indexed journals and 178 (up from 170) papers in indexed conferences. Collaboration with the P&E domain resulted in two new Invention Disclosures (ID) with five more IDs from advances in a software ecosystem for real-time processing of geospatial data streams (project MELOA).

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

Contributions towards explainable AI included a survey on causal discovery and inference methods[1]. On Natural Language Processing, contributions included improvements on Neural Language Models, published[2] in Artificial Intelligence, and Narrative Extraction[3].

The generation and evaluation of synthetic data was improved by using Generative Adversarial Networks (GANs) to create synthetic tabular data for textual data augmentation and defining metrics to evaluate the quality of the synthetic data created, both on a statistical and utility basis.

Multiple contributions targeted the fundamentals of graph mining and time series analysis, including: the summarisation of large and massive semantic graphs using a quotient graph approach based on an equivalence relation on URIs; the development of a novel concept of spatial network motifs able to characterise networks with spatial features; and improved centrality measures in specific networks[4].

Multiple contributions regarding deep learning applications included: the development of deep learning models with applications to Biology (automatic species identification[5]); in astrophysics, the automatic determination of stellar parameters from spectra datasets; on indoor location by determining the location within a building based on models trained on Bluetooth RSSI measures or on video frames grabbed in loco; waste collection[6]; bioinformatics[7]; and cohort studies in medicine[8]. Data science in port management is being explored in Port XXI, funded by ESA**.** Sensor-based perception for autonomous vehicles is being improved with project Theia, with Bosch Braga.

Contributions in multisensory AR/VR explore the impact on the user's sense of experience[9], namely presence[10] and enjoyment[11] applied e.g. to cultural heritage exploration[12]. Linked data are being explored for interaction and visualisation[13]. Developments in fundamental research and prototyping in 3D multimodal interaction in immersive environments include shape-changing haptic devices, DeskVR[14] interaction, and Immersive visualisation. Contributions to immersive training include a recommendation platform and a framework for the assisted creation and edition of collaborative virtual environments [15].

A fusion of state-of-the-art AI algorithms with human computation macro tasks (next generation crowd computing) is being used to analyse scientific publications to reveal patterns and gaps.

Methods and tools to boost the quality of future software systems

Research on formal specification languages and code quality included a new extension to the Alloy language to address quantitative problems, published[16] at ESEC/FSE, one of the top CORE A* conferences in the area. The concept of quantamorphisms was proposed to simplify the programming of quantum computers, published[17] in the IEEE Transactions on Software Engineering (IEEE TSE), the top journal in the software engineering area. Another result showed the relation between quantum memory usage in any quantum algorithm and in its simulation. Contributions on software engineering for the cloud[18] and for HPC[19] were also published in the IEEE TSE. On logic programming, we highlight a survey in parallel logic programming and the development of a type

[1] https://doi.org/10.1002/widm.1449
[2] https://doi.org/10.1016/j.artint.2022.103661
[3] https://doi.org/10.1007/978-3-030-99739-7_32
[4] https://doi.org/10.1093/comnet/cnac031
[5] https://rubisco.dcc.fc.up.pt/biolens
[6] https://doi.org/10.1007/978-3-030-93733-1_20
[7] https://doi.org/10.1186/s12859-022-05065-3
[8] https://doi.org/10.1038/s41598-022-13946-z
[9] https://doi.org/10.1109/TVCG.2020.3010088
[10] https://doi.org/10.1007/s10055-021-00530-5
[11] https://doi.org/10.1007/s00530-022-00898-7
[12] https://doi.org/10.1016/j.cag.2021.10.001
[13] https://doi.org/10.1145/3485731
[14] https://doi.org/10.1109/VR51125.2022.00041
[15] https://doi.org/10.1109/TLT.2022.3157065
[16] https://doi.org/10.1145/3540250.3549154
[17] https://doi.org/10.1109/TSE.2021.3117515
[18] https://doi.org/10.1109/TSE.2021.3052177
[19] https://doi.org/10.1109/TSE.2020.3001257

system for Prolog. A generic high-level interface implementing synchronisation procedures for memory reclamation in lock-free data structures is being studied. Research on source-to-source compilation is ongoing. Live code refactoring has also been addressed [1].

Tools and techniques developed to help verify infrastructure safety rules in railway network models resulted in a publication[2] in MODELS (renowned CORE A). A method and tool for testing robotic systems developed with ROS won the Best Paper Award at the ENASE conference.

Performance, interoperability, and dependability of critical information systems

Work on partitioned Bloom filters in the design of data structures, applicable to indexing in distributed databases, was published[3] in the IEEE Transactions on Computers, one of the top journals in computer science. Different strategies for offloading tasks in hybrid topology clouds are being implemented and evaluated[4]. Research on filesystem-based fault-injection has resulted in a prototype[5] already used to highlight long-standing issues in database durability. Storage-level performance has been addressed with a framework[6] for data planes, with implementations optimised for HPC and key-value stores. Related research addressed the advancement of Deep Learning on HPC[7]. Issues with metadata intensive applications have also been addressed [8].

On interoperability, project ILIAD defined a reference architecture to enable on-demand interoperable processing requests to the underlying models of the Digital Twin of the Ocean. Projects InterConnect and ENERSHARE (collaboration with P&E domain), and CircThread (collaboration with the ISE domain) are ongoing. The collaboration with the P&E domain on interoperability resulted in a publication[9] at WSDM, a CORE A* conference.

Trustworthy control of data confidentiality and provenance

Research contributions include methods for the prediction of user preferences in mobile devices in a privacy-preserving manner and controlled, policy-based, confidential searching/sharing of Indicators of Compromise (IoC) through encrypted search mechanisms and a shared encrypted reverse-index. A middleware-based approach for data access management with flexible and dynamic policies in a blockchain has been developed as a result of the SIS^1 project. A project focused on the design and implementation of the novel architectures using federated repositories, privacy-preserving mechanisms to support federated machine learning, and blockchain-based mechanisms for tracing data transformations is ongoing. An improvement on Searchable Symmetric Encryption, leveraging TEEs, was published[10] in IEEE Transactions on Dependable and Secure Computing. An extension for Chrome to detect manipulated photos in a webpage was developed.

An evaluation of blockchain for identity management (IdM) focusing on privacy-preserving approaches and its applications to healthcare scenarios in on-going.

[1] https://doi.org/10.1145/3551349.3559532
[2] https://doi.org/10.1145/3550355.3552439
[3] https://doi.org/10.1109/TC.2022.3218995
[4] https://github.com/jqmmes/jay
[5] https://github.com/dsrhaslab/lazyfs
[6] http://authenticus.up.pt/P-00X-BHA
[7] http://dx.doi.org/10.1109/ccgrid54584.2022.00011
[8] https://doi.org/10.1109/CLUSTER51413.2022.00075
[9] http://dx.doi.org/10.1145/3488560.3508496
[10] https://doi.org/10.1109/TDSC.2020.3012100

4.4 POWER AND ENERGY

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 optimisation 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 2022

Massive RES integration through power electronic-based interfaces

The main scientific outcomes produced during 2022 were the following:

- Optimisation tool to determine the most adequate share of hybridisation technologies for existing offshore farms (Wind+Wave+Offshore floating PV) considering meteocean data – EU SCORES;
- Rule-based adaptive control strategy for grid-forming inverters in islanded power systems for improving frequency stability (PhD work of José Gouveia concluded in 2022);
- Fault-ride-through strategies for grid-tied and grid-forming smart-transformers suited for islanding and interconnected operation in multi microgrids (PhD work of Justino Rodrigues concluded in 2022);
- Methodology and tool to size H2 facilities for security of supply purposes based on the outcomes of the Sequential Monte Carlo Simulation (PhD work of Bruno Santos);
- Quantification of the benefits of electrolizers participating on automatic frequency restoration reserve and frequency containment reserve (SEST 2022).

Large-scale modelling and optimisation of energy systems

The main scientific outcomes produced during 2022 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 because 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 and test with real data of a digital twin in MATLAB® Simulink for photovoltaic power plants, focused in generating faults of power converter electronics (AI4PV project);

- New stochastic security constrained multicriteria unit commitment, with temporal trajectories of renewable production and the operators set goals for operation cost, required additional power, RES curtailment, and compliance with the dynamic security constraints (Smart4RES project);
- Experiment conducted with 105 participants from the energy industry in the framework of IEA Task 26, to investigate existing psychological barriers in the industry to adopt probabilistic forecasts and to better understand human decision processes (published in Meteorological Applications journal);

Data-driven methodologies for energy systems

The main scientific outcomes produced during 2022 were the following:

- Methodology and software tool to segment medium voltage grids into grid zones, enabling the DSO to publish flexibility needs per grid zones (EEM 2022);
- Methodology and tool for planning the expansion of generation systems with uncertainty, based on Monte Carlo Tree Search (PhD work of Tiago Abreu);
- Methodology and tool to size H2 facilities for security of supply purposes based on the outcomes of the Sequential Monte Carlo Simulation (PhD work of Bruno Santos);
- Predictive network coordination framework (EUniversal project), that can forecast technical problems in MV and LV networks and coordinating the mobilisation of flexibility resources (CIRED 2022);
- Data-driven method based on smart meter data, to estimate sensitivity factors, for three-phase unbalanced LV grids, respecting a privacy-preserving protocol (PSCC 2022, EPSR journal);
- Development of a social welfare maximisation framework for data markets in renewable energy forecasting (Smart4RES, ENERSHARE and GreenDataAI);
- Preliminary model for the MIBEL market model (CEVESA) optimal allocation of the interconnection capacity among single-price areas for both energy and automatic frequency restoration reserve*;*
- A general framework for energy sharing and settlement of renewable energy communities, including advanced business models (EEM 2022);
- A P2P-validation tool that simulates a local energy market with positive or real dynamic allocation coefficients and activates local flexibility (Energies)*;*
- Methodology and software tool to segment medium voltage grids into grid zones, enabling the DSO to publish flexibility needs per grid zones (EEM 2022)**;**

Health conditions of electrical assets under smart grid operation

The main scientific outcomes produced during 2022 were the following:

- CEVESA reengeniering to include hybridisation to improve its outputs based on real market data (EEM 2022), to allow for multiple renewable generation profiles and to improve maintainability;
- Improvement of the lithium-ion battery model through a thermal model (ISGT Europe 2022) in the Smartglow project;
- Methodology and tool to assess the reliability of distribution systems with storage, renewable generation, and demand response, via Pseudo-Sequential Monte Carlo simulation (PhD Inês Trigo);
- Predictive network coordination framework (EUniversal project), that can forecast technical problems in MV and LV networks and coordinating the mobilisation of flexibility resources (CIRED 2022).

Cybersecurity and IOT for electrical infrastructures

The main scientific outcomes produced during 2022 were the following:

- Data-driven method based on smart meter data, to estimate sensitivity factors, for three-phase unbalanced LV grids, respecting a privacy-preserving protocol (PSCC 2022, EPSR journal);

- Microservice for assessing the consumer flexibility response to assess the behavioural response of consumers to dynamic incentives, helping retailers and aggregators to identify responsive consumers and their expected reliability to provide flexibility (InterConnect project);
- Design and implementation of the fourth generation of a home energy management system (HEMS) within the InterConnect project. Acting as a SAREF-based hub of services for demand side flexibility, it can optimise the energy use for market-based services, including the support to energy communities;
- Implementation of an ISO 15118 smart EV charger with edge computational capabilities supporting traditional centralised management platforms as well as distributed management of chargers.

5 TEC4 INITIATIVES

5.1 Overview

A TEC4 ("TEChnologies FOR …") is an organisational approach aiming at structuring the market-pull innovation process, as opposed to the science-push that occurs naturally in the Research Centres. This supports the establishment of the adequate balance between the two complementary dynamics and supports the full knowledge-to-value chain.

The short-term objectives of the TEC4 initiatives are the creation of innovative, knowledge-based solutions and services, with high export potential, based on internationally competitive research and innovation capabilities, contributing to the resilience and growth of the Portuguese economy. Their long-term objectives comprise the identification of scientific and technical challenges, embracing multiple specialities, involving and exploiting the full potential of INESC TEC in application domains that are easily understood and incorporated by businesses. Creating and maintaining these virtuous innovation cycles within each TEC4 is the main medium to long-term challenge.

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

The application areas addressed by the TEC4s are aligned with European, national and regional priority domains, developing and consolidating internal R&D competencies around socio-economic pillars. Furthermore, the attraction of international partners to the TEC4 initiatives, supports INESC TEC internationalisation strategy, facilitates the national companies an easy access to international partners and enables the attraction of foreign direct investment into the region and the country.

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

Typically, a TEC4 encompasses:

- A concrete market domain, represented by businesses and associations;
- A group of centres with their multidisciplinary competences, dedicated to the challenges of that market domain;
- An R&D infrastructure that supports the scientific and innovation activities and provides added value services to businesses that cannot be found in the market.

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

- Identification of market segments where INESC TEC competencies can create value;
- Identification of internal research lines with highest potential impact in business – based on the assessment of market needs;
- Identification of the R&D infrastructure (i.e., laboratories, equipment, demonstration facilities and other technical means) supporting the offer of added value services to businesses;
- Identification of new potential partners and stakeholders that can bring added value to the 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.

5.2 Main achievements in 2022

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	640
New entities	159
Entities already existing in our database	481
INTERNATIONAL COMPANIES MEETINGS/CONTACTS	349
New entities	200
Entities already existing in our database	149
PROPOSALS	
DIRECT CONTRACT SUBMITTED PROPOSALS	62
Mono centre proposals	52
Inter centre proposals	10
INESC TEC Global value (K€)	4441
DIRECT CONTRACT ADJUDICATED PROPOSALS	31
Mono centre proposals	26
Inter centre proposals	5
INESC TEC Global value (K€)	1365,09
EUROPEAN PROGRAMS SUBMITTED PROPOSALS	43
Mono centre proposals	24
Inter centre proposals	19
INESC TEC Global value (K€)	26922,5
EUROPEAN PROGRAMS ADJUDICATED PROPOSALS	17
Mono centre proposals	12
Inter centre proposals	5
INESC TEC Global value (K€)	10292
NATIONAL I&D SUBMITTED PROPOSALS	38
Mono centre proposals	14
Inter centre proposals	24
INESC TEC Global value (K€)	44077,8
NATIONAL I&D ADJUDICATED PROPOSALS	22
Mono centre proposals	9
Inter centre proposals	13
INESC TEC Global value (K€)	25350,4
EVENTS PARTICIPATION (conferences, trade fairs, etc.)	229
EVENTS ORGANISATION (conferences, trade fairs, etc.)	17
INTERNAL MEETINGS	391
NEW STRATEGIC PARTNERSHIPS	11

5.3 TEC4AGRO-FOOD

Coordinator: Filipe Neves dos Santos

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-creating 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.

TEC4AGRO-FOOD has as main application areas Smart (digitalisation) Precision ("right time, right amount, right place") Agriculture and Forestry, Food Security and Bioeconomy. TEC4AGRO-FOOD may act in all phases of the smart precision agriculture/forestry cycle, from variability measurement to action with variable rate technologies (VRT), encompassing data analysis and decision and prescription map:

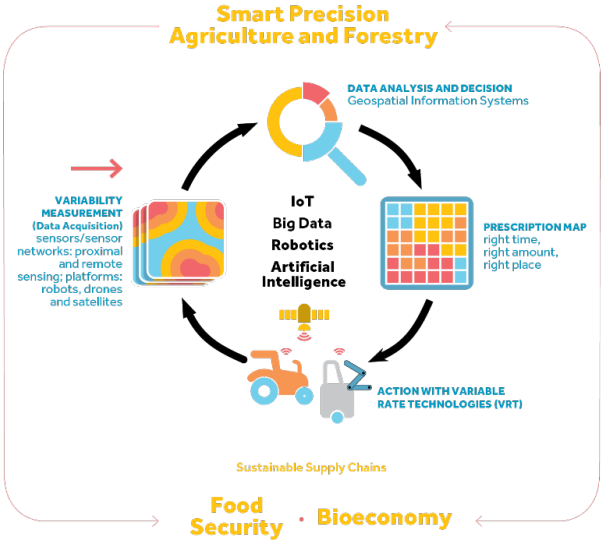


Figure 5.3.1 - Precision Agriculture/Forestry Action Cycle

TEC4AGRO-FOOD provides innovation services of advanced 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 2022

Continuing to follow the overall strategy of full implementation of the projects' portfolio and redouble efforts with companies and at international level, as well as the strategy defined in the TEC4AGRO-FOOD's Strategic Plan, in 2022 TEC4AGRO-FOOD pursued 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 reached a sustainable position regarding research and innovation programmes, namely H2020 and HEU. 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) should also be highlighted.

TEC4AGRO-FOOD's main achievements in 2022 are presented below:

- Completion of TEC4AGRO-FOOD's Strategic Plan;
- Prizes:
  - ✓ Entrepreneurship and Innovation Crédito Agrícola 2021: (Agro-Industry 4.0) SpecTOM (5.0k€) (CAP, CRIIS, SAL and TEC4AGRO-FOOD) and (BfK) Smart Trap (HumanISE, CRIIS, SAL and TEC4AGRO-FOOD);
  - ✓ "R&D that Marks" VIDA RURAL 2022: Metbots (CAP and CRIIS);
  - ✓ IF Design award prize 2022: Weta Robot (SCORPION project) (CRIIS).
- INESC TEC projects' external events/final events: Final Webinar INFRAVINI; PRYSM - Final Demonstration; FDCONTROLO: Field Day; SPIN: Field Day;
- Conclusion of CholdaDIGITAL (HumanISE and CTM);
- National Programmes approvals:
  - ✓ (PT2020 Copromotion Projects) FLOREST@ (93.9k€) (HumanISE);
  - ✓ (RRP Agendas) Vine & Wine PT (1 058.1k€) (CRIIS), transForm (1 802.1k€) (CESE, CAP, CEGI, CITE, CRIIS and HumanISE) and InsectERA (895.1k€) (CRIIS, CEGI and CITE);
  - ✓ (RRP Initiatives Portfolio) Wine4cast (169.3k€) (CRIIS and CAP) (FCUP coordinator) and PhenoBot (300.0k€) (INESC TEC coordinator) (CAP and CRIIS);
  - ✓ (FoodLoop) Urban Robotic Gardens (CRIIS).
- European Programmes approvals:
  - ✓ (HEU) (first stage) (HORIZON-CL6-2022-FARM2FORK-02-04-two-stage) OpenAgroAccess (277.8k€) (CRIIS);
  - ✓ (DIGITAL-2021-EDIH-INITIAL-01) Seal of Excellence SFT-EDIH (CRIIS);
  - ✓ (HORIZON-CL6-2022-FARM2FORK-01-11) WATSON (425.1k€) (CTM and CRIIS);
- R&D Services and Consulting - International approval: (SmartAgriHubs) DivaX (22.9k€) (CITE and CTM);
- Events: AgroIN 2022 (sponsor as "RTO Partner"); SmartAgriHubs Final Event; The Twin Revolution as seen from the Future - INESC Brussels HUB Summer Meeting; VIDA RURAL Conferences "(R)evolution underway in winemaking" (with Mário Cunha (CRIIS) as keynote speaker);
- 4th edition of INESC TEC Science & Society magazine: "Digital (R)evolution in Agro-Food and Forestry";
- Visits to INESC TEC: Elvis Fusco, CEO of Shunji Nishimura Technology Foundation; East Lapland (ERDF Project).

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 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 25 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. Domains involving wind energy (on-shore and off-shore), solar PV generation, energy storage systems, electric mobility and planning and operation of islanded system are the ones where TEC4ENERGY had a larger activity in leveraging new projects. Also the distribution of natural gas with the incorporation of hydrogen or renewable gases became an area of further development.

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 2022

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 also 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, 2022 was a consistent year in what regards new flagship projects. It can be highlighted the approved European funded projects *SINNOGENES*, *iSTENTORE*, and contributions for the submission of *AI4REALNET* and *RE2GRID* projects, representing a total of 1.7 M€, where

TEC4ENERGY played a relevant role. In 2022 there was also the materialisation of two important National funded PRR projects, *H2Driven e NEXUS,* with an accumulated revenue of 4.4 M€.

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 2022, 22 national direct R&D contract proposals were submitted to the energy sector (13 of which successfully approved and 8 still waiting for decision). To stress the development of projects in the field of natural gas distribution, like the ones with Portgás and Dourogás. These national direct R&D contract proposals amounted to 810 k€. The 13 approved projects led to an income of 485 k€.

At international level, it was leveraged the emergence of some direct R&D and consultancy proposals such as *Grid_In_CM (EDF)*, *PV_STORAGE_PT (Lightsource BP)*, that constitutes a total of 50 k€.

The contract Program with EDP, involving namely E-Redes and EDP Generation, was pursued also during 2022, with relevant contracts.

In total, TEC4ENERGY successfully leverage in 2022 a set of National and EU projects, including pluriannual propositions, that will lead to a total of expected income for INESC TEC of 5.5 M€.

5.5 TEC4HEALTH

Coordinator: Miguel Coimbra

Business Developer: Carlos Alexandre 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, seeking to promote synergies with its partners and leading to the development of successful projects, contracts and technology transfers.

TEC4HEALTH monitors results in the TRL range 5-9 and focuses on applied research leading to products, processes and services that can be transferred in broad areas of application: *i)* healthcare providers (primary, secondary and long-term care); *ii)* auxiliary diagnostic and therapeutic means; *iii)* life support and monitoring (medical devices, e-health, m-health); *iv)* pharmaceutical, pharmacy and clinical life science industries.

Mapping the experience of INESC TEC with current worldwide scenario led to the identification of key challenges to continue to be addressed in the next years: cancer (breast, lung, colorectal, stomach, uteri and esophagus), neuro/brain diseases (epilepsy, depression, Parkinson and Alzheimer), cardio and respiratory diseases and active healthy living. INESC TEC's innovation services in artificial intelligence, biomedical instrumentation, information systems, medical robotics and health management make it a very attractive research institute for any type of partner working in these health challenges.

The centres with scientific and technological competences more aligned with TEC4HEALTH challenges are: CAP (Applied Photonics), C-BER (Biomedical Engineering Research), CEGI (Management and Industrial Engineering), CITE (Innovation, Technology and Entrepreneurship), CTM (Telecommunications and Multimedia), HumanISE (Human-Centered Computing and Information Science) and LIAAD (Artificial Intelligence and Decision Support).

5.5.2 Main achievements in 2022

The activity of the TEC4HEALTH 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;
- Participation in the WG of Health Technologies of the INESC Brussels Hub: regular meetings to prepare a strategic roadmap for the next 10 years, participation in the Summer Meeting (Brussels) and occasional meetings to brainstorm partnerships and establish contacts with the European ecosystem;
- TEC4 materials: creating content for the new TEC4HEALTH website and getting iterations to improve INESC TEC's CRM.

External:

- Hospitals: consolidation of relations with some of the main hospitals in the northern region of Portugal, namely the *Centro Hospital Universitário de São João* (CHUSJ), IPO Porto and *Centro Hospitalar Vila Nova Gaia/Espinho* (CHVNG/E);
- Companies (highlight of new strong connections): opportunities in sectors such as bioinformatics, dentistry, information systems, pharmaceuticals and telemedicine;
- Representing INESC TEC: Health Cluster Portugal general assembly's [2], EIT Health RIS Hub Univ. Porto events [2], Info EU sessions [3], EARTO Health WG [3] and international delegations visits to INESC TEC [2];

- Promoting INESC TEC: MEDICA fair, B2B Health Innovation Market (ANI) [2], Horizon Europe Brokerage Events (EU) [5] and Health Biomatch (Bioga);
- Lectures: *Reunião Monotemática SPG 2022*, EUGLOH Congress and *28º Congresso Nacional de Medicina Interna*;
- Participation in the consultation and review of the European Commission's funding programmes.

Projects:

- National: mediation of INESC TEC's intervention in mobilising health agendas (RRP);
- 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.

Despite the approval of service contracts and a mobilising RRP agenda for the health area during 2022, there is still potential for more successful projects and technology transfers in the coming years.

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 2022

In 2022, TEC4INDUSTRY focused mainly in the national opportunities related with the Recovery and Resilience Plan (PRR), in order to maximise the use of national funds to promote Portuguese manufacturing and advanced technologies industries.

PRR Initiatives

If in 2021 TEC4INDUSTRY was very active 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, in 2022, the objective was to submit the last phases of the PRR proposals, align consortiums and budgets and prepare the start of these large projects.

Mainly in the manufacturing related proposals, the TEC4INDUSTRY actively participated in the setup of different project ideas: Produtech R3 agenda for advanced production systems, CITEVE agenda for digitalisation of industrial processes and water consumption, VW Autoeuropa agenda for drones and augmented reality implementation in automotive industry, Blueconomy 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.

Moreover, TEC4INDUSTRY supported the setup of the national TestBed initiative, working together with NOS and Navigator to build effective TestBeds and preparing potential services that INESC TEC centres can provide in the context of this national TestBed network. Finally, TEC4INDUSTRY also supported the submission of a proposal to the PRR initiative related with the decarbonisation of industry.

European Projects

At the 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 highlights the submission of the proposal SmartGuard with ProGrow, Yazaki and Continental ES. In terms of European projects, the TEC4INDUSTRY supported and promoted participation in several proposals in the following topics: Social innovation in food sharing to strengthen urban communities' food resilience, AI and Human Collaboration, as well as Efficient trustworthy AI.

Also in 2022, TEC4INDUSTRY deployed efforts to initiated the preparation of 2023 calls, with focus on the following topics: Drivers and success factors for progress towards Industry 5.0; Factory-level and value chain approaches for remanufacturing (Made in Europe Partnership), Efficient trustworthy AI - making the best of data (AI, Data and Robotics Partnership), Achieving resiliency in value networks through Modelling and manufacturing as a service, Boosting generation and diffusion of advanced technologies in SMEs based on a supply chain model. Moreover, supported the re-submission of different open calls, mainly related with Galactica and Change2Twin European projects.

Research Contracts

At national level, TEC4INDUSTRY provided an important contribution to promote R&D contracts with national companies and established an important strategic partnership with Kaizen Institute to deliver added-value services to Iberian manufacturing industry, combining lean and digital expertise to cope with complex problems, as well as a strategic partnership with NOS to leverage the adoption of 5G technologies in manufacturing companies.

In partnership with Schaeffler Portugal, a proposal was submitted in the quality control using artificial vision technologies. In 2022, a proposal for digital maturity assessment was presented and accepted by Fucoli-Somepal. Also, a new business relationship was established with the Brazilian company FIOCRUZ to support the digital roadmap operationalisation for the new vaccines factory in São Paulo. Finally, TEC4INDUSTRY promoted a new partnership with Amtrol-Alfa company to specify and develop a new information system to track and monitor the production of gas smart bottles production through RFID.

Advanced Training in Industry

Following the advanced training strategy initiated in 2020, TEC4INDUSTRY was active preparing the 3rd edition of the Industry 4.0 advanced training course with INEGI, and delivered a special course in Industry 4.0 for Kaizen Institute, customised to their specific needs. Moreover, specific workshops were given to national foundry and metal industry sectors. Moreover, the TEC4INDUSTRY team has been working with the iiLab team to define and setup a strategy for hands-on training in the new laboratory at PORTIC (new location).

INESC TEC Promotion

In terms of INESC TEC services promotion, TEC4INDUSTRY was very active in the participation in the Hannover Fair 2022, with a stand in the Produtech and Portuguese entourage, in this special year that Portugal was the partner country. Also, the TEC4INDUSTRY team participated as speaker in different events for INESC TEC promotion, such as: Assimagra event about the digitalisation in the stone industry, Qualify.teca event promoted by AECOA, EIT Manufacturing Summit 2022 in Brussels, the Meat Meeting'22 organised by TECMEAT and dedicated to the meat industry, the KIT-AR webinar related with the augmented technologies application in industry and the event organised by INFORMESP dedicated to the "future of metal industry in Portugal". Other important events where TEC4INDUSTRY participated were the visit to the Digital Competence Center (DCC) at RWTH ITA, the participation in the SAP 4.0 project and the participation in EIT Manufacturing events promoted by INESC TEC team.

New Companies Leads

2022 was also a fruitful year to extend the TEC4INDUSTRY network, in terms of academia, manufacturing and technologies companies, as well as consulting companies. In terms of leads' creation, the highlights are: University of Plymouth, Lukasiewicz Research Network, Portugal Foods, Schaeffler Portugal, TTTEC, Smartex, Gislótica, PNO Consulting, PETROTEC, Maia City, Fisola, Vasco Consult, IDEKO, Systems4You, PTC Group, JungleAI, Amtrol-Alfa, Plataforma Blue Bioeconomy, Fujitso, ST Malta, Fucoli-Semapal, Dalma, Renault Cacia, TUGBOT, Amorim Florestal, Altice, Zendal, FIOCRUZ, Fravizel, Lactogal, between others.

5.7 TEC4SEA

Coordinator: Eduardo Silva

Business Developer: Carlos Pinho

Communication, dissemination and continuous engagement: Ana Paula Lima

5.7.1 TEC4SEA Presentation

TEC4SEA is the INESC TEC initiative towards the Blue Economy established and emerging sectors, aiming to stimulate related industries and partners to overcome the main future challenges in these sectors. Towards these objectives, TEC4SEA brings together R&D+i Institutions, businesses, and associations, increasing synergies and critical mass, raising up a north based Ocean Engineering Excellence Network capable of leading international initiatives in the Sea Economy.

The multidisciplinary application-oriented solutions addressed by TEC4SEA cover a wide range of industries currently facing several changes and a considerable number of future challenges in the horizon. From specific national challenges in each of the Blue Economy sectors, to the Horizon Europe and Mission's objectives, the new European vision targeting 2050, up to global challenges. 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.

The centres involved in TEC4SEA projects during 2022 were the following: CAP - Applied Photonics; CEGI - Management and Industrial Engineering; CITE - Innovation, Technology and Entrepreneurship; CESE - Enterprise Systems Engineering; CPES - Power and Energy Systems; CRAS - Robotics and Autonomous Systems; HumanISE - Human-Centered Computing and Information Science; and CTM - Telecommunications and Multimedia.

5.7.2 Main achievements in 2022

TEC4SEA managed to achieve most of the goals set for 2022, 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 (namely in the energy and industrial domains with CPES, CESE and CEGI). Common opportunities were achieved following this work.
- Internal alignment and engagement to explore INESC TEC's positioning and strategy in different opportunities (RRP, Horizon Europe, among others). Based on this alignment, the sea domain initiatives are present in most of the active programs according to the position and strategy defined.

External:

- Explore and leverage INESC TEC involvement in the EMSO-PT and Tec4Sea infrastructures.

- Promote and disseminate the resources and capacities of the Tec4Sea infrastructure, entering in new R&D+i and subcontracted opportunities.
- Develop and pursue national and international mechanisms to establish INESC TEC Sea domain as a Centre of Excellence. New international partnerships were strengthened to continue pursuing this ambition.
- Assume a position in the Ocean Renewable Energies test site (Aguçadoura's test site). INESC TEC is currently the main shareholder of CEO – Companhia da Energia Oceânica.
- Continue to strengthen our relationship and collaboration mechanisms with national core players, such as: Fórum Oceano, IPMA, CIIMAR, INEGI, AIR CENTER, IBS, B2E and +Atlantic and widen the close collaboration mechanisms to entities in the autonomous regions (Azores and Madeira).
- Strengthen the collaboration with entities in the entrepreneurial ecosystem to help revitalise a competitive and innovative Blue Economy in Portugal. New partnerships were established with complementary entities (e.g., Venture Capital).
- Strengthen a close collaboration platform with the Portuguese Navy, following their initiatives and previous invitations.
- Identify and establish close collaboration mechanisms/protocols with international leading organisations (e.g., FIEC, Seabed Authority).
- Foster the successful accomplishment of all the Sea related initiatives within the “Plano de Recuperação e Resiliência” (PRR) – from bottom-up project proposals to top-down initiatives (Hub Azul Norte - Leixões).
- Continue to consolidate international relations (Europe, Latin America, India, South Korea).
- Contribute for the European establishment of the Portugal Blue Digital Hub, led by Fórum Oceano.

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 exploited:

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 digitise by exploiting the data belonging to the companies. 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 2022

The effects of COVID-19 pandemic began to vanish and some in person activities were possible during 2022. So, we participated in the following events with a stand:

- QSP SUMMIT a conference/fair dedicated do enterprise management and marketing.
- CEMTEx inaugural event (Army Experimentation Centre).
- NIAG – NATO Industrial Advisory Group - Industry Day

And we participated like member of the panel in:

- Aeronautic seminar organised by CCILF (Chambre de Commerce et d'Industrie Luso-Française)

Workshop - Digital Transition in the Public Administration, Guimarães, 20/06 (speaker) Market strategic plans documents to Finance, Construction and Internet sectors were revised in order to incorporate the pandemic effects and the lessons learned.

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) and companies with the CAE 631 (Data processing activities, hosting of information and related activities; web portals) was added.

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

In order to promote INESC TEC activities related with these new sectors, exploring the list before described, 161 meetings took place with national and international enterprises and associations, of which 80 were new contacts. As a result of those meetings, 45 new leads were identified, a total de 16 proposals were submitted (with total value of 4 193 304,68 €) and six proposals were approved (with a total value of 2 092 830,13 €).

Some of the meetings were made with international investors interested to evaluate the R&D institutions existing in Porto in order to take a decision about creating new companies in the region.

The most relevant points in 2022 were:

Internet Market

- Participation in QSP Summit 2022 with a stand promoting examples how INESC TEC can contribute to improve the consumer experience.

Construction sector

- Mobilising project REV@CONSTRUCTION led by Teixeira Duarte began its activities;
- BUILT COLAB: meetings with INESC TEC participating in the Board of Directors;
- DIGITALbuit: Approved the international Digital Innovation Hub for the Construction and railroad sectors, with the participation of sector clusters.

Financial Sector

- Partnership with the Banco MONTEPIO with new proposals and direct contract;
- Proposals of direct contracts under discussion with various national e international Fintechs.

Aeronautics, Space and Defence

- Cluster AED – member of the Board of Directors;
- Founding member of EASTRO, a spin-off association from EARTO's Space WG.

Public Administration and Mobility

- Founding member of Rail CoLAB.

The most relevant transversal activities were:

Training:

- Two sessions of a training course at LIAAD, on how to obtain a direct contract (basis of business development) and the use of INESC TEC tools (proposal filling, budget estimation, CRM).
- CRM – Specific training session for Board of Directors' Assistants.

CRM

- Launched to general use in December 2021.
- Development of new functionalities upon user request.

Website TEC4s

- Development of a new version, according to identified requirements.

6 RESEARCH AND DEVELOPMENT CENTRES

6.1 CTM – CENTRE FOR TELECOMMUNICATIONS AND MULTIMEDIA

Coordinators: Filipe Ribeiro and Rui Campos

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 2022, CTM accomplished its mission by directing its activities towards 4 main areas of research: Optical and Electronic Technologies (OET); Wireless Networks (WiN); Multimedia and Communications Technologies (MCT); and Visual Computing and Machine Intelligence (VCMI). CTM contributed to research in neuromorphic computing and 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 audiovisual data interpretation and management provided the means to make sense of the acquired data; the semantic knowledge built from the integration of the network of sensors allows acting over the environment and the content.

6.1.2 Research outcomes in 2022

The main broad research achievements obtained by **CTM in 2022** were:

- 41 articles published in relevant scientific journals, 90% of them in Q1 and Q2 journals;
- 5 PhD theses and 54 MSc theses successfully defended;
- Organisation of the 10th Edition of VISUM Summer School with more than 70 registered participants;
- Awards: semi-finalist of the EC innovation radar prize; EAB Max Snijder Award 2022; IEEE Portugal Section outstanding MSc thesis award; best student paper award in IbPRIA conference;
- CTM Open Day 2022 targeting undergrad students and Summer Internships with 28 students.

The main achievements obtained by the **OET Area in 2022** were the following:

- **World first demonstration of successful integration of Thin-Film-Transistor (TFT) and memristor**, resulting in proof-of-concept for cost-effective, flexible artificial neural networks hardware;
- **Novel antenna array design method demonstrated at 12.5 GHz** enabling the reduction by 25% of the number of phase shifters of a beam-scanning reflect-array;
- **Simple and fast method for calculating broadband spectral optical properties of biological tissues**, which can be used to develop light propagation models for diagnostic and treatment procedures.

The main research achievements obtained by the **WiN Area in 2022** were the following:

- **Traffic- and energy-aware placement algorithms for slicing-aware aerial networks** that enable significant gains in network performance and resource efficiency against state-of-the-art counterparts;
- **Machine Learning based path loss modules** enabling digital twins of wireless networks in ns-3;
- **Simulation platform for multimodal underwater communications** enabling faster evaluation of underwater data muling communications solutions and the reproduction of past experiments.

The main research achievements obtained by the **MCT Area in 2022** were the following:

- **Multi-instrument symbolic music generation driven by musical emotion**, based on conditioning a state-of-the-art transformer on continuous-valued valence and arousal labels;
- **A new large-scale dataset of symbolic music** paired with emotion labels in terms of valence and arousal, two orders of magnitude larger than the existing datasets;
- **A Portuguese text corpus** created from online newspapers with a total of 394 825 480 tokens and 33 089 734 sentences;
- **US patent for colour similarity evaluation** between a first and a second colour.

The main research achievements obtained by the **VCMI Area in 2022** were the following:

- **Tackling unsupervised multi-source domain adaptation with optimism and consistency**, a novel algorithm that achieves state of the art results in unsupervised multi-source domain adaptation;
- **Privacy-Preserving Case-Based Explanations,** a more rigorous privacy-preserving methodology capable of anonymising case-based explanations without compromising their explanatory value;
- **Semi-Supervised Approach for EGFR Mutation Prediction on CT Images,** a novel end-to-end lung cancer characterisation, using CT images, in a semi-supervised approach;
- **Synthetically Generated Structure-Aware Occlusions,** a challenging, realistic, and diverse, publicly available occluded face recognition benchmark.

6.1.3 Innovation outcomes in 2022

The main broad innovation achievements obtained by **CTM in 2022** were the following:

- CTM researchers organised one advanced training course (VISUM) and one internal advanced training on the SLURM platform;
- Development of framework in partnership with a company for anatomopathological diagnosis of histological samples, making the process fully digital and automated;
- Development of technology for innovative intelligent mobility solutions, characterising emotional states of autonomous shared vehicle occupants, detecting and preventing unwanted behaviours;
- More than ten direct contracts with national and multinational companies.

The main innovation achievements obtained by the **OET Area in 2022** were the following:

- **Validation of Bluetooth Low Energy angle-of-arrival based localisation solution for indoor environments,** in partnership with a national telecommunications company, involving the collection and publication of an open dataset of experimental data using four transmitters (BLE beacons), and one receiver covering 21 positions in an area of 12x12 meters;
- **FPGA implementation of digital beamforming algorithm for communications with low earth orbit satellites**, in partnership with a national antenna manufacturing company.

The main innovation achievements obtained by the **WiN Area in 2022** 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 2022** were the following:

- Software package for Mid-level Harmonic Audio Features extraction for Musical Style Classification;
- Software Library for salience/heat maps generation of focus of attention on multiview content.

The main innovation achievements obtained by the **VCMI Area in 2022** were the following:

- **Algorithm for matching of fingerprint templates**, improving the detection of minutiae points and deployment in javacard technology;
- **Software for Computer aided detection of deep inferior epigastric perforators in computed tomography angiography scans**, reducing the time and subjectivity inherent to the manual annotation of perforators' vessels and facilitating the pre-operative planning of DIEAP flaps.

6.1.4 Activity Overview

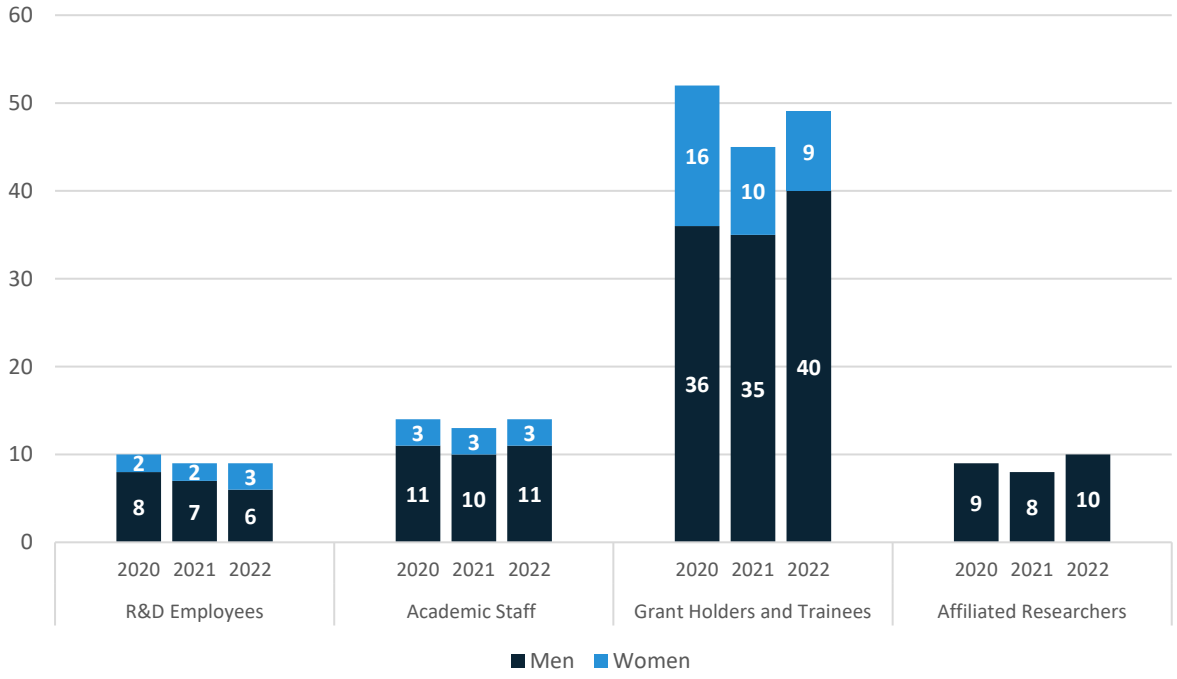
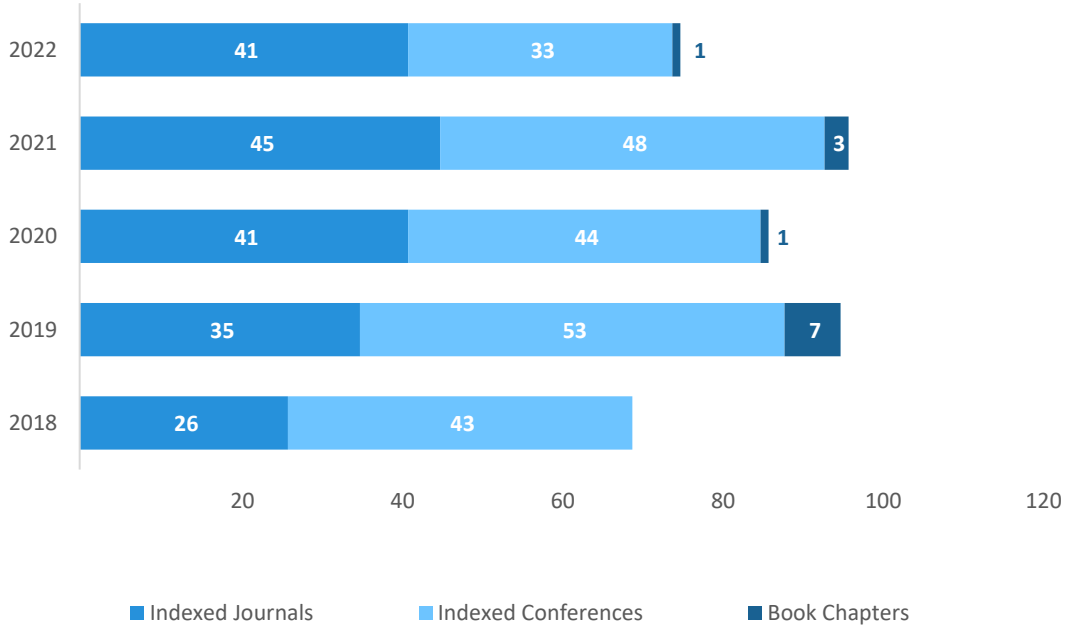


Figure 6.1.1 - CTM - Research team evolution

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



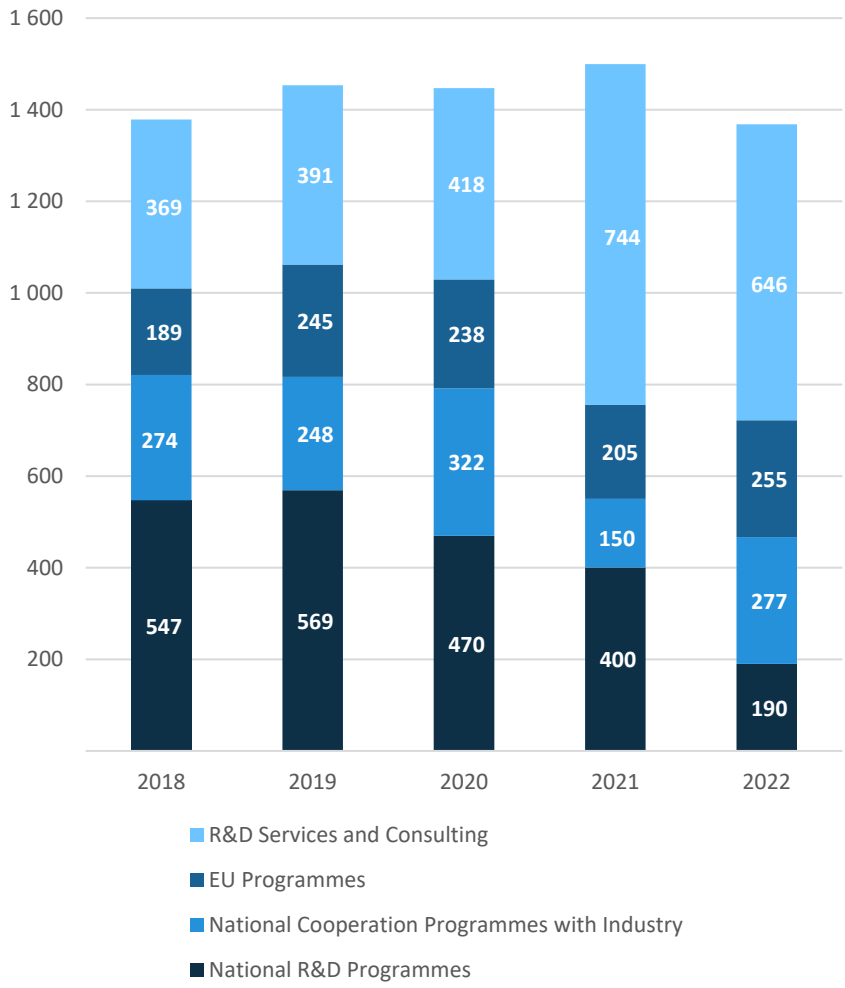


Figure 6.1.3 – CTM - Project funding evolution (k€)

6.2 CAP – CENTRE FOR APPLIED PHOTONICS

Coordinators: Paulo Marques and Ireneu Dias

6.2.1 Presentation of the Centre

CAP accomplishes its mission within the NIS domain 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 microfabrication and were involved in the creation and continuous maintenance and upgrade of the physical infrastructure to support these activities (advanced optics lab and cleanroom) supporting advanced laboratory lectures of MSc and PhD teaching programs. These activities lead to better prepared students in these topics and an enhancement and widespread interest on many related subjects.

6.2.2 Research outcomes in 2022

Integrated Optics and Microfabrication

Characterisation of laser direct writing in Ultra Low Expansion (ULE) glass; this includes direct writing of waveguides plus the possibility of glass micromachining. While waveguide writing proved unsuccessful due to photodarkening effects leading to high losses, the results on glass machining where similar to those of fused silica. The progress on ULE machining allowed the fabrication of reference cavities which are insensitive to temperature variations. These cavities were employed in the fabrication of high-resolution temperature sensors for applications in space (tens of microKelvin). In order to improve the visibility of these reference cavities, different configurations where tested. Due to the lower performance of the waveguides also written by femtosecond laser exposure due to photo darkening, V-grooves for the coupling of optical fibres was successfully explored.

The glass micromachining capabilities were employed on the fabrication of long, uniform and glass embedded 3D metallic electrodes that will be employed for optical signal processing.

Additionally, large area microfluidic devices for biomedical research were produced having in mind vesicle separation. These devices find use in liquid biopsy applications.

Physical sensors

As part of the LIRA project, Fabry-Perot cavity sensors were developed with a sensitivity of 100 micrometers at 50 Kelvin, and with a dimension of 80 mm. A White-light interrogation system was also developed for absolute temperature measurement and with the ability to read at 1KHz. It was intended to obtain micro kelvin resolution with the use of a Fabry Perot cavity based on integrated optics and written on a glass with zero thermal expansion in the -10 ºC and 40 ºC region.

In the WipTherm project, a high-power laser at 1550 nm for micro-thermoelectric generators arrays was fabricated. The laser was manufactured in erbium-doped fibre using a multimode fibre developed at Xlim through a European project collaboration. The laser has a wavelength of 1565 nm with a maximum continuous (CW) power of 15 W. Using graphene, in a ring laser, as a saturator absorber, it was possible to generate mode-locking and Q-switching in the order of nanoseconds.

In the sensing area, a linear cavity laser was developed for index measurement.

Bio sensors

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.

A Processing pipeline for LIBS analysis of complex mineral samples was implemented and validated with real mining samples. The smart LIBS software enabled several modes of operation qualitative (mapping and threshold decision) or quantitative. The new tools were validated by bench marking a diversity of prototypes, Lab systems and commercial systems, demonstrating the viability of decision making with LIBS in real operational scenarios in the raw material sector.

Quantum Optical Engineering

During 2022 our efforts were focused on three operational objectives, which were completely achieved:

- Development and deployment of an experimental setup for the realisation of quantum light fluid analogues.
- Research on the topic of neuromorphic-based optical computing, exploring the concepts of extreme learning machines, random neural networks, and reservoir computing.
- Research and development of digital twins and physics-informed computational solutions for training the setup parameters.

6.2.3 Innovation outcomes in 2022

- 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;
- An optical tweezers system was equipped with a fully automated scanning system, enabling the automatic trapping, and identification of large number of cells (100's). These capabilities enable capturing large data sets of scattering data, improving the recognition and discrimination capabilities of complex living cells (tested with micro algae);
- A LIBS system dedicated to the characterisation of organic coating in cork was implemented and validated, in partnership with local industry;
- Deployment of a tabletop experimental testbed of quantum light fluid analogues;
- Deployment of an optical computing experimental setup based on the concepts of extreme learning machines and diffractive neural networks;
- Development of computational libraries for the in-silico training of optical neural network setups.

6.2.4 Activity Overview

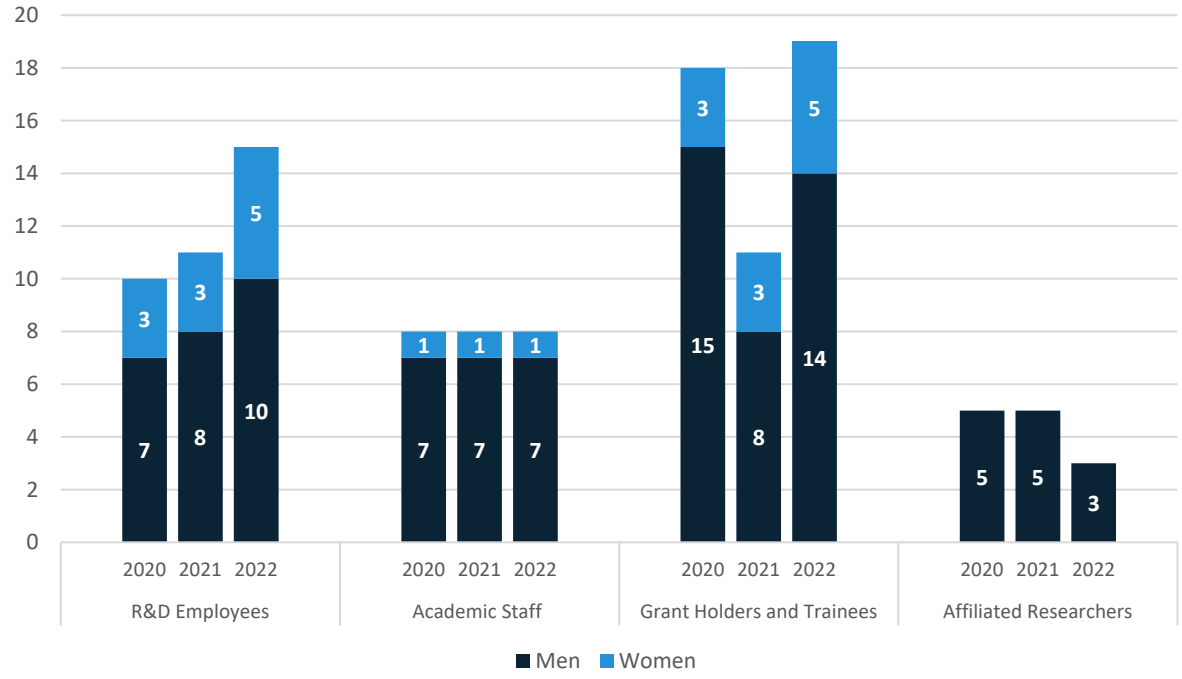


Figure 6.2.1 - CAP - Research team evolution

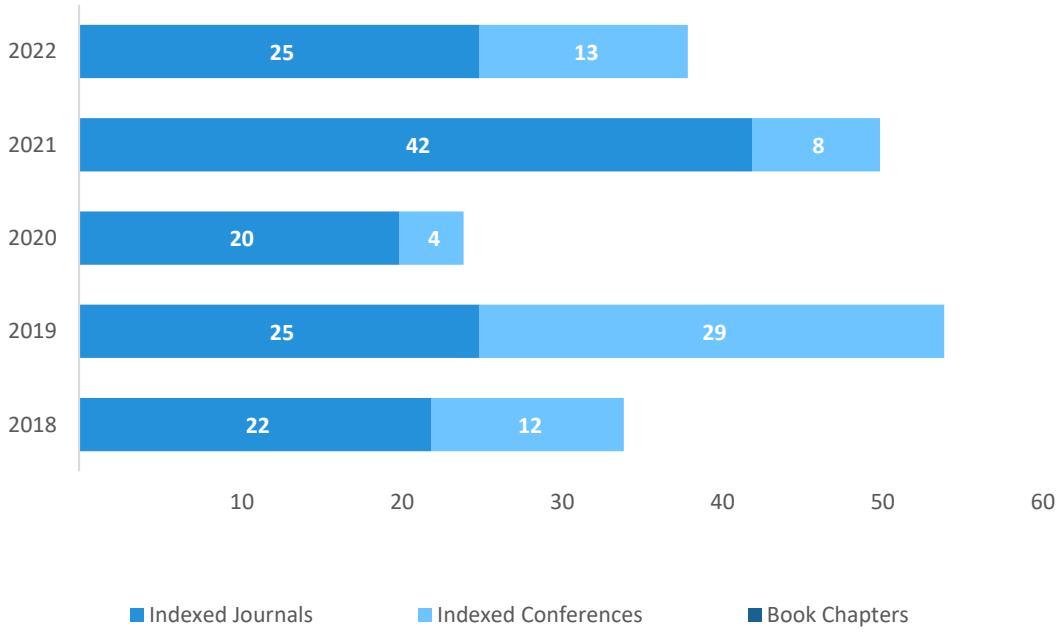


Figure 6.2.2 - CAP - Evolution of publications by members of the Centre

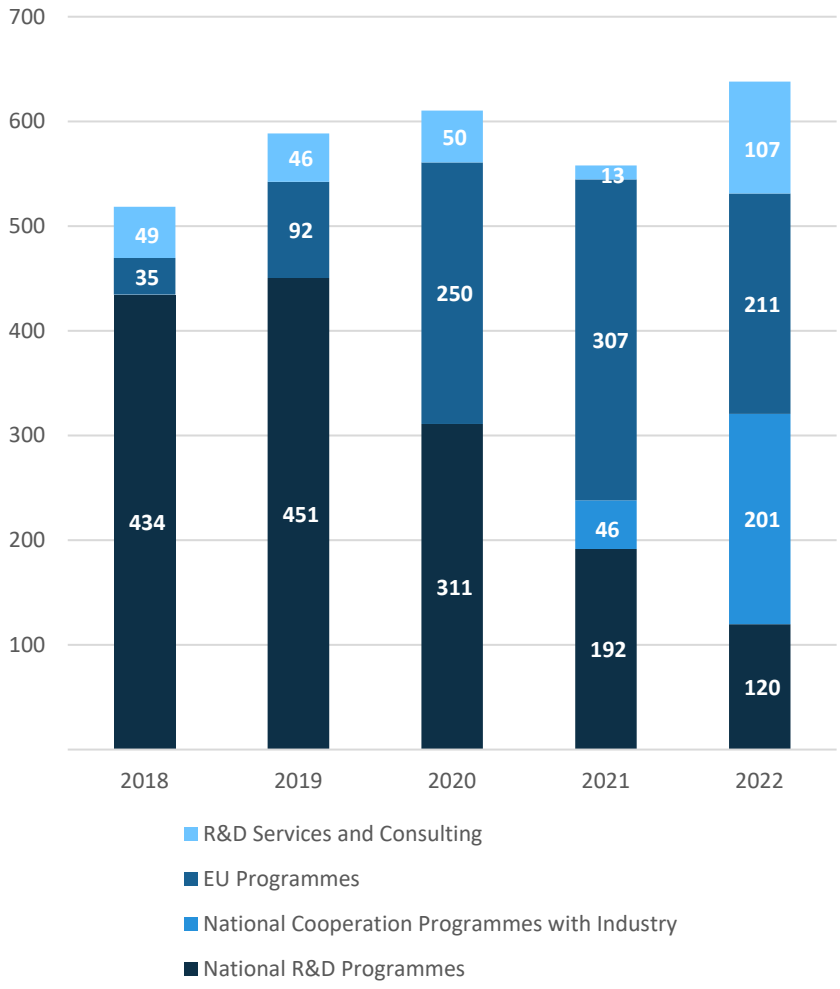


Figure 6.2.3 – CAP - Project funding evolution (k€)

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 over 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 2022

In 2022, CRAS researchers published 18 papers in recognised scientific journals, most of them in 1st or 2nd quartile journals. This equals the planned number for the year and it is an increase in the number of journal publications compared to previous years. 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 international conferences.

There were other important signs of recognition by the international community of the scientific merit of the Centre's researchers: several PhD students participated in international workshops and short courses, some of them after competitive selection processes. One PhD student won a scholarship for a 4 month-long stay at MIT, and a Senior researcher gave an invited talk also at MIT. During the year, the Centre received the visit of several international delegations, most of them with recognised scholars in robotics trying to establish partnerships.

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

- FCT funded QuALTOS project ended, with important advances in the application of feature extraction algorithms in acoustic images taken from underwater vehicles (RL1, RL3).
- Both UNEXUP and Insite EIT RM European projects finished successfully at the end of 2022, with important results, the first one, in autonomous explorations of flooded confined environments (RL1, RL3, RL4), and the second, in the exploration of underwater application of LIBS for mineral explorations (RL2, RL4).
- Hipersea P2020 project was concluded in 2022 and had developed and tested the first underwater system in the world for the capture of deep-sea species and bringing them to surface ensuring the same pressure and temperature conditions. This system was tested and validated in a scientific field mission, with IPMA Research vessel Mario Ruivo, where live species were capture at 1000m depth (RL2, RL4).
- During the Spring project (EU-India), there were significant advances in the development of robotic based tools for efficient assessment of pollution in large rivers (RL2, RL4).

6.3.3 Innovation outcomes in 2022

In the scope of ongoing R&D Projects and Contracts, several important achievements were demonstrated:

- Under a contract with a Brazilian hydroelectric power plant, a custom underwater inspection system was demonstrated in Brazil, with the ability to assess sedimentation in underwater shafts with zero visibility (INOV1, INOV2);
- Within the K2D project (MIT-Portugal program), a new concept of sensor network was demonstrated, based on the complementarity of AUVs and underwater long-range communications cables (INOV3, INOV4);
- The DORM project ended, demonstrating the concept of a service underwater vehicle, with a new variable buoyancy system demonstrated for the MARES AUV, increasing the overall efficiency of the vehicle motion (INOV3);
- In Unexup, the upscaling process continued and results in the new UX1NEO Deep robot, a version with a depth rating of 1500m and extra scientific sensors (INOV1, INOV2, INOV3);
- New subcontract with NIVA, a Norwegian R&D Institute, for the development of a new water sampling device for DNA collection for underwater platforms (INOV2);
- In EMSO_PT, field validation of the EGIM system onboard Mario Ruivo at Madeira tore (INOV3);
- Related with a contract with KRISO (Korea Research Institute of Ships and Ocean), INESC TEC underwater position, navigation and awareness technologies were integrated in KRISO underwater crawler system (INOV2);
- Patent filing of "Artuga", a fiducial marker for relative positioning of drones (INOV2).

Several workshops, seminars, and summer schools 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, namely:

- Event “IN THE BLACK'22 - A New Era of Ocean Exploration”;
- SOE’22 | Space, Ocean, and Earth Insights – BIO, GEO and TEK come together to discuss the current frontier of Space Exploration;
- Deepfield thematic Workshop on Deep Learning Methods in Aerial Robotics;
- Seminar "Applied Research in Marine Robotics at INESC TEC", at MIT, under the seminar series "Multidisciplinary Simulation, Estimation, and Assimilation Systems".

Several dissemination activities, field missions and demonstrations were done this year. The most relevant examples are:

- Multiple UNEXUP field missions were performed around Europe, in Hranicka Propast, Czech Republic, the world record in cave dives had been achieved; in Käfersteige mine, Germany, a total distance of 8.5 km was completely mapped in one dive;
- Participation in the NATO exercise REP(MUS)2022, organised by the Portuguese Navy;
- ARDITI – demonstration of robotic systems during the inauguration of the Madeira Oceanic Observatory.

6.3.4 Activity Overview

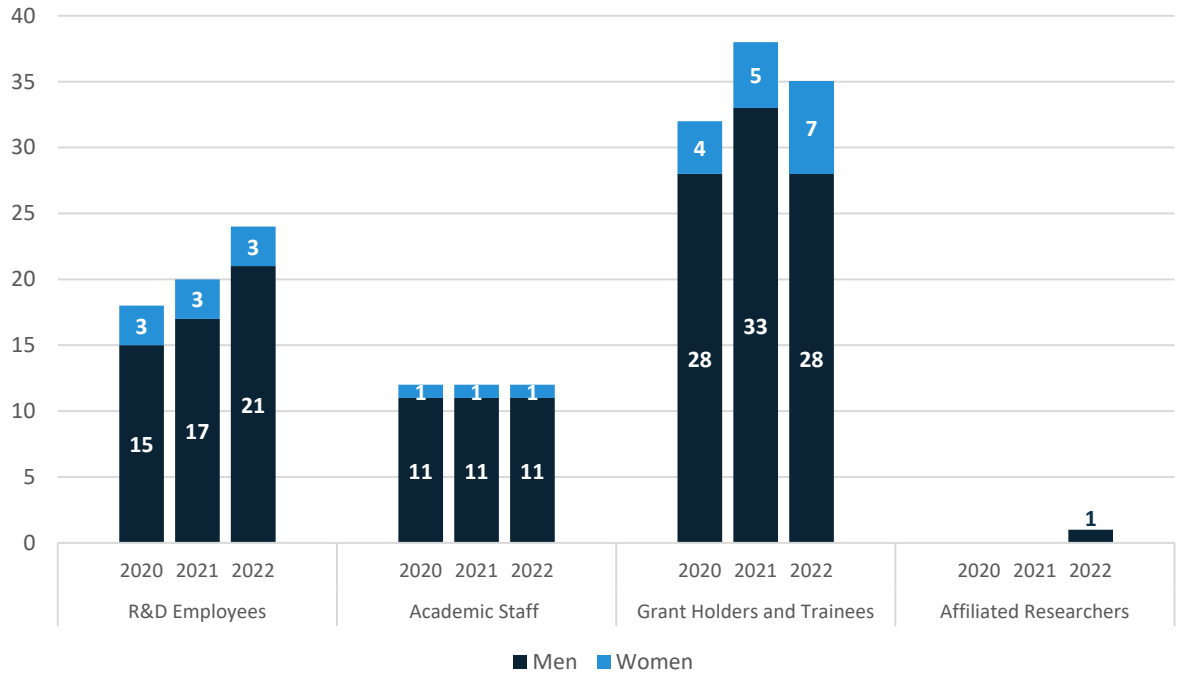


Figure 6.3.1 CRAS - Research team evolution

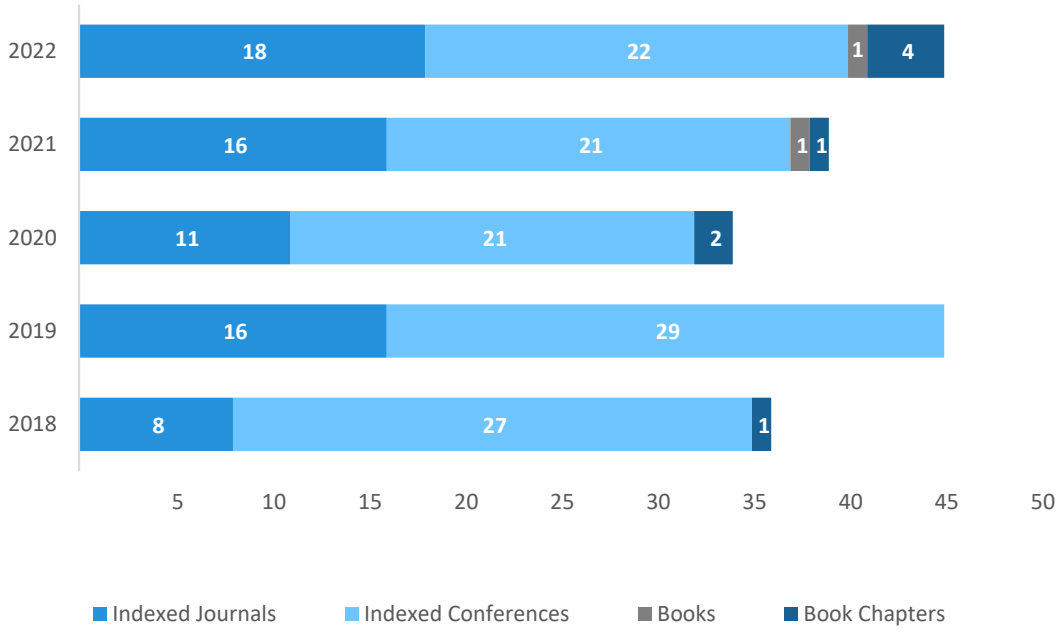


Figure 6.3.2 - CRAS - Evolution of publications by members of the Centre

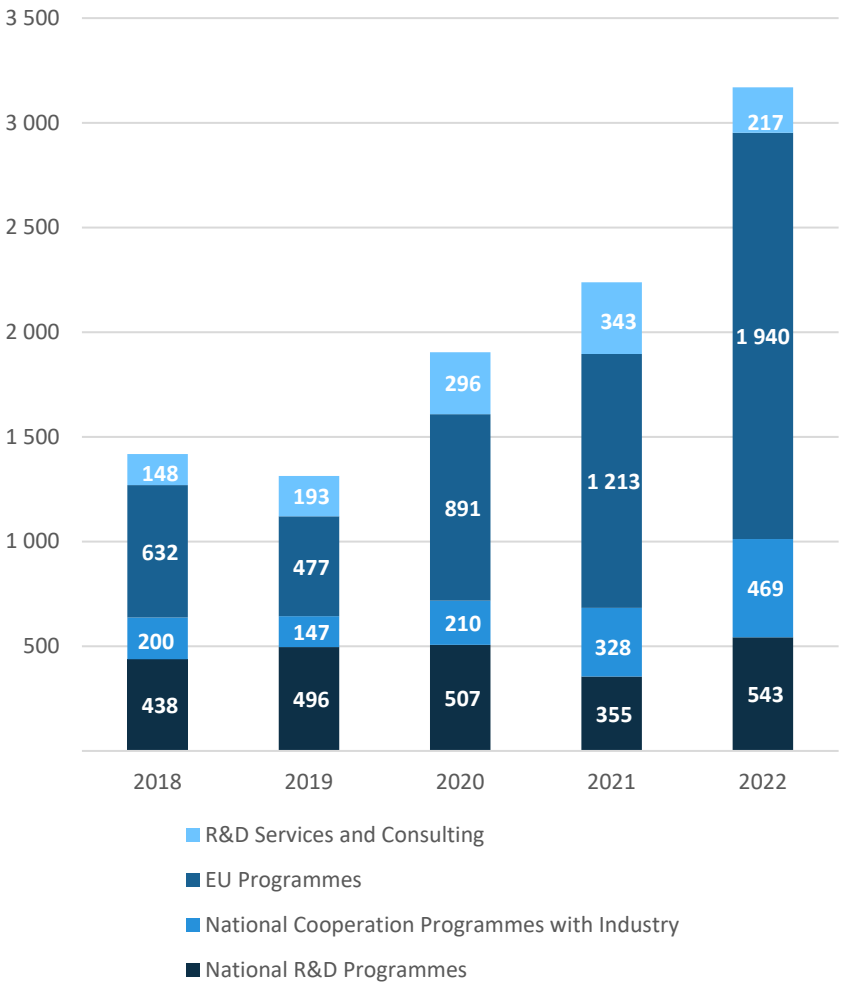


Figure 6.3.3 - CRAS - Project funding evolution (k€)

6.4 C-BER – CENTRE FOR BIOMEDICAL ENGINEERING RESEARCH

Coordinator: João Paulo Cunha

Assistant to the Centre Coordination: Duarte Dias

6.4.1 Presentation of the Centre

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

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

6.4.2 Research outcomes in 2022

Following the "*Main Objectives for 2022*" from the document "*INESC TEC 2022 Activity Plan*", C-BER has achieved the following outcomes in the presented planned areas:

Organisation, human and material resources: The planned R&D projects have been executed with small differences from the workplans. Following the intense EU project submission planned and executed in recent years, 2022 was a year of good crops as C-BER secured 3 EU funded projects **(+500k€ funding)**. Three other projects have been approved. In 2022 C-BER hosted 16 PhD theses (2 /PhD member) and 30 MSc theses (3.75 /PhD member) in several areas, mainly, Bioengineering, Electrical and Computer Engineering and Computer Science. From these, 30 MSc and 3 PhD were completed in 2022.

Publications: Among the 31 international journal papers published in 2022 (***3.875 papers/PhD***), ~90% of them in SCOPUS "1st and 2nd Quartiles", some high-impact papers are worth to be mentioned: *Journal of Expert Systems with Applications* paper[1] on a novel deep learning (DL) approach to Lung CT image processing (IF=6,954); *Nature/Scientific Reports* paper[2] on DL for near-real-time pathological motion detection for clinical neurology use (5th most cited Scientific Journal in 2021/IF=4,996); *IEEE Journal of Biomedical and Health Informatics* paper[3] on the largest public dataset in cardiac auscultation (IF=5,772); *Journal of Clinical Medicine* paper[4] on the discovery of quantitative early gait alterations in Hereditary Amyloidosis neurodegenerative disease patients (IF= 4,964).

Internationalisation: The above mentioned three EU projects involving partners from 7 different countries were a landmark result of internationalisation of C-BER in 2022. Furthermore, members of C-BER have now 5 editor positions in high-ranking scientific journals: *Nature/Sci. Rep.*, *Frontiers in Signal Processing*, *Frontiers in Neuroscience, Medical Physics and Mathematics; and participated in two Sensors (Basel)* – Special Issues as guest editor. Following the plan, we successfully became members of the EBRAINS Association that provides high-level research infrastructures and services in the neuroengineering area[5]. The planned 7 international R&D

[1] doi: 10.1016/j.eswa.2022.119350
[2] doi: 10.1038/s41598-022-23133-9
[3] doi: 10.1109/JBHI.2021.3137048
[4] doi: 10.3390/jcm11143967
[5] https://ebrains.eu

cooperations with reference research groups were enforced, namely with LMU-Munich, Carnegie Mellon-Pittsburgh, EmoryU-Atlanta, EPFL-Lausanne, UniTwente-NL, Real-Hospital-Recife and PoliMi-Milano

Dissemination Actions: In 2022, our researchers were members in 14 Program Committees of International Scientific Events. Members of C-BER were actively involved (Chair and co-Chair) in the organisation of the IEEE EMBS Portugal Chapter bi-annual conference to be held in Porto in June 22-23, 2023.

6.4.3 Innovation outcomes in 2022

Startups: C-BER has generated 3 spin-off startups. Following the planned action INOV1 from the document "*INESC TEC 2022 Activity Plan*", startup#3 *WeSENSS-Wearable SENSors for Safety* obtained EIT Manufacturing 33k€ funding to WeSENSS startup to bootstrap the MVP of "connected worker" with partners in oil&gas and other hazardous professionals' security&wellbeing for the future funding round of the spin-off company that licensed IP from C-BER.

Innovation Infrastructures: Following planned INOV2 action, we have submitted to FCT call for infrastructures interest manifestation the "*NeuroTechLabs - Portuguese Network for Neurotechnology Research and Innovation*" that aims to be a national reference and a recognised infrastructure by EBRAINS at the European level, with a focus on R&D+I in neurotechnology.

Patents & IP Creation: Also, as planned in INOV3 action, we have continued to fill the patent pipeline during 2022. As a result of those actions, C-BER has submitted 2 new patents. Furthermore, we have submitted 5 technology disclosures (pre-patent descriptions) and 3 pre-disclosures (draft descriptions) that show we have a "full pipeline" of IP creation. C-BER has now reached the 50 patents (from 12 different inventions) score – top in INESC TEC patent indicator.

6.4.4 Activity Overview

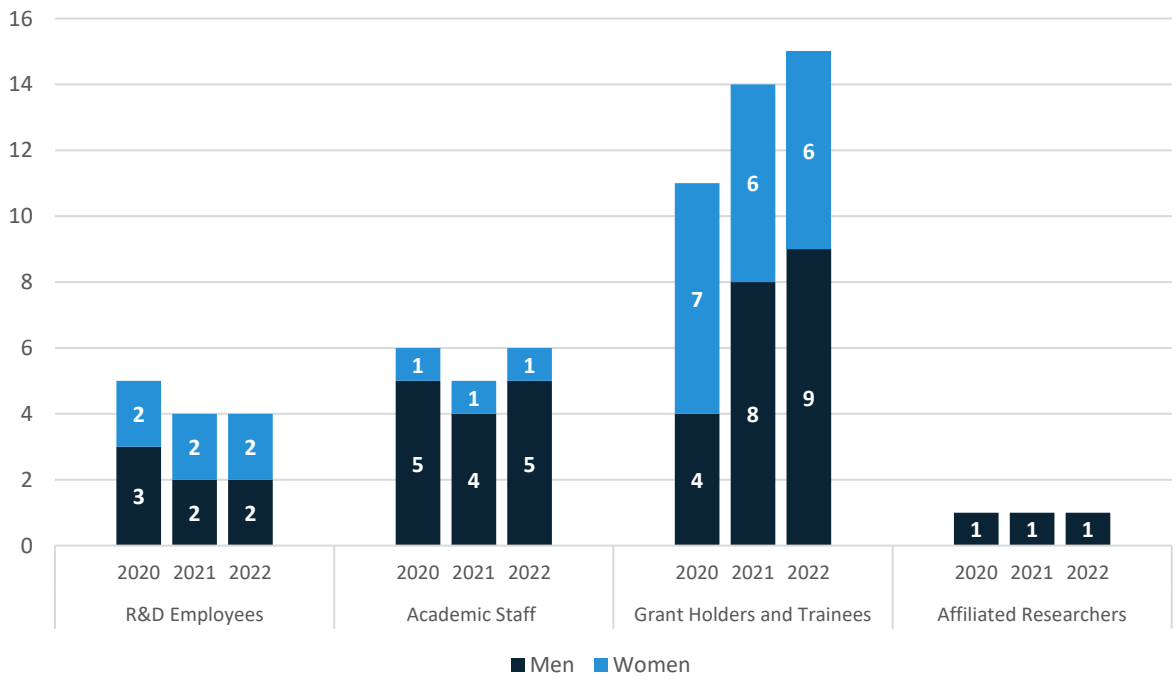


Figure 6.4.1 - C-BER - Research team evolution

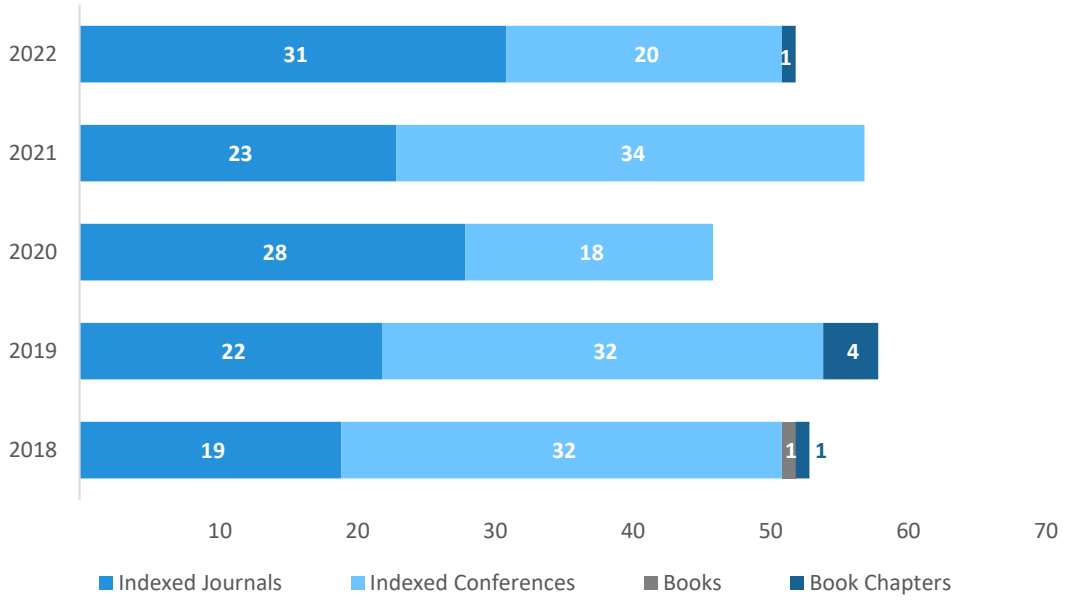


Figure 6.4.2 - C-BER - Evolution of publications by members of the Centre

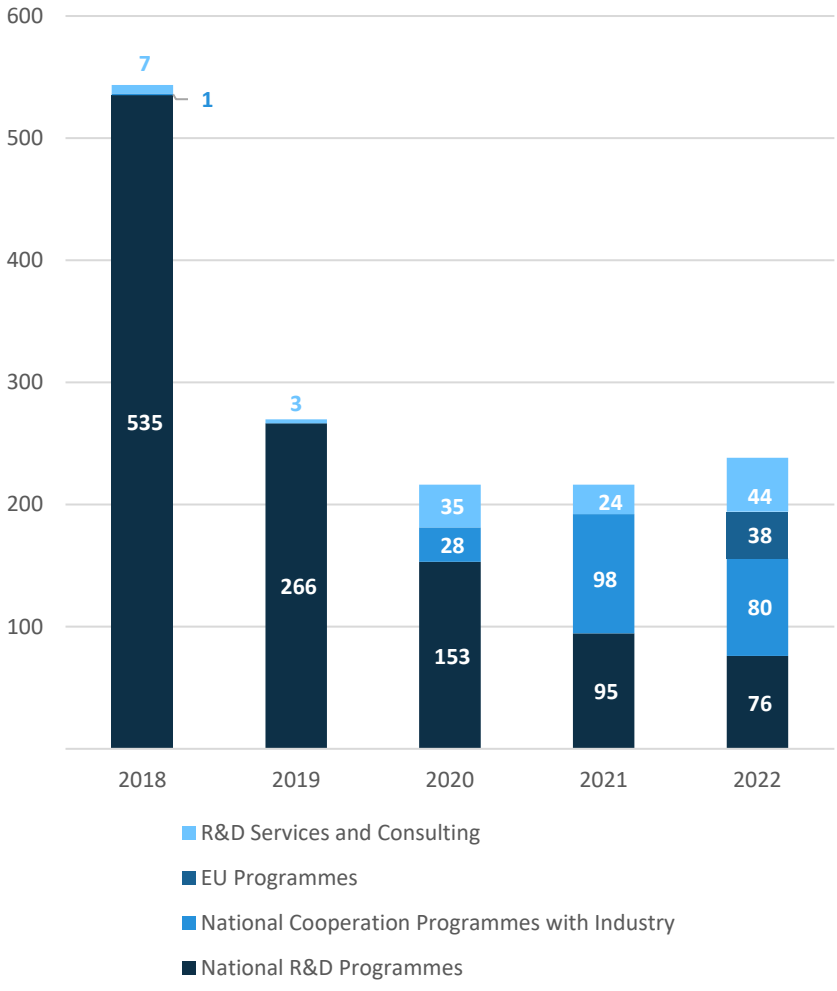


Figure 6.4.3 – C-BER - Project funding evolution (k€)

6.5 CPES – CENTRE FOR POWER AND ENERGY SYSTEMS

Coordinators: Manuel Matos and Ricardo Bessa

Assistant to the Centre Coordination: David Rua

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, peer-to-peer (P2P) energy trading, Renewable Energy Communities design and operation, and Energy and Flexibility management, under the Smart Grid paradigm.

The research results range from technology readiness level (TRL) 2, with fundamental research carried out, to TRL 8, with prototyping and demonstration of technology. Part of the activity of the centre is developed in the Smart Grids and Electric Vehicles Laboratory (SGEVL) that provides a real environment for testing and validation. The Centre is a world reference in the definition of technical solutions to support large scale integration of RES in the electrical system.

CPES has two IEEE Fellows, is a strong player in European Commission competitive funding and is regularly awarded contracts with national and international companies, with a robust track record in technology transfer, consulting, and support to public policies development. Researchers of CPES were distinguished with IEEE PES Renewable Energy Excellence Award, CIGRE and ESIG Excellence Awards. Researchers have regularly won IEEE PES competitions in meta-heuristics applications to power systems. Junior researchers won the Portugal best MSc thesis prize awarded by the Portuguese TSO and other prizes to MSc and PhD theses. In 2022, CPES participated in 16 EU projects, coordinating two of them.

6.5.2 Research outcomes in 2022

- Methodologies and tools for multi-energy infrastructures operation (day-ahead and real-time) that include electrolysers and ammonia production plants;
- Quantification of the benefits of electrolizers participating on automatic frequency restoration reserve and frequency containment reserve (SEST 2022);
- Development of a reduced-order digital twin of multiple interconnected control areas to analyse frequency stability problems (IREP 2022);
- Optimisation tool to determine the most adequate share of hybridisation technologies for existing offshore farms (Wind+Wave+Offshore floating PV) considering metocean data – EU SCORES;
- Predictive algorithm for flexibility procurement by the system operator (flexible assets and procured active and reactive power in short-term markets). Reduces the human cognitive load when analysing multiple options and trajectories, setting a human-in-the-loop approach (Smart4RES project);
- Rule-based adaptive control strategy for grid-forming inverters in islanded power systems for improving frequency stability (PhD work of José Gouveia concluded in 2022);
- Fault-ride-through strategies for grid-tied and grid-forming smart-transformers suited for islanding and interconnected operation in multi microgrids (PhD work of Justino Rodrigues concluded in 2022);
- Preliminary model for the MIBEL market model (CEVESA) optimal allocation of the interconnection capacity among single-price areas for both energy and automatic frequency restoration reserve;
- A general framework for energy sharing and settlement of renewable energy communities, including advanced business models (EEM 2022);
- A P2P-validation tool that simulates a local energy market with positive or real dynamic allocation coefficients and activates local flexibility (Energies);
- Methodology and software tool to segment medium voltage grids into grid zones, enabling the DSO to publish flexibility needs per grid zones (EEM 2022);

- Methodology and tool for planning the expansion of generation systems with uncertainty, based on Monte Carlo Tree Search (PhD work of Tiago Abreu);
- Methodology and tool to assess the reliability of distribution systems with storage, renewable generation, and demand response, via Pseudo-Sequential Monte Carlo simulation (PhD Inês Trigo);
- Methodology and tool to size H2 facilities for security of supply purposes based on the outcomes of the Sequential Monte Carlo Simulation (PhD work of Bruno Santos);
- Predictive network coordination framework (EUniversal project), that can forecast technical problems in MV and LV networks and coordinating the mobilisation of flexibility resources (CIRED 2022);
- Data-driven method based on smart meter data, to estimate sensitivity factors, for three-phase unbalanced LV grids, respecting a privacy-preserving protocol (PSCC 2022, EPSR journal);
- Experiment conducted with 105 participants from the energy industry in the framework of IEA Task 26, to investigate existing psychological barriers in the industry to adopt probabilistic forecasts and to better understand human decision processes (published in Meteorological Applications journal);
- New stochastic security constrained multicriteria unit commitment, with temporal trajectories of renewable production and the operators set goals for operation cost, required additional power, RES curtailment, and compliance with the dynamic security constraints (Smart4RES project);
- Development of a social welfare maximisation framework for data markets in renewable energy forecasting (Smart4RES, ENERSHARE and GreenDataAI).

6.5.3 Innovation outcomes in 2022

- Decision support tool to plan investment in energy assets (EV, PV and buildings renovation) aiming at energy systems decarbonisation;
- Grid-code compliance studies for eight PV farms (5 in Azores, 3 in Portugal mainland), including two cases of over-equipment, and a waste-to-energy powerplant (Azores);
- CEVESA reengineering to include hybridisation to improve its outputs based on real market data (EEM 2022), to allow for multiple renewable generation profiles and to improve maintainability;
- Digital platform and a set of integrated microservices for the management and operation of renewable energy communities (Digital CER P2020 project);
- Microservice to assess the behavioural response of consumers to dynamic incentives, helping retailers and aggregators to identify responsive consumers and their expected reliability to provide flexibility (InterConnect project);
- Improvement of the lithium-ion battery model through a thermal model (ISGT Europe 2022) in the Smartglow project;
- Improved parallel version of the PS-MORA tool including advanced functionalities for assessing multi-area adequacy of generation systems that also include models for the transmission network and losses;
- Tool for maximising the use of renewable energy sources in islanded systems with battery storage systems, based on a post-mortem analysis of the Sequential Monte Carlo Simulation outcomes;
- Design and implementation of the fourth generation of a home energy management system (HEMS) within the InterConnect project. Acting as a SAREF-based hub of services for demand side flexibility, it can optimise the energy use for market-based services, including the support to energy communities;
- Implementation of an ISO 15118 smart EV charger with edge computational capabilities supporting traditional centralised management platforms as well as distributed management of chargers;
- Maintenance of the Elergone Energias load forecasting system (in production) and development of automatic bidding strategies;
- Finalisation of the IOTA data market prototype (INESC TEC seed project: VALOREM);
- Joined the Global Smart Grids Innovation Hub from Iberdrola and IEA Task 51;
- Development and test with real data of a digital twin in MATLAB® Simulink for photovoltaic power plants, focused in generating faults of power converter electronics (AI4PV project);
- Test with field data and integrate the low voltage state estimator of INESC TEC with ENEIDA DeepGrid®.

6.5.4 Activity Overview

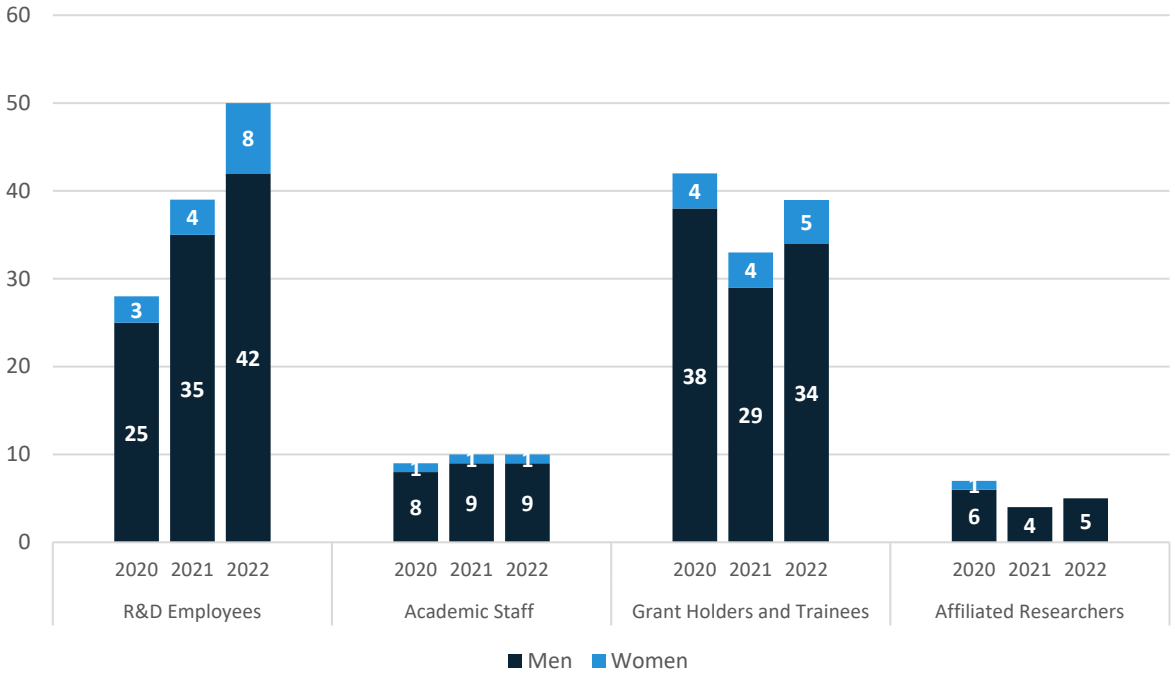


Figure 6.5.1 - CPES - Research team evolution

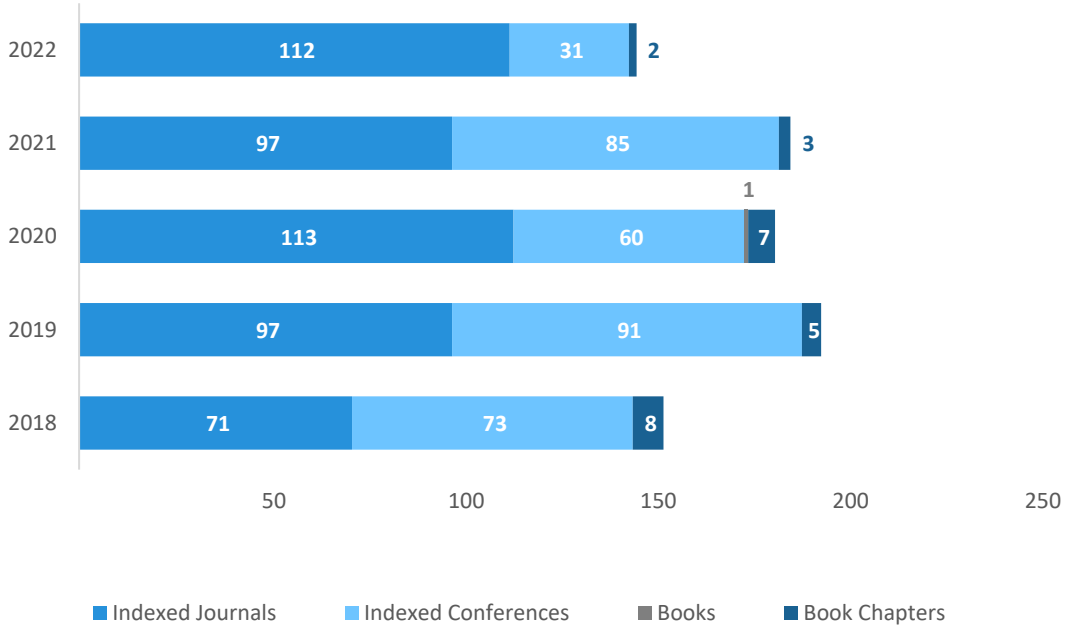


Figure 6.5.2 - CPES - Evolution of publications by members of the Centre

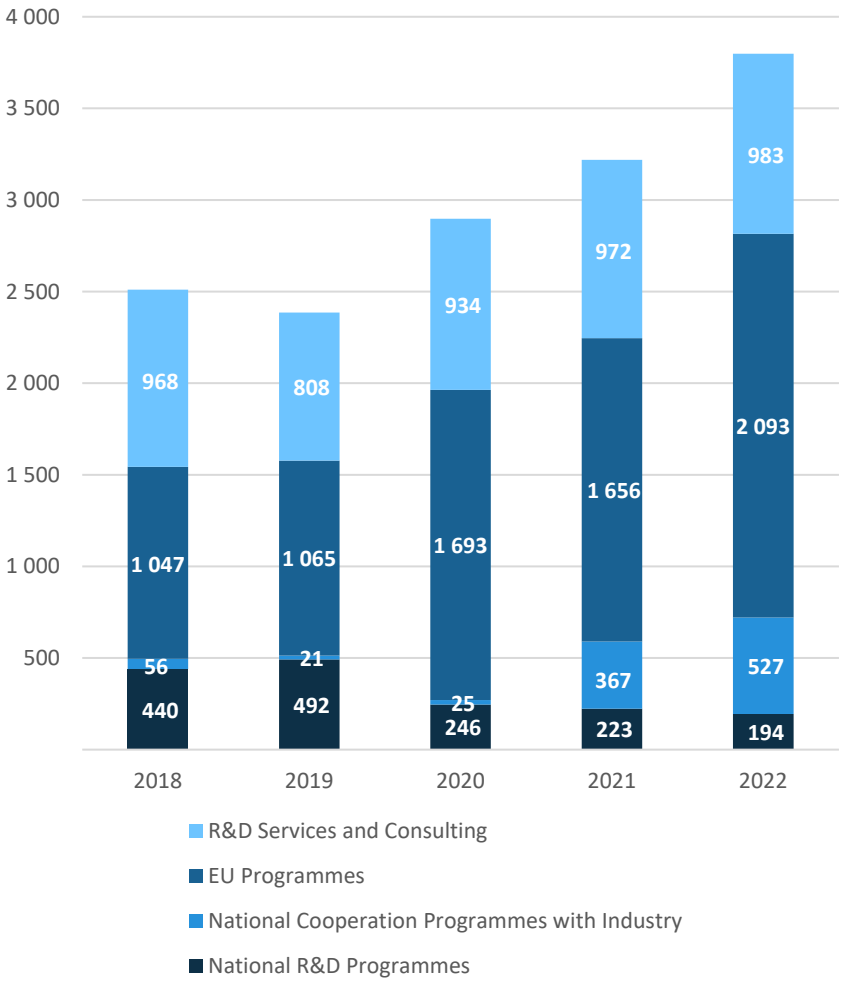


Figure 6.5.2 - CPES - Project funding evolution (k€)

6.6 CESE – CENTRE FOR ENTERPRISE SYSTEMS ENGINEERING

Coordinators: António Lucas Soares and Rui Rebelo

6.6.1 Presentation of the Centre

CESE is a multidisciplinary research centre that contributes to a sustainable, resilient, and human-centred industry through systems engineering. It plays both roles of research and business partner in creatively co-developing solutions for complex challenges, and in developing the capabilities of industrial organisations for an on-going digital and green transformation. 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 2022

RL1. Manufacturing Systems Design and Management

During this period, two main objectives defined in the plan of RL1 continued to be pursued, namely the combination of optimisation algorithms with simulation models in operations management, aiming at making manufacturing systems and supply chains more efficient and resilient, and the integration of Data Science and Artificial Intelligence approaches into decision support systems. For example, in the P2020|COMPETE project rePLANT, a simulation-optimisation DSS to manage disruptions in a biomass supply chain is being developed. Also, the research on reinforcement learning (RL) for decision support in manufacturing systems resulted in a new approach to WIP management in Assembly Manufacturing Systems. A new research topic began to be explored: the application of the concept of Digital Twin to Complex Infrastructures and Environments. In the FCT project FuturePharma (Pharmaceutical supply chain of the future), a simulation model has been developed to support strategic decision-making in the design of more efficient, flexible and resilient supply-chains. Currently, this model is being extended to handle environmental and social sustainability concerns. In collaboration with our partners (Universities of Coimbra and Lisboa), a reference architecture for this type of chains is being successfully designed.

RL2. Supply Chain Management

RL2 has contributed to the literature and practice by exploring the contemporary challenges faced by supply chains and by addressing strategies (and related enabling technologies) to increase their resilience and sustainability. Within the scope of the ReSChape project, the main trends and vulnerabilities faced by European companies were examined in order to develop models that allow the management and design of supply chains capable of responding to current requirements. The development of circular supply chain models has been explored in different sectors, such as plastics, packaging, textile, shoes, and food, in the context of the projects SoTecIn Factory and STVgoDigital. The role of visibility and trust was studied using a model to evaluate the quality, quantity and timeliness of the information shared between supply chains partners, generating a set of recommendations for managers, as well as the role of buyer-seller power relationships in the digital transformation process of SMEs.

RL3. Industrial Information Systems

In the confluence of Digital Enterprise Architectures and Industrial Data and Information Management research topics, research has been developed in the CircThread project regarding interoperability architectures for data and information management in inter-organisational contexts. Emerging technologies and initiatives such as International Data Spaces are being explored, designing abstract digital solutions for the integration of value chains both vertically and horizontally. A multidimensional concern of data governance stands out, addressing aspects of semantics, quality, and integrity of people-centered data. The results of this research were presented and published in four international conferences. In the topic of Design and Impact of IIS, socio-technical design, the activities in developing a design theory for the development of digital-twin based architectures led the study of the role of Industry 4.0 reference architectures in digital transformation processes, based on the theoretical constructs of boundary objects. Still in the Transformer 4.0 project, a literature review of the Cognitive Digital Twin concept as enabler of Product-Service Systems was presented in a conference, paving the way to a CDT-based PSS architecture.

RL4. Technology Management in Industry

During this period, RL4 explored in theory and practice the main topics related to technology management – Technology Adoption Strategies, Transition of companies to Circular Economy and drivers and barriers to Digitalisation. The kick-off of several European projects related to the topics above – Demo4Green, GreenAPS, ReSchape, SoTecIn Factory, Change2Twin and ConFacts, among others, reinforced the development of research applied to ongoing demands of the manufacturing industry, supporting their transformation to address the new challenges of a post-pandemic economy. Several papers were published in the topics of adoption and implementation of Industry 4.0 technologies in several industrial sectors. In particular, two reviews regarding human-robot collaboration were published. Maturity models continued to be studied and applied, and a study on the manufacturing industry in the northern region of Portugal was published. In the Transformer 4.0 project, the research on socio-technical systems design led to a paper describing the value of the concept of operations analysis for digital transformation using digital twins.

RL5. Transportation and Logistics

In the FCT exploratory project e-LOG, a decision support tool is being developed, to assist the design and assessment of innovative services in urban logistics, with particular focus on the "last mile" and the environmental impacts of parcels distribution. In the Horizon 2020 funded project MAGPIE project (Smart Green Ports as Integrated Efficient Multimodal Hubs), we have designed, in close collaboration with CPES and working with the ports of Sines and Rotterdam, several use cases, and helped structuring concepts and modelling physical and data flows. The NEXUS Agenda, led by the Port of Sines and involving a consortium of 35 entities, started in this period and will result in an ecosystem of products and services for Digital and Green Transition in the transport and multimodal sector. CESE is responsible for research activities in optimisation and simulation models, and decision support tools, in the context of three work packages.

6.6.3 Innovation outcomes in 2022

Within the scope of digital transformation, the Digital Maturity Assessment and Industry 4.0 Roadmap services have assumed a 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. Moreover, a regional and cross sector strategic project was executed with two industrial associations focusing on three main sectors: Automotive, Industrial Equipment Manufacturers, and Metalworking. Industrial OT/IT integration services were also important due to the number of services provided as well as the acquired knowledge. DIH services, mainly in the scope of Digital Twin Technology Adoption, were also executed, both for national and international companies. Innovation projects were designed and implemented by companies with success. In particular, CESE was responsible for the development of a Digital Twin that replicates the operation of a PV power plant and uses near real-time field data (actuating/control set-points on the inverters) comprising APIs, data ingestion, and data management layer. The outcome was a software package (software distribution based on a containerized infrastructure – e.g., Docker) and documentation for the Digital Twin backbone. The approach was based on a set of Open-Source software components that enabled the load, transformation, and storage of data flows coming from the inverters, meters, and sensors, and provided subsequently the APIs to the O&M functions.

6.6.4 Activity Overview

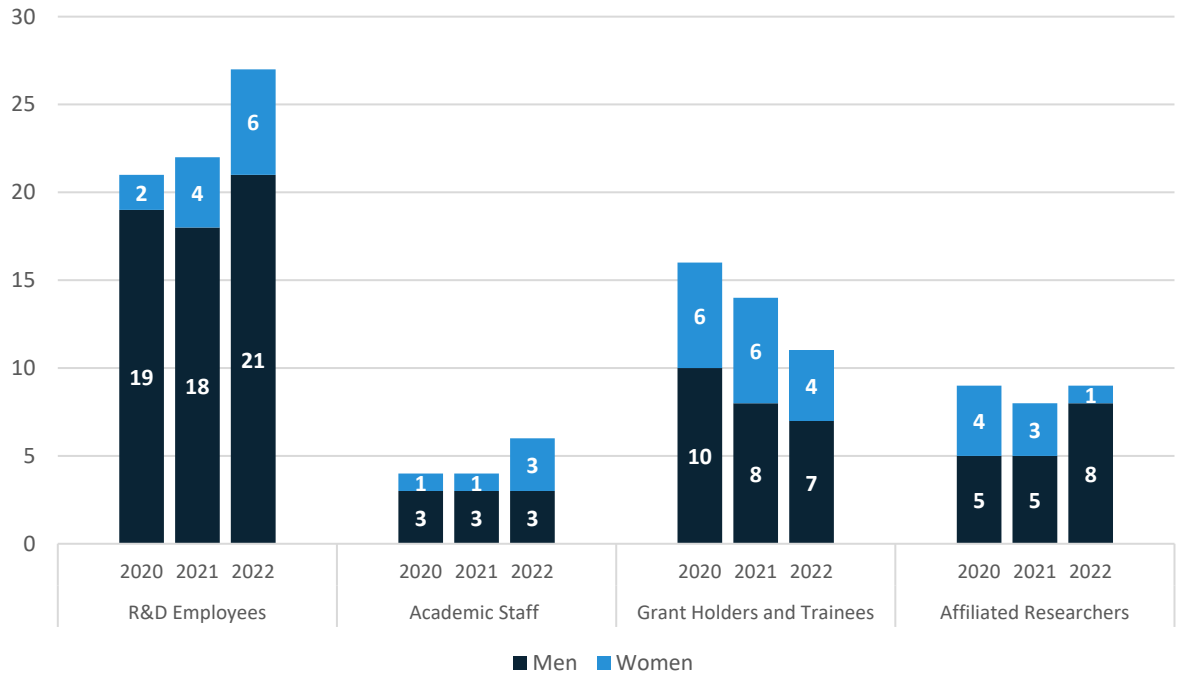


Figure 6.6.1 - CESE - Research team evolution

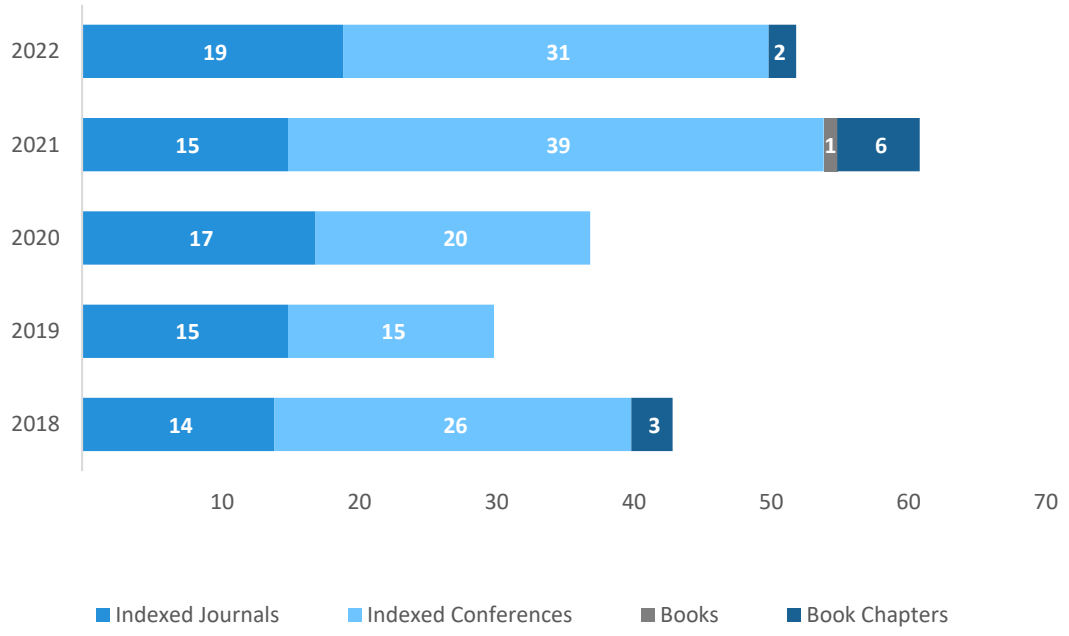


Figure 6.6.2 - CESE - Evolution of publications by members of the Centre

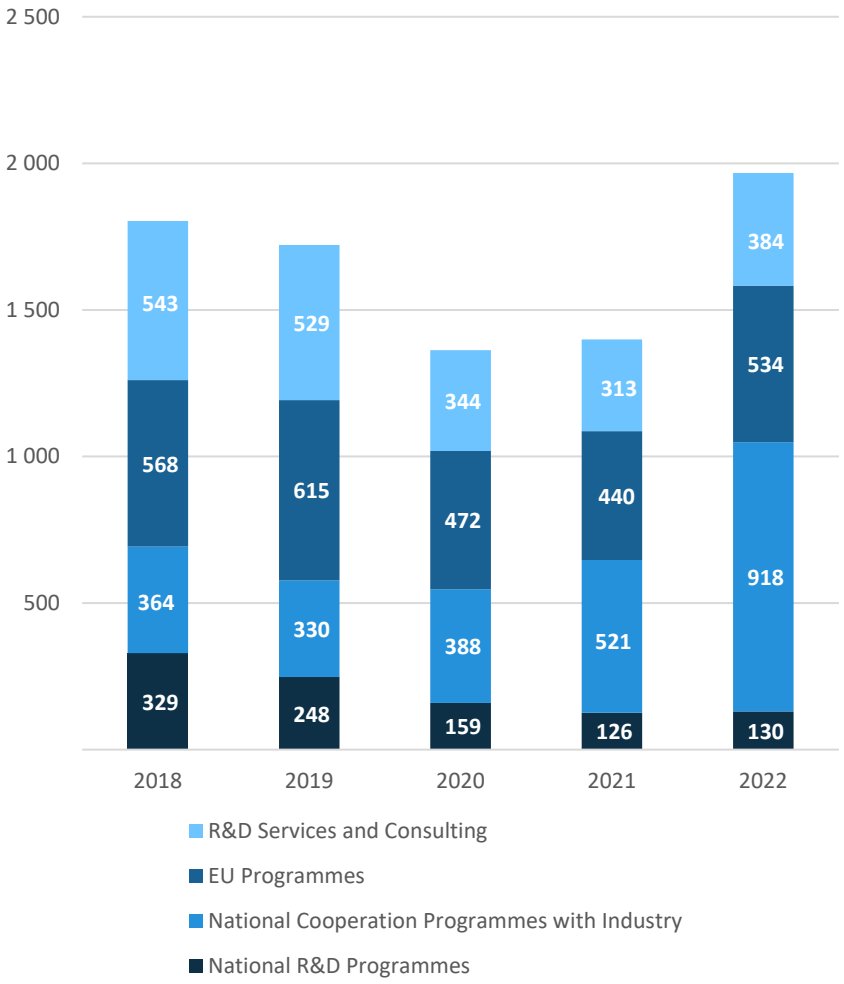


Figure 6.6.3 - CESE - Project funding evolution (k€)

6.7 CRIIS – CENTRE FOR ROBOTICS IN INDUSTRY AND INTELLIGENT SYSTEMS

Coordinators: António Paulo Moreira and Germano Veiga

Assistant to the Centre Coordination: Luís Rocha

6.7.1 Presentation of the Centre

The Centre for Robotics in Industry and Intelligent Systems (CRIIS) 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 2022

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

RL1. Navigation, Localisation and Coordination of Mobile Robots

In this research line, a multi-robot coordination system, considering communication failures, is under development, with useful outputs for different projects (PRODUTECH 4S&C and Continental FoF, among others). The modules 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. They were tested and validated in SCORPION and NOVATERRA and are being incorporated into a single package to be explored in higher TRLs. Two PhD candidates defended their PhD theses successfully, in the scope of this line.

RL2/3. 2D/3D Industrial Vision, Advanced/Intelligent Sensing and Control

An architecture for a robotic grasping planner that is easily configurable, modular, portable, and unified has been developed in this RL. It offers a large selection of tools for producing a list of potential grasping positions while considering both the geometry of the object and the tool of the robotic arm. During robotic arm operation, the best candidate is chosen by considering not only the object's position but also the robot's effort to get there, and the likelihood of a collision with the surrounding area and with other objects. In order to detect objects in cluttered environments for pick and place operations, an object detection pipeline was also developed, with deep learning used for 2D detection, and 3D point clouds used for the final segmentation. To facilitate the generation of data through simulation and speed up the training of the AI model, a blender-based tool was created. Also in this research line, and in the context of agriculture, a new module called FollowMe is being developed to be incorporated in agricultural robots that will cooperate with humans. Besides, two variants of Variable Rate Technologies were developed with advanced perception systems for precision spraying robots. These modules were tested and validated in TRL 7.

RL4. Human Robot Interfacing and Augmented Reality

Regarding the Centre's projected spatial augmented reality system, a new portable solution was developed, for easy transportation and deployment considering constructions areas. For this purpose, the usage of short throw projectors and smaller sensing devices was investigated. Also in this RL, an augmented reality-based system was designed to improve human-robot interaction and safety in collaborative workspaces. The system monitors the operator's hands and head, allowing the robot to move concurrently with the operator if they maintain a pre-determined distance apart. The AR system also allows for easily programming production tasks, through a holographic robot and programming panel.

RL5. Future Industrial Robotics and Collaborative Robots

In this line, CRIIS has developed a module called FollowMe, that can be used for robots to follow individuals performing agricultural tasks, in operations support logistics. FollowMe uses time-of-flight based sensors and a visual camera to understand where the human workers are and understand their actions. To enable better and simple interactions with robots, advanced but intuitive Human-Robot-interfaces are being developed in a

smartphone and Android ecosystem. In terms of future robotics systems, two lines are being explored – tethered drones and quadruped robots – for application on industrial and agricultural robots.

RL6. Vertical Integration, IoT, Industry 4.0

An AI-based solution is being developed to keep the Digital Twin component (Advanced Plant Model) of the Open Scalable Production System (OSPS) continued, benefiting from the integration of cloud-based services on two levels: (1) the utilisation of cloud-hosted Machine Learning services for object recognition and localisation, which facilitates the creation of training models and computation; (2) the usage of a cloud-based robot simulation tool that facilitates the development of algorithms before deployment in real systems. The OSPS framework has been enhanced with support for ROS2, integration with the Robotics and Automation MarketPlace (RAMP), and usage in several European-funded R&D activities, including H2020 AI REGIO, H2020 BetterFactory, and H2020 Mari4YARD. The AgIoT module features were expanded and have reached V3.0 for SmartTrap (based on the AgIoT solution), and 10 units were deployed in real farms for a long pilot test. SmartTrap will enable the detection of agricultural disease vectors in a faster and more cost-effective way.

6.7.3 Innovation outcomes in 2022

INOV1. Flexible Production using Robotics

The main innovation activities were: (1) industrial deployment of a robot perception system for silo top referencing, developed based on a 2D laser scanner; (2) industrial deployment of a Lean AGV for intra-logistics operations in the textile industry; (3) raising the TRL of a mobile manipulator technology, designed for intra-logistics activities, from TRL 5 to TRL7, in Mari4_YARD project.

INOV2. Inspection, Control and Embedded Systems

Development of a 3D artificial vision system to validate the position of parts in a washing basket, after manual placement, and for subsequent robot manipulation, in the automotive industry.

INOV3. Cloud-based Robotics

The development of cloud-based integrations with robotic systems is leveraging a partnership between CRIIS, Amazon Web Services (AWS), and RackSpace in the scope of the Open Clouds for Research Environments (OCRE), as part of the European Open Science Cloud (EOSC) activity. Four innovation tracks are currently being pursued: (i) integration of cloud-based robotic simulation within Continuous Integration / Continuous Deployment (CI/CD); (ii) container-based development and orchestration of robotic applications; (iii) leveraging cloud Services to support AI-based methodologies in robotic operations; (iv) web-based solutions for the development and monitoring of robotic applications and data.

INOV4. Agricultural Robotics

The main innovation activities were: (1) moving a spraying robot's Manufacturing Readiness Level from level 4 to level 7, in project SCORPION (with TEYME); (2) the testing and validation of the CRIIS navigation stack on steep slope agricultural robots. In this line, the Weta Robot has won an iF Design award, for the best design for agricultural robots. The level of maturity of AgIoT modules has increased and they were successfully used in several public demonstrations, in spraying and in fertilisation machinery and robots.

6.7.4 Activity Overview

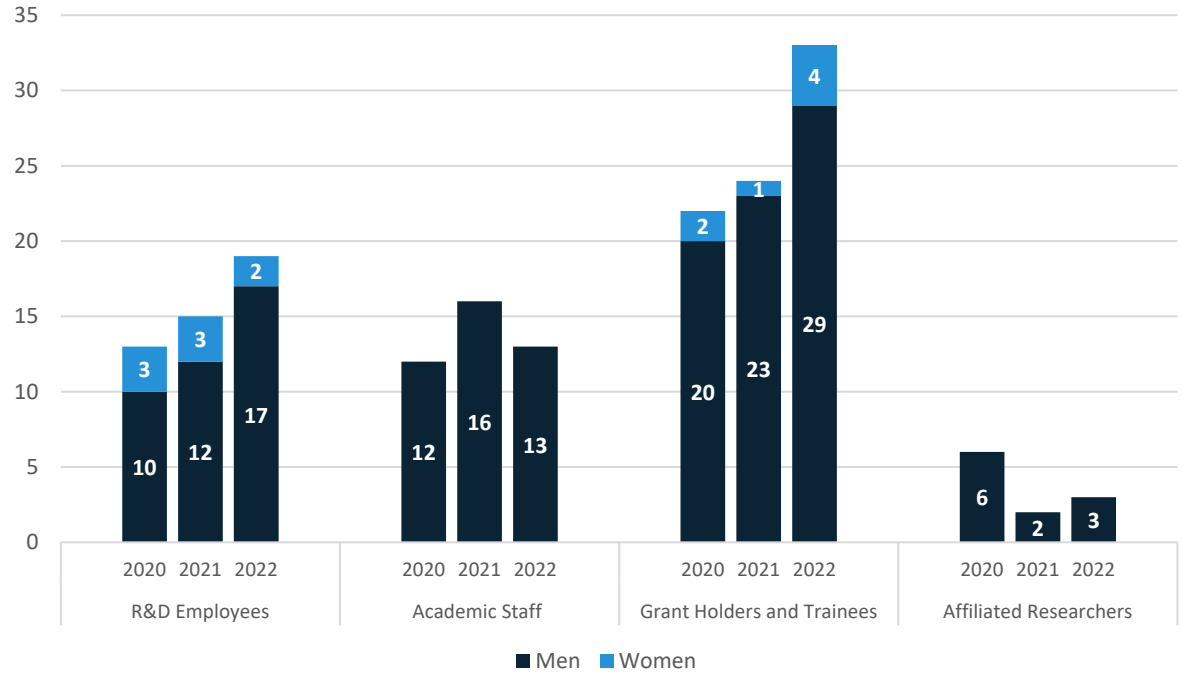


Figure 6.7.1 - CRIIS - Research team evolution

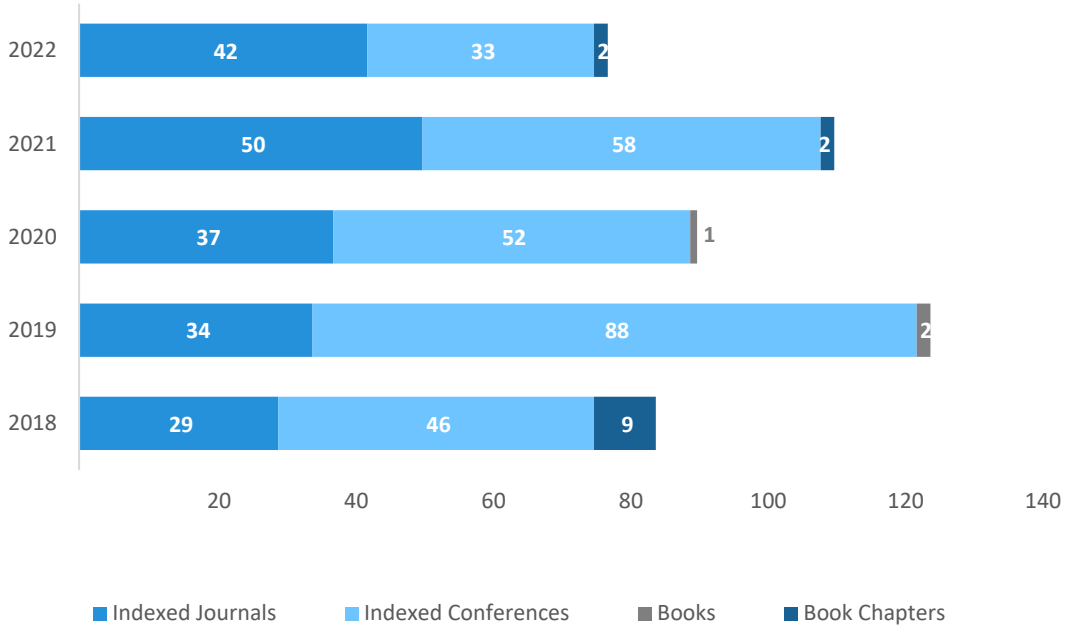


Figure 6.7.2 - CRIIS - Evolution of publications by members of the Centre

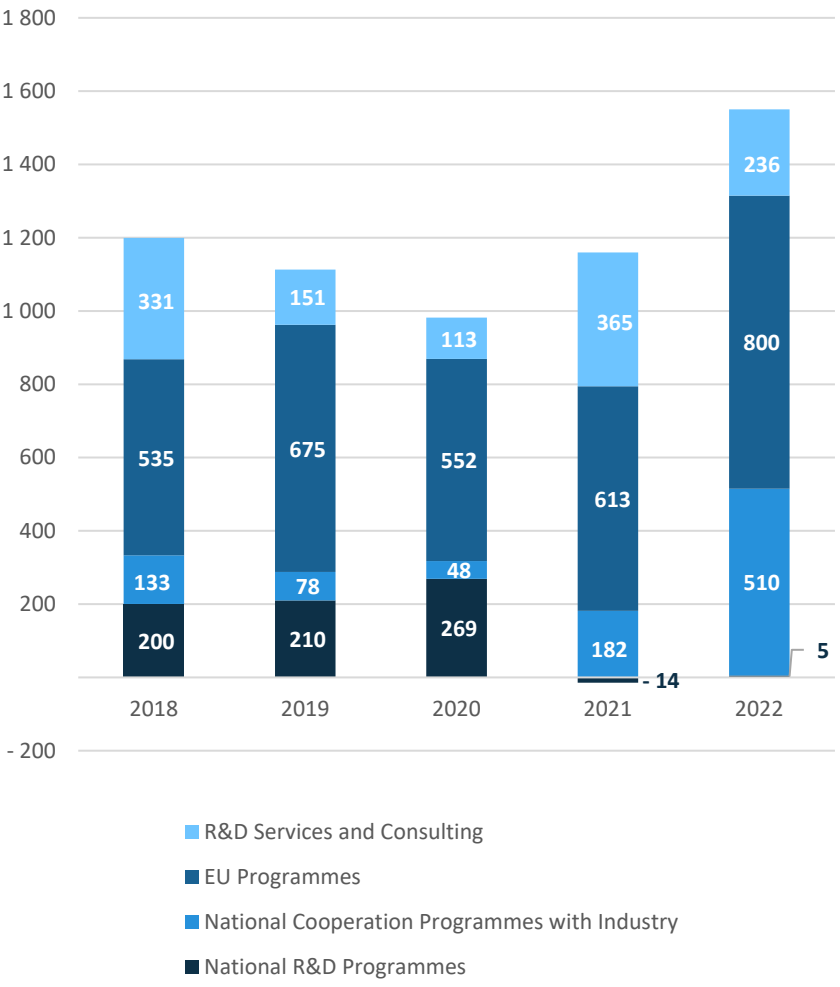


Figure 6.7.3 - CRIIS - Project funding evolution (k€)

6.8 CEGI – CENTRE FOR INDUSTRIAL ENGINEERING AND MANAGEMENT

Coordinator: Lia Patrício

6.8.1 Presentation of the Centre

CEGI is an international reference in systems engineering and management, with a focus on management science and service science. CEGI leverages research competences in systems engineering and management with a vision of innovative technology enabled system solutions and an ever-integrated and flexible value chain across different industries (e.g., manufacturing, energy, mobility, and others). To address the challenges posed by this vision, the combination of competences in Service System Design and Innovation, Business Analytics, Operations Research and Operations Management is crucial.

6.8.2 Research outcomes in 2022

CEGI's scientific domain focuses on systems engineering and management, particularly on management science and service science. Building upon these research domains in management science (business analytics, operations research, operations management, and performance evaluation) and service science (human-centred approaches and service system design and innovation), CEGI tackles classes of problems covering the full cycle of systems development, from understanding, to conceiving, developing, implementing, operating, and evaluating. In 2022, CEGI completed several important key projects and received approval of new ones, particularly funded by FCT and PRR. CEGI published 45 articles in highly ranked journals and completed 7 PhD theses.

Operations Research & Operations Management

In the area of production and operations management, the FCT project **SiuSMS** (Smart (inter)urban shared mobility systems: integrating pricing and fleet management for a sustainable mobility planning future) was completed in 2022. This project integrated pricing and fleet management decisions for shared mobility systems, namely car rental and car sharing. Over four years, this project resulted in 7 publications, 5 MSc dissertations, and 1 PhD soon to be completed. A new exploratory FCT-funded project accepted in 2022 (project **MOSH** - Modelling shared mobility: advanced demand modelling and learning for the sustainable shared mobility of the future) stemmed from the results of project SiuSMS.

DeltaCP (Uncertainty in Cutting and Packing problems: robust planning and optimised replanning in manufacturing and transportation) was a joint FCT-FAPESP project that ended in 2022. This project aimed to propose models and algorithms for the incorporation of uncertainty in the resolution of cutting and packing problems. Over four years, this project resulted in 16 publications in top-tier journals, 1 MSc and 3 PhD dissertations.

During 2022, the first year of project **BeFresh** was executed. This project focuses on grocery retailing, developing policies for perishable products. The main goal is to reduce total waste by tackling its leading causes, such as poor inventory management at the store-level, complex consumer behaviour, and mismatch of supplier-retailer decisions. In 2022, this project had, as on-going related work, 3 MSc and 1 PhD dissertations. This work resulted in 2 publications.

Intralogistics is an interdisciplinary field that focuses on optimising and automating internal logistics processes to improve efficiency and productivity. CEGI worked in 2022 in the development of advanced optimisation algorithms for pallet loading that are integrated into intelligent systems that control intralogistics flows and robotic palletization, namely in projects **CrossLog** (Automatic mixed-palletizing for cross-docking logistics centres) and **Produtech R3** (Mobilising Agenda of the Production Technologies Sector for Reindustrialisation). This work resulted in 5 publications and 1 MSc dissertation.

Business Analytics

The EU project TRUST-AI had major developments in 2022. The first version of the TRUST-AI framework was developed, tested and made available in gitlab. This prototype allows users to run any algorithm, and integrates interfaces specifically designed to interact with genetic programming (or other tree-based algorithms), while

managing computing resources. Two MSc theses have resulted from this work, and one paper is planned to be submitted to an international conference. One workshop was also conducted to explore the framework during 2022.

Service Science

In the EU-funded smart city project POCITYF, which implements and tests Positive Energy Districts in eight historical cities, CEGI is responsible for a WP on citizen engagement. In 2022, CEGI conducted qualitative and quantitative studies with citizens of two lighthouse cities and stakeholders of the eight cities to understand citizen engagement behaviours and drivers. Based on this understanding, CEGI conducted several cocreation workshops with citizens and stakeholders of the different cities, and developed a key deliverable with a new approach and tools to develop strategies for citizen engagement with sustainable energy transitions. Within this project, 1 PhD was completed in 2022, while 2 PhDs are ongoing. An article on customer engagement and value cocreation with smart energy services was published in the Energy Policy journal.

Key publications

- Ali, S., Galrão Ramos, A., Carravilla, M.A., Oliveira, J.F., 2022. On-line three-dimensional packing problems: a review of off-line and on-line solution approaches. Computers & Industrial Engineering: 108122.
- Gonçalves, L., Patrício, L. 2022. From smart technologies to value cocreation and customer engagement with smart energy services. Energy Policy 170 (2022): 113249
- Oliveira, B.B., Carravilla, M.A., Oliveira, J.F., 2022. A diversity-based genetic algorithm for scenario generation. European Journal of Operational Research. 299, 1128–1141.
- Santos, A.G., Viana, A., Pedroso, J.P. (2022). 2-echelon lastmile delivery with lockers and occasional couriers. Transportation Research Part E: Logistics and Transportation Review (162)
- Santos, M.J., Martins, S., Amorim, P., Almada-Lobo, B, 2022. On the impact of adjusting the minimum life on receipt (MLOR) criterion in food supply chains. Omega, 112, 102691.

6.8.3 Innovation outcomes in 2022

The contribution to society through knowledge transfer is also a central point of the activity of the Centre. CEGI contributes to advancements in the Manufacturing Sector (with a focus on logistics, production and operations), the Energy Sector (focusing on citizen engagement, asset management expertise and enhanced performance evaluation), the Health Sector (on the de-materialisation of processes and the improvement of insights), the Retail and Agro-Food Sectors (with sustainable operations of the supply chain), and the Transportation and Mobility Sector (focusing on improving freight transports, urban mobility and shared services). These innovation outcomes result from both technology transfer of research projects and consultancy projects.

CEGI European projects developed important innovation outcomes in 2022. Particularly in **Trust-AI**, multiple applications are being explored, within and beyond the project. As an example, in online retail the algorithms are being used to predict customer willingness to pay and cost to serve (paper to be submitted). The application of Genetic Programming to this problem was explored in a consultancy project with Farfetch (**DRIVEN**), which will also result in a paper. Finally, in-store picking of online orders is being approached with Reinforcement Learning algorithms, which resulted in a paper submission and the participation in the consortium of a European project proposal (**PEER**).

The consultancy projects **Best Order 2 and 3** were undertaken during 2022. This project conducted with OCP Portugal led to the creation of a new business area in pharmaceutical distribution, based on the digitisation of crucial supply chain activities, namely demand forecasting, inventory management and also revenue management of OCP Portugal customers - the pharmacies. This new business is unique at the European level, enabling greater integration and visibility of the entire supply chain. In a second stage, with the growth of the platform, it will also generate market insights in real time, through the analysis of data from pharmacies spread across the country that are a proxy for market dynamics.

6.8.4 Activity Overview

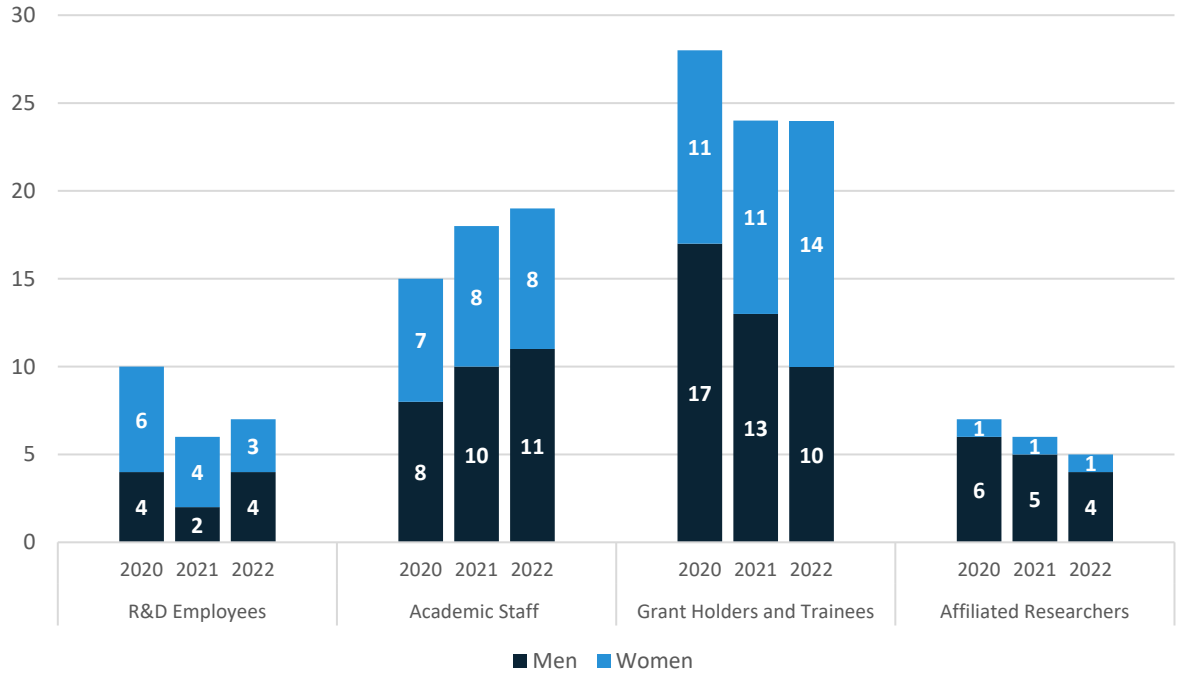


Figure 6.8.1 - CEGI – Research team evolution

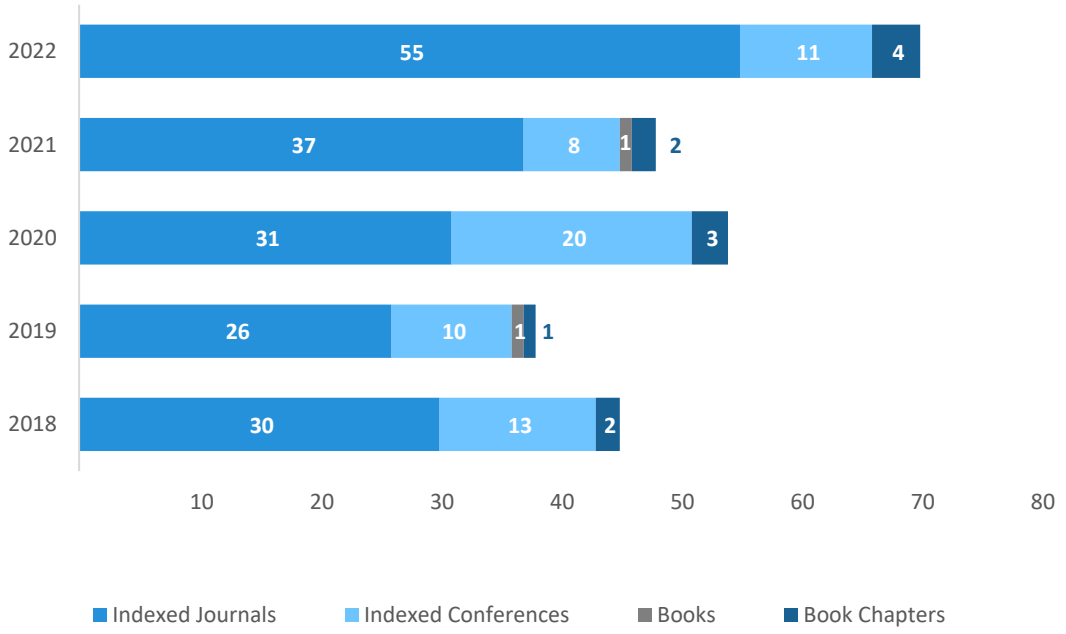


Figure 6.8.2 - CEGI - Evolution of publications by members of the Centre

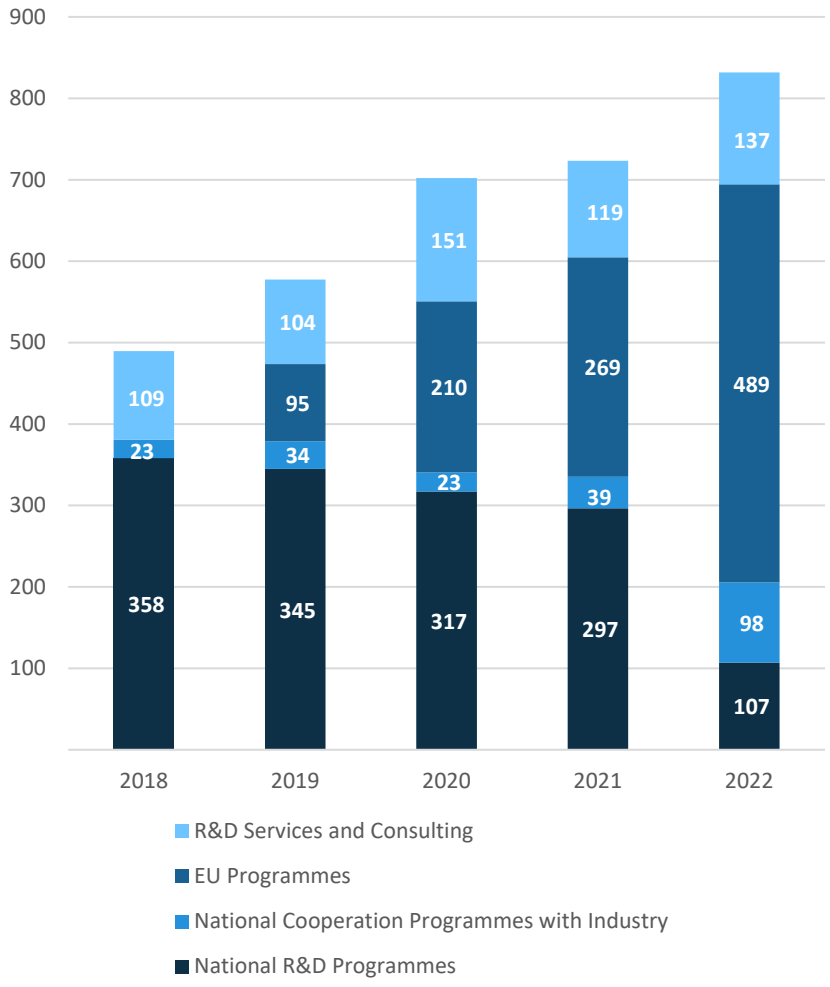


Figure 6.8.3 - CEGI - Project funding evolution (k€)

6.9 CITE – CENTRE FOR INNOVATION, TECHNOLOGY AND ENTREPRENEURSHIP

Coordinator: Alexandra Lobo Xavier

6.9.1 Presentation of the Centre

CITE aims to strengthen Innovation towards a responsible and sustainable economy and society, by empowering researchers, and public and private organisations in processes of Innovation, Technology Management, and Entrepreneurship. The Centre seeks to leverage research outputs for market uptake and society benefits empowering researchers and organisations, and foster an entrepreneurial mindset in research communities, businesses, and society in order to generate new technological concepts and new business models to address socio-economic challenges.

The Centre's research scope encompasses:

- developing theories, concepts, models, and tools, to support Innovation and Technology Management, and the Front End of Innovation, with a focus on technology-driven innovation;
- addressing current and future challenges of Responsible and Sustainable R&D and Innovation;
- applications to all organisation types, public and private, and including SMEs and start-ups;
- exploring quantitative and qualitative research, with a focus on action and design science research;
- applying the outputs of the R&D activities to consulting and executive training programs.

CITE defines the following Research Lines: RL1. Innovation Management (IM) & Fuzzy front end of Innovation (FEI); RL2. Technology Management and Policy; RL3. Business Model Innovation; RL4. Co-creation Methodologies for Customer-Centric Innovation to support Entrepreneurship.

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 business consultancy, supporting technology-based entrepreneurial projects.

6.9.2 Research outcomes in 2022

During 2022, CITE has been involved in three main R&D European projects: FIRE RES, VR2CARE, and SotecIn Factory.

CITE coordinates the participation of INESC TEC in FIRE RES and has developed an "Open Innovation Campaign Handbook", a tool to support the implementation of an Open Innovation Campaign at an International level in 2023 (RL4). It also participates in the project's Responsible Innovation Committee. One framework, "Challenge Design Canvas", was applied in the following workshops (RL4): Challenge Design Workshop for an open innovation campaign for the FIRE RES project – Porto in July 2022, Barcelona in September 2022, and Lousã in November 2022; An Innovation Management and Technology Road-mapping for Digitisation Workshop in Cooperation with CESE, September 2022.

CITE maintains an active participation in European project VR2CARE, especially in its exploitation activities, as a result of the participation in European networks such as the Active and Healthy Ageing partnerships (as a result of EIP_AHA), namely in the SAFE consortium (28 countries), and in international and national thematic networks for "Smart Healthy Age-Friendly Environments".

Under the SoTecIn Factory (Social and Technological Innovation Factory for Low-Carbon and Circular Industrial Value Chains) project, CITE was in 2022 engaged in Scientific Coordination and Quality Control tasks, for launching the activities in 2023.

CITE maintains an active participation in National and International Technical Committees for Innovation Management (CT169; ISO TC 279) and by participating as a national expert (RL1). CITE is also present in the Food-Waste national task force (RL1,2,3).

6.9.3 Innovation outcomes in 2022

INOV1. LET in, the Laboratory for Technology Entrepreneurship

During 2022, CITE coordinated two international accelerator programs – EIT Jumpstarter 2022 (bootcamp and local training activities, and pre-accelerator) and Tech2Market – and also participated in the implementation of two more acceleration programs – GreenMA (Green Manufacturing Accelerator) and Demo4Green (Green Manufacturing: Demonstrating technologies to fight Climate Change), the latter in collaboration with CESE.

Under those programs, CITE provided expert training and mentorship to 30 early-stage entrepreneurial projects. In Demo4Green, CITE was responsible for the business creation work package and for the design of the Demo4Green Coaching & Mentoring Programme. From the EIT Jumpstarter 2022 Local Training, 4 of the 8 Teams trained by INESC TEC reached the final of the competition, 3 were awarded with 1st and 2nd place in EIT Health and 1st and 3rd place in EIT Manufacturing. CITE also participated in sTARTUp Day in Tartu, August 2022, in representation of the GreenMA project, and in the Jumpstarter 2022 Final Event, November 2022.

INOV3. The Journal of Innovation Management (JIM)JIM is an open-access, multidisciplinary peer-reviewed journal co-founded by a CITE researcher, who is also currently one of the journal's co-editor-in-chiefs. It hosts 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. JIM publishes 4 issues every year. Since the first issue in September 2013, 246 articles were published.

INOV4. Innovation Management Consulting Activities

One advanced consulting contract for the implementation of Innovation Management Systems has been concluded during 2022. As a result, the company Agroinsider has been certified by NP 4457:2007.

Leveraging work in the DIVAx project, services for company Europeanisation were built to support the expected "Europeanisation" of R&D&I that will allow companies to strengthen their position in the European market. The approach relies on each partner bringing expertise and sharing it with the others to provide relevant and efficient international support to companies. Two kinds of services have been implemented: ecosystem services (international event) and business services (proposed before and during the international event with the CITE team supporting one Portuguese SME).

INOV5. EEN Portugal

Under the umbrella of Enterprise Europe Network, in 2022 CITE served more than 150 SMEs through the network's activities (communication and dissemination events, innovation support, partnership and international cooperation opportunities) and supported 14 unique SMEs in the network client journey.

INOV6. Executive Training

CITE submitted two new proposals to EIT Manufacturing, 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: Turing II and Transformation pathways – Developing CO2 Roadmaps for Energy-Intensive Industries (TransPathCO2). The projects will deliver a capacity-building, upskilling learning program that can be taken by participants to develop their company-specific transition pathway. CITE will perform professional education in a blended learning environment. Both proposals have been accepted for funding in the meantime.

During 2022, INESC TEC organised and delivered several advanced training activities, exploring the topics of innovation. Embedded in EIT Manufacturing's Tech2market program, a digital learning tool has been developed on the topic of business creation: i) Problem and business need definition; (ii) Define a Business Plan; (iii) Screening of a team; (iv) Roadmap – a tool for start-up evaluation. As a consequence, one learning path has been published in SkillsMOVE, addressing a mentorship program, start-up evaluation process and business modelling for exploitation of R&I projects.

6.9.4 Activity Overview

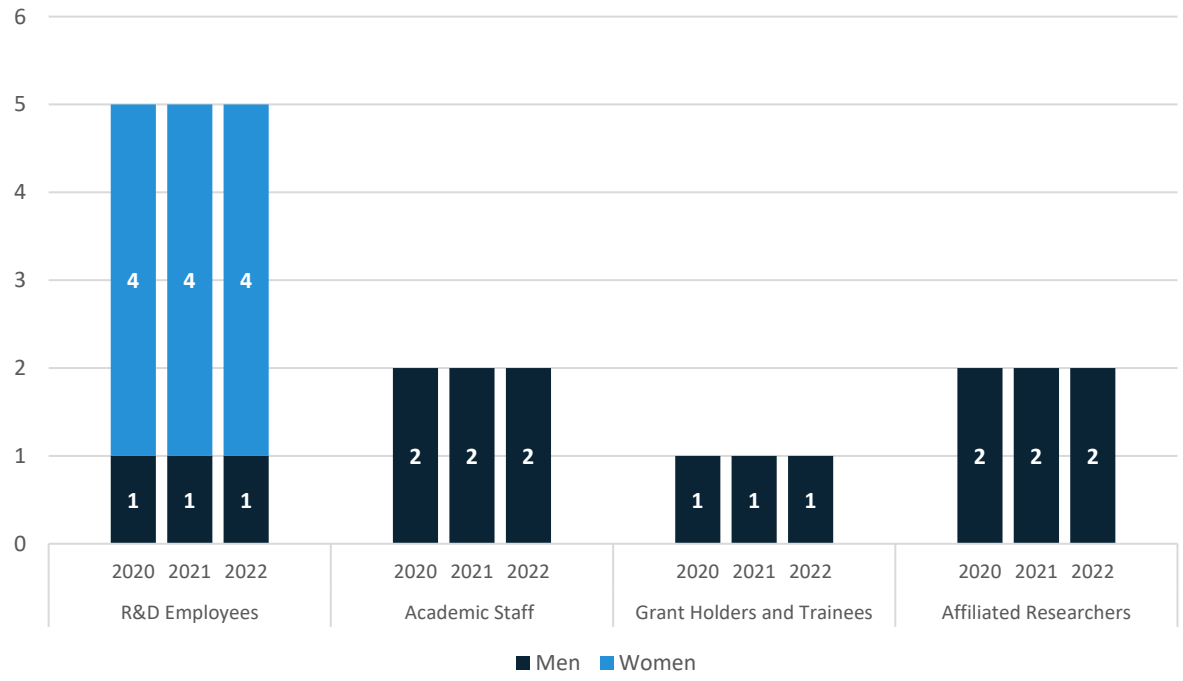


Figure 6.9.1 - CITE - Research team evolution

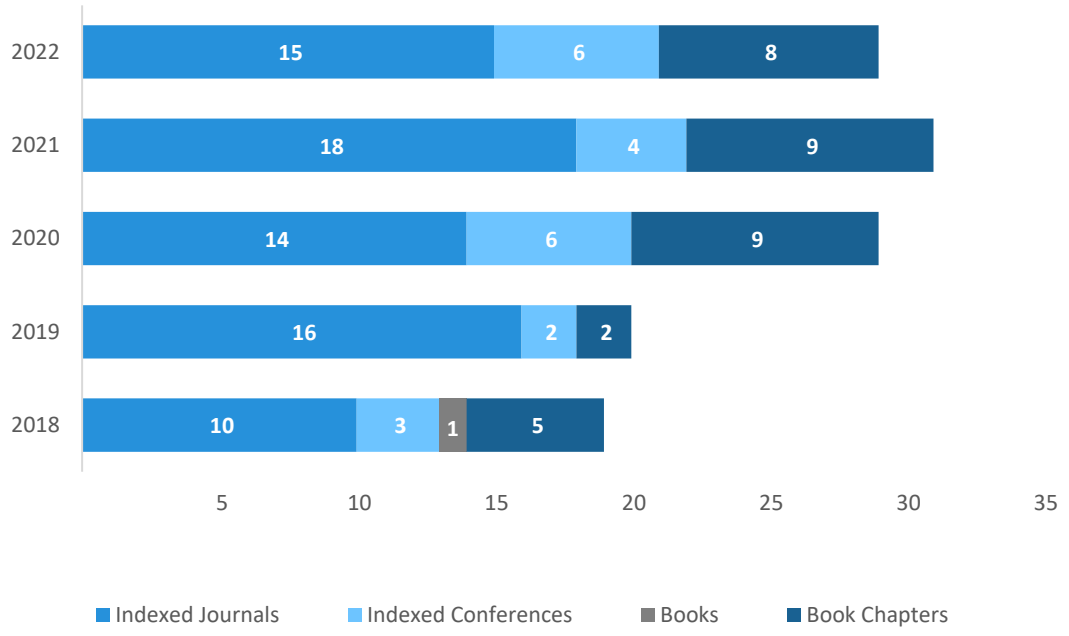


Figure 6.9.2 - CITE - Evolution of publications by members of the Centre

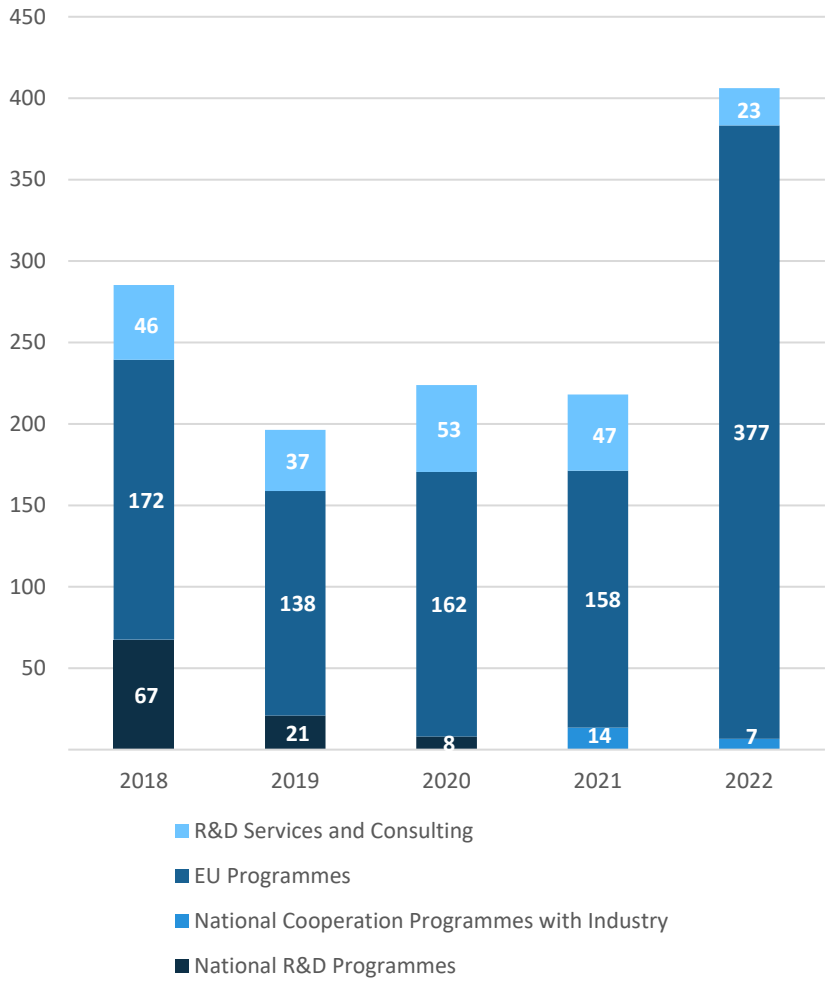


Figure 6.9.3 - CITE - Project funding evolution (k€)

6.10 HUMANISE – CENTRE FOR HUMAN-CENTERED COMPUTING AND INFORMATION SCIENCE

Coordinators: Ademar Aguiar and Artur Rocha

6.10.1 Presentation of the Centre

In 2022, the centre was formally renamed HumanISE, a final step of the process started in 2020 of rethinking, repositioning and refocusing the centre at the forefront of human-centred computing (HCC), computer science (CS) and information science (IS). At the centre, engineers, scientists, and designers focus on researching and developing methods and tools for different kinds of software systems (e.g., applications, platforms, information systems, digital games, etc.) capable of leveraging human abilities and practices within their communities and environments. In close cooperation with prestigious academic and industrial partners, we aim to pursue high-quality research, innovation, consultancy, and technology transfer. We focus on five main research areas and four innovation areas.

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

6.10.2 Research outcomes in 2022

Computer-Human Interaction (CHI). The CHI group worked on several research activities and projects, leading to multiple publications. In the H2020/PAFSE project, the team has contributed to the communication and dissemination strategy and planned and implemented specific 3D Modelling, animation and printing educational scenarios in Northern Portuguese schools. The H2020/VR2Care project has started. The VR2Care ecosystem is a technological response to the factors that condition the practice of physical exercise, designed using co-creation methodologies and is led by one CHI group element. Also, some CHI group elements participated in the ILIAD project on the Citizen and Science for the pilots. In the NG-CrAI project, we are collaborating to bring the next generation of crowd computing systems, a fusion of state-of-the-art AI algorithms with human computation macro tasks, to support scientific discovery through unveiling patterns, correlations, trends, and gaps in publications. In the NORTE2020/Walking PAD project, we developed a virtual assistant. Furthermore, the team organised three international conferences:

- International Conference of Innovative Technologies and Learning – ICITL 2022;
- Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion - DSAI2022; and,
- International Conference on Technology and Innovation in Learning, Teaching and Education - TECH EDU 2022.

Computer Graphics and Interactive Digital Media (CGDM). The group has created a 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. And there are developments in fundamental research and prototyping in 3D multimodal interaction in immersive environments, including shape-changing haptic devices, DeskVR interaction, and Immersive visualisation. During 2022 two projects have been concluded successfully: PAINTER and M2S. There was also the creation of one advanced training program with the Industry for giving competencies on developing simulator platforms using game engines. And the participation in an Advanced training program within the Industry 4.0 paradigm in a partnership with the iiLab. Project TRIO was launched and had been developing workshops on promoting digital literacy. The group has also continued the contract with EIT Manufacturing to create a recommendation platform for training in immersive environments. Project TRIO was launched. Finally, four PhD theses were concluded in Informatics and Digital Media, as well as 31 MSc theses.

Information Management and Information Systems (IMIS). The EPISA project (FCT) was successfully concluded. A final workshop organised at INESC TEC joined all project partners to share results and plan future

collaborations. The second edition of the international workshop LinkedArchives'22 was organised in the context of TPDL'22.

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 agile software development process, and the design and implementation of the 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 a few international conferences, namely: the 15th IEEE International Conference on Software Testing, Verification and Validation (ICST 2022), the International Conference on the Art, Science, and Engineering of Programming (<Programming> 2022), the 22nd IEEE International Conference on Software Quality, Security, and Reliability (QRS 2022), and the 22nd International Conference on Agile Software Development (XP 2022).

Special Purpose Computing Systems/Embedded Systems (LASPeCS). Two new projects were approved, one European (A-IQ Ready) and one national (Unify), which are scheduled to start in 2023. The lab focus on A-IQ Ready will be on novel compilation techniques to decrease the effort of mapping computation to custom RISC-V extensions. In Unify, the lab will work with state-of-the-art compilation techniques (e.g. MLIR) to map computation to heterogeneous targets, such as CGRAs. The team continued researching source-to-source compilation, in particular for transforming loops into custom RISC-V instructions specialised for streaming and vectorization, proposed a C subset and a set of standard transformations that can improve the usability of using C as an IR, and explored Java bytecode decompilation as a means to provide generic source-level analysis for energy-related code smells.

6.10.3 Innovation outcomes in 2022

Geospatial Information Systems Engineering. Application of AI techniques, particularly Machine Learning, to identify and automatically count the insects that plague the olive groves, from images. Development of an intelligent module to automate the process of pest identification from trap images placed throughout olive orchards, to be able to quickly anticipate the occurrence of crop pests and diseases (INOLIVE 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). In SIGIPRO (P2020 project) we 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). Two out of four active H2020 projects were successfully concluded. RECAP Preterm performed privacy-preserving analyses over harmonised studies across its network of federated nodes, and produced promotional videos and e-learning modules. iReceptor Plus (iR+) implemented repository-agnostic security for immunogenetics. Furthermore, it developed a proof-of-concept for block-chain based traceability of transformations of human RNA data. ImmuneML (DSL and tools for Machine Learning on Immunology) was cited 30+ times since its publication in 2021 (Nature Machine Intelligence). INESC TEC facilitated the integration of ImmuneML with the iR+ gateway and prototyped its use in a federated learning context. PHR co-leads the common repository working group of the AIRR community, and participates in the standards, and software ones. It prototyped visualisation tools for immunogenetic data. Inno4Vac proceeded with the conceptualisation of an in-silico platform to accelerate mRNA vaccines development, with participation of industrial partners (GSK, Sclavo, Sanofi). A study for the implementation of a repository for genetic information at the University Hospital Centre of São João was performed.

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. This led to 5 Invention Disclosures. ILIAD defined a reference architecture to enable on-demand interoperable processing requests to the underlying models of the Digital Twin of the Ocean. It builds on open standards and best practices (OGC, IEEE) for the description of containerized EO processing pipelines, exploring interoperable deployments on cloud and/or HPC infrastructures. The FCT/MIT EESDataLab project is evolving the automatic representation and quantification of change on spatiotemporal phenomena though ML-based Point Set Registration techniques. A MoU has been signed with DITTO - Digital Twins of The Ocean, a program endorsed by the UN Decade of Ocean Science for

Sustainable Development (2021-2030). 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 develops research in three key areas: (i) Enterprise Computing; (ii) Data Management Systems and Applications; (iii) Digital Business and Learning. Bringing all those key areas together, Intelligent Organisational Ecosystems has been the main research line, supported by two major (multiannual) projects: (P1) Data4Bus, a project to define a Data Management process within a Portuguese Bank, from the Technological Architecture to the policies and procedures needed to support all activities in a highly regulated context; (P2) IT4IT, a project which aims the transformation of a monolithic structure of I.T. and Information Systems delivery in the context of a Portuguese Bank, into a digital services management and delivery, defining an "Extended IT" concept, aligned with IT4IT Reference Architecture and COBIT2019. Other projects in Requirements Engineering, Information Systems (Planning, Design, Management) and Enterprise Architecture have been developed, namely: (P3) CoolBizDoc, a pilot project in which one of the results was the creation of a data dictionary, to support the data management of a platform that includes the management of financial products, customers, risk and reporting to the sector's regulatory entities; (P4) FLOREST@, a project in which it will be developed a collaborative information infrastructure, that will enable the collection and organisation of data to generate indicators and risk models of forest regions. Connected to this research, ISAC has several active projects, with a mix of research and specialised consulting.

6.10.4 Activity Overview

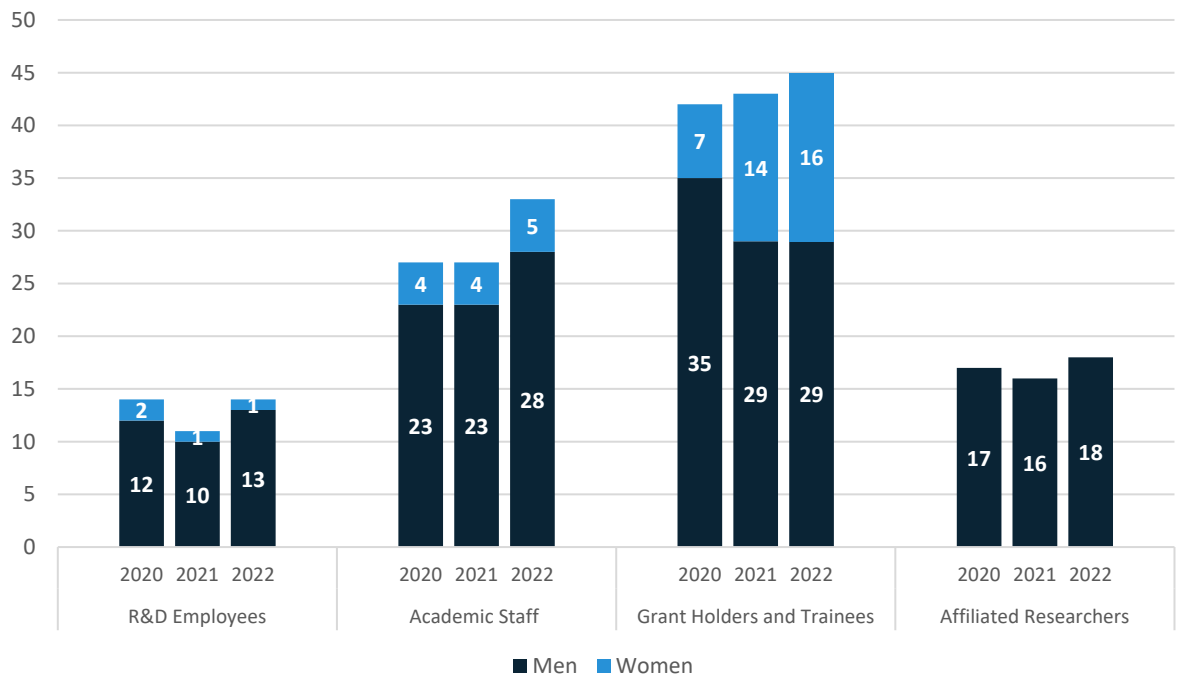


Figure 6.10.1 - HumanISE - Research team evolution

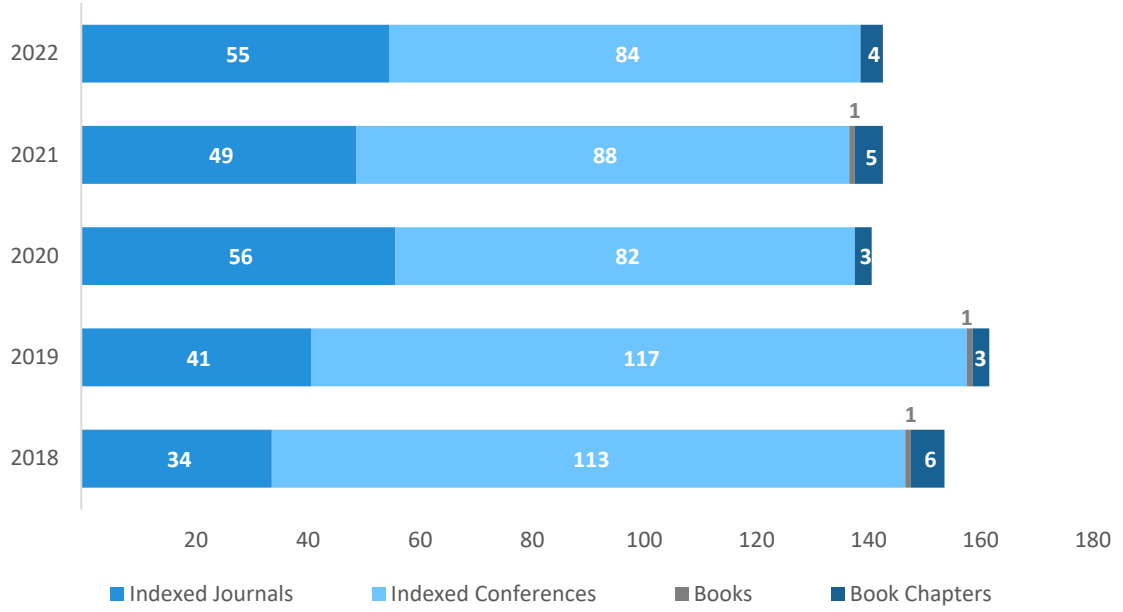


Figure 6.10.2 - HumanISE - Evolution of publications by members of the Centre

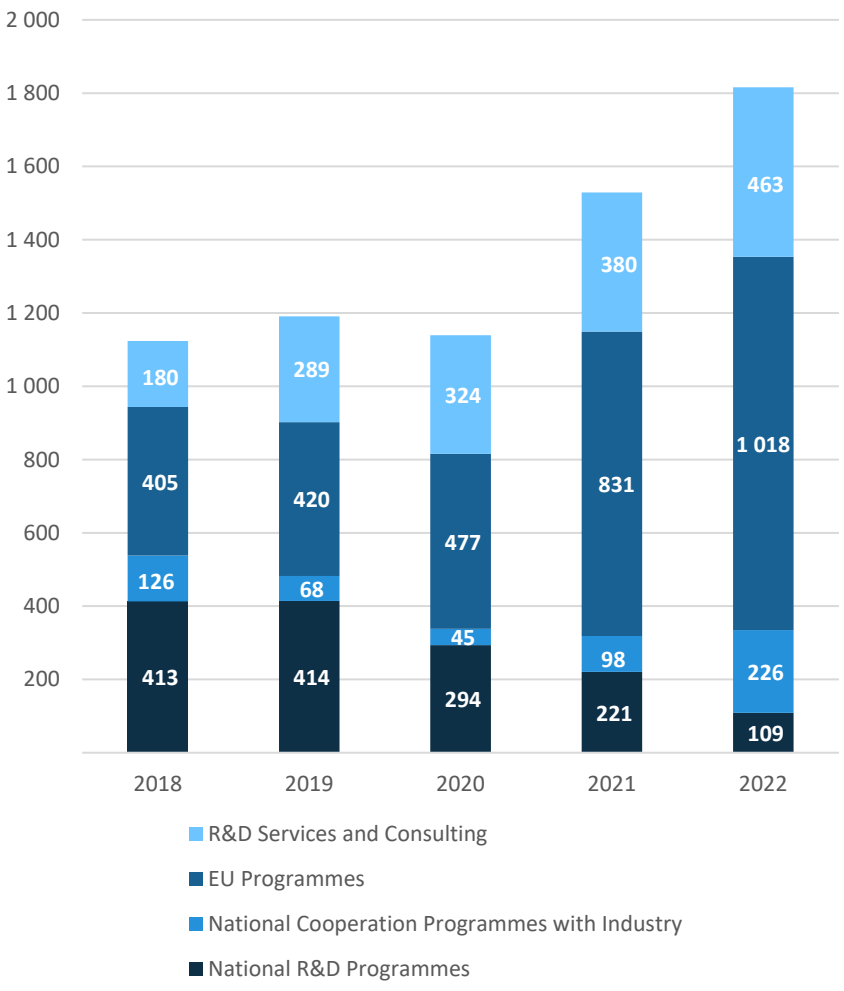


Figure 6.10.3 - HumanISE - Project funding evolution (k€)

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 Cluster focusing on Intelligent and Adaptive Systems and Mathematical Modeling in Decision Support.

LIAAD aims to produce high quality cutting-edge research in the international forefront of our research areas and promoting transfer of knowledge and technology. The Centre has been working in the area of Machine Learning and Data Science since 1991, and later including Optimisation and Mathematical Modeling. 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 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 2022 LIAAD had a total of 122 members, with 32 core researchers and 30 grant holders and trainees. 23 of the researchers were Academic staff mostly from the University of Porto, but also from P. Porto, I.P. Tomar, U. B. Interior, U. Portucalense, I. P. Viana do Castelo and I. P. Leiria.

6.11.2 Research outcomes in 2022

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 27 of the 47 journal papers published. Other strong areas are **Modeling and Optimisation** (7 papers), **Statistics** (6 papers) and **Mathematical Modeling** (3 papers).

In the European **Network of Excellence on Artificial Intelligence,** which started in 2020, LIAAD has continued its involvement in micro projects.

The research on Narrative Extraction brings together a team of researchers on **Natural Language Processing** with several publications and ongoing projects. We organised Text2Story2022, a workshop with 50. In **User Modeling**, we lead the organisation of the ORSUM workshop at RecSys (Online Recommender Systems and User Modeling). Ricardo Campos was 3rd place at this year's edition of the Arquivo.pt award.

In **Large Scale ML** LIAAD organised new editions of the Data Streams track at ACM SAC 2022, the IoT Stream for Predictive Maintenance workshop at ECMLPKDD 2022, the SoGood workshop (data mining for **social good**), also at ECML/PKDD, the KDBI - Knowledge Discovery and Business Intelligence stream at EPIA 2022. João Gama was program chair of PAKDD 2022 – the Pacific Asia Conference on KDD and published a special issue of the Machine Learning journal. European project Emeritus was officially launched.

6.11.3 Innovation outcomes in 2022

- We continued the collaborations with IPO Porto and Hospital Santo António.
- We were involved with companies in a number of application and knowledge projects, namely XPM, SIGIPRO, OnlineAIOps, Transformers, Theia, DAnon, Promessa, CityAnaliser, Produtech, ContinentalFoF, SadCopQ and AgWearCare.
- We continued the participation in project Port XXI, funded by ESA - the European Space Agency, to prospect the use of data science in port management.

6.11.4 Activity Overview

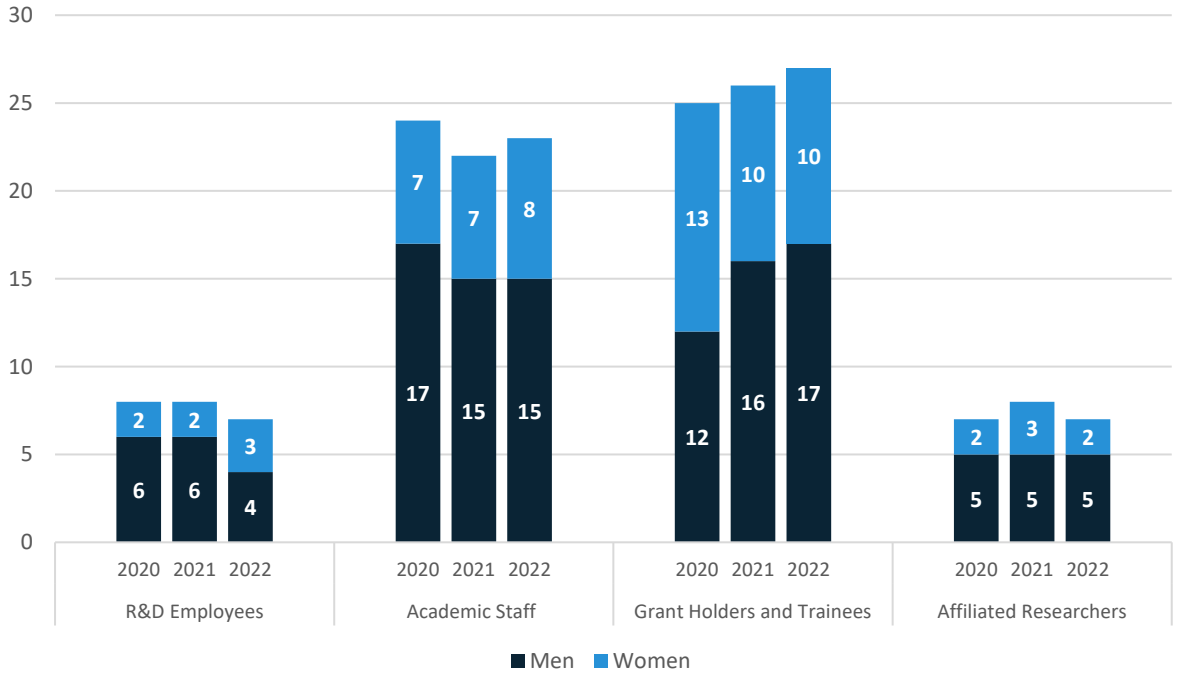


Figure 6.11.1 - LIAAD - Research team evolution

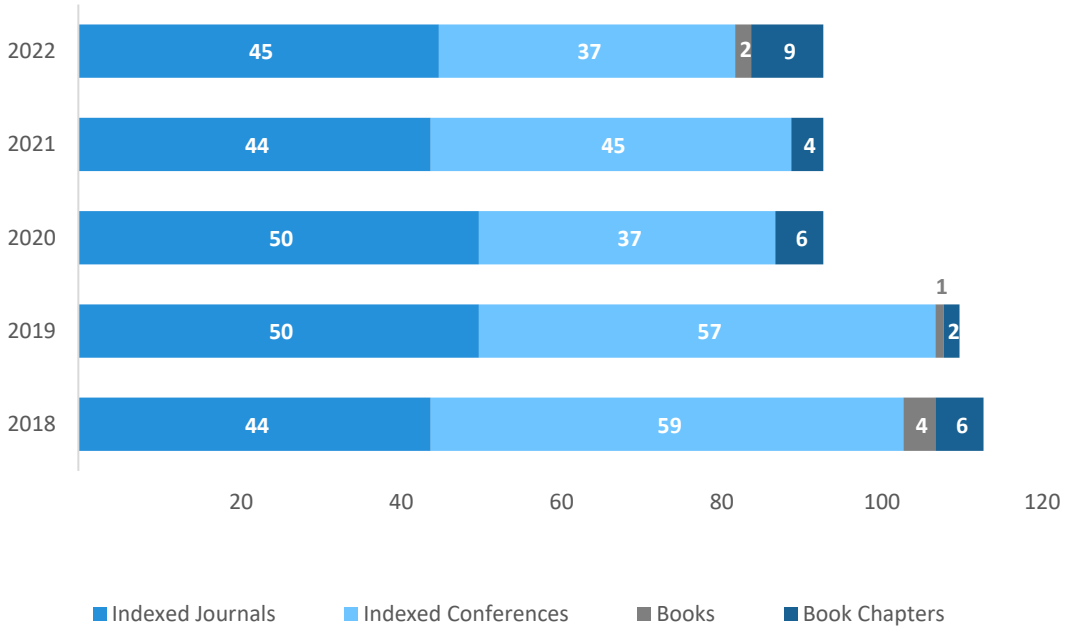


Figure 6.11.2 - LIAAD - Evolution of publications by members of the Centre

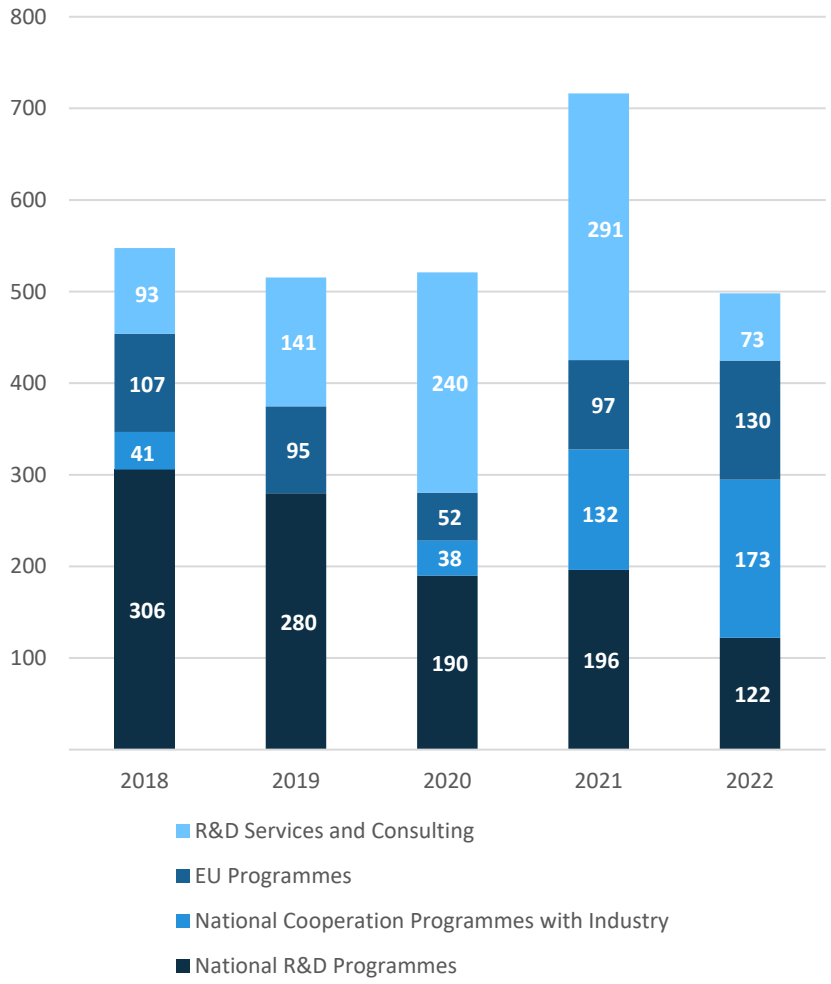


Figure 6.11.3 - LIAAD - Project funding evolution (k€)

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, security and privacy, information mining, with a focus on scalable software systems for challenging multidisciplinary applications in Engineering, Life Sciences, Social Networks and the Internet of Things. The core research team includes mostly faculty members at the CS department at FCUP for a total of 16 PhD researchers in 2022 (one less than in 2021). The research environment is enriched with talented junior researchers (grant holders and trainees) for a total of 31 core researchers that together build the necessary critical mass and scientific competences to fulfill our mission.

6.12.2 Research outcomes in 2022

A key goal for 2022 was to maintain CRACS's international visibility, renown and publication output, after the significant improvement observed in 2020 and 2021. In fact, we achieved similar outputs for the number of participations in program committees of international events, from 43 and 41 in 2020 and 2021, respectively, to 42 events in 2022, and for the number of international events organised by CRACS members, from 7 and 6 in 2020 and 2021, respectively, to 11 events in 2022. In this regard, we would like to highlight the organisation of the International School and Conference on Network Science (https://netscix.dcc.fc.up.pt) and to emphasise the election of Sandra Alves to Executive Officer of ACM SIGLOG. Regarding the total number of publications in indexed journals and conferences, there was an expected decrease from the 68 publications reached in 2021 to 41 publications in 2022, a number more in line with the previous years.

In terms of project funding, we would like to emphasise our participation in project Theia, a P2020 project with Bosch Braga, and the successful application of PRIVATEER, a Horizon Europe - Joint Undertaking project, funded to start in 2023. These projects are very important for CRACS as a way to increase our funding level, which has decreased significantly in recent years. Finally, we would like to highlight the ERC Starting Grant won by Bruno Loff, on "The hardness of finding good algorithms", to address the following meta-complexity question: "Fix some computational model (e.g., decision trees, communication protocols, data structure problems, etc), and suppose we are given a full description of a computational problem and wish to find an efficient algorithm to solve it, or at least to estimate its computational complexity – How hard is this algorithm-finding/complexity-estimation task?".

In the followings, we enumerate in more detail CRACS's main research outcomes in 2022:

- Logic programming: (i) survey of research in parallel logic programming covering the period since 2001; (ii) development of a type system for Prolog; (iii) development of Prolog/Python interface for the Yap Prolog system; (iv) development of system to predict hypoglicemia and hyperglicemia.
- Lock-freedom: study of a generic high-level interface implementing synchronisation procedures for memory reclamation in lock-free data structures. This is an essential step to enable a wider usage of lock-freedom in modern multi-core programming environments without garbage collection.
- Quantum complexity: we show that, analogously to the classical case, any quantum algorithm which uses M cells of quantum memory, but such that only m cells are being used at any given time, can be simulated by an algorithm that uses only O(m log M) cells.
- Intersection types and linearity: (i) expansion based on intersection types showing a clear relation between algebraic properties of intersection types and the substructural rules – idempotent intersection is related with the contraction rule and commutative intersection with the exchange rule; (ii) definition of a new notion of rank for the non-idempotent intersection types based on linear types – using this new notion, we extend the rank-2 type system and the type inference algorithm to use the quantitative properties of the non-idempotent intersection types to infer quantitative information related to resource usage; (iii) using a notion of minimal typing derivations in a non-idempotent intersection typing system, we solved a longstanding open conjecture relating weak linear lambda-terms and terminating terms.

- Edge-computing and edge-clouds: continuation of the development of the JAY framework (https://github.com/jqmmes/jay) that allows users to implement different strategies for offloading tasks in hybrid topology clouds (infrastructure, cloudlet, femto, edge) and to evaluate their performance with respect to chosen metrics (e.g., execution time, energy consumption).
- Trust, privacy and security: (i) methods for privacy-preserving prediction of user preferences in mobile devices; (ii) evaluation of use of blockchain for identity management (IdM) in the context of the Internet of things (IoT) while focusing on privacy-preserving approaches and its applications to healthcare scenarios; (iii) controlled, policy-based and confidential searching/sharing of Indicators of Compromise (IoC) available in a group of Malware Information Sharing Platform (MISP), using encrypted search mechanisms and a shared encrypted reverse-index of IoCs;
- Fake image detection: development of Chrome extension to detect manipulated webpage photos.
- Automated assessment: (i) assessment of web interfaces by combining structural matching and functional testing; (ii) new tools to support gamification of programming exercises.
- Synthetic data: (i) Generative Adversarial Networks to create synthetic tabular data for textual data augmentation; (ii) metrics for synthetic data quality, on both statistical and utility bases.
- Deep learning applications: deep learning models with applications to Biology (species identification), astrophysics (determination of stellar parameters such as effective temperature, surface gravity, and metallicity from spectra datasets), and indoor location (location within a building based on models trained on Bluetooth RSSI measures or on video frames grabbed in loco).
- Graph mining and time series analysis: (i) summarization of large and massive semantic graphs using a quotient graph approach based on an equivalence relation on URLs; (ii) development of a novel concept of spatial network motifs able to characterise networks with spatial features; (iii) development of NetF, a set of features able to characterise time series through the topological properties of several possible complex network mappings of the time series; (iv) introduction of MHVG2TMS (multilayer horizontal visibility graphs for multivariate time series analysis) as a new mapping able to characterise multivariate time series using complex networks.

6.12.3 Innovation outcomes in 2022

In what follows, we enumerate CRACS's main innovation outcomes in 2022:

- Fault tolerance: modular implementation of a Byzantine fault tolerant (BFT) middleware library in Rust (https://github.com/SecureSolutionsLab/febft). This is an optimised version of FCUL's original BFT-Smart implementation. Initial results show a 4x performance increase.
- Trust, privacy and security: extended Log4j observability tool used to detect and prevent malicious JNDI (/LDAP) lookups (https://github.com/SecureSolutionsLab/eLogJ). Currently tested in a controlled environment using AYA, a Rust eBPF library.
- Automated assessment: participation in the development of a Massive Online Open Course (MOOC) targeted to computer programming educators.
- 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, Biolens provides 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. 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, FEUP, Bosch Aveiro, Bosch Ovar, and the Museum of Natural History and Science at UPorto/Galeria da Biodiversidade.

6.12.4 Activity Overview

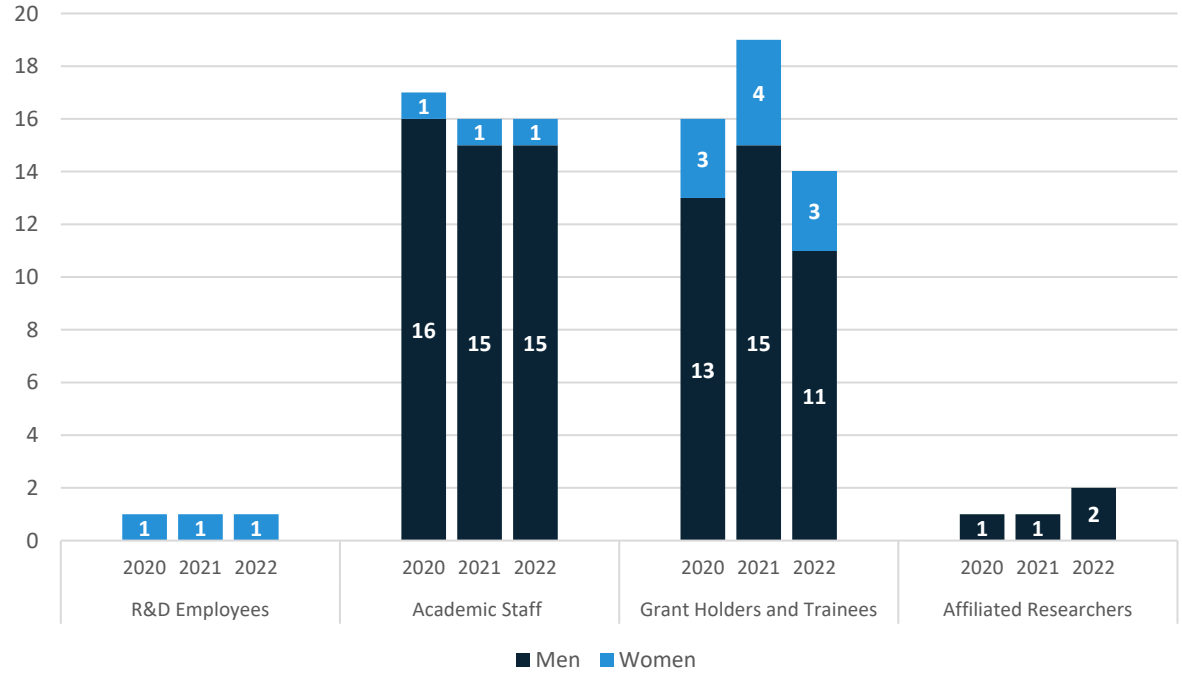


Figure 6.12.1 - CRACS - Research team evolution

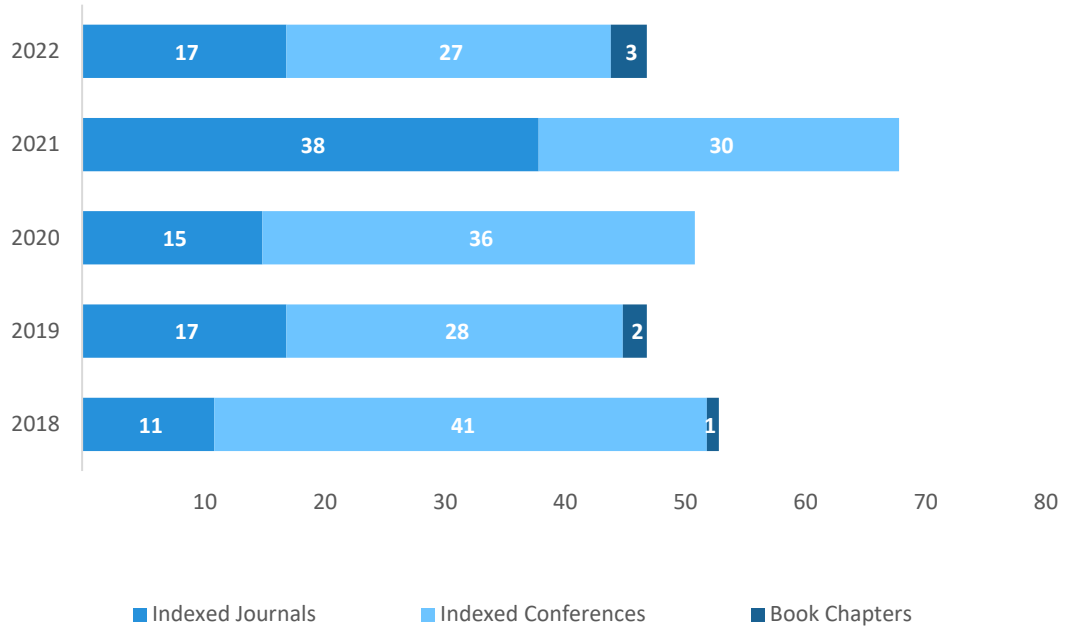


Figure 6.12.2 – CRACS - Evolution of publications by members of the Centre

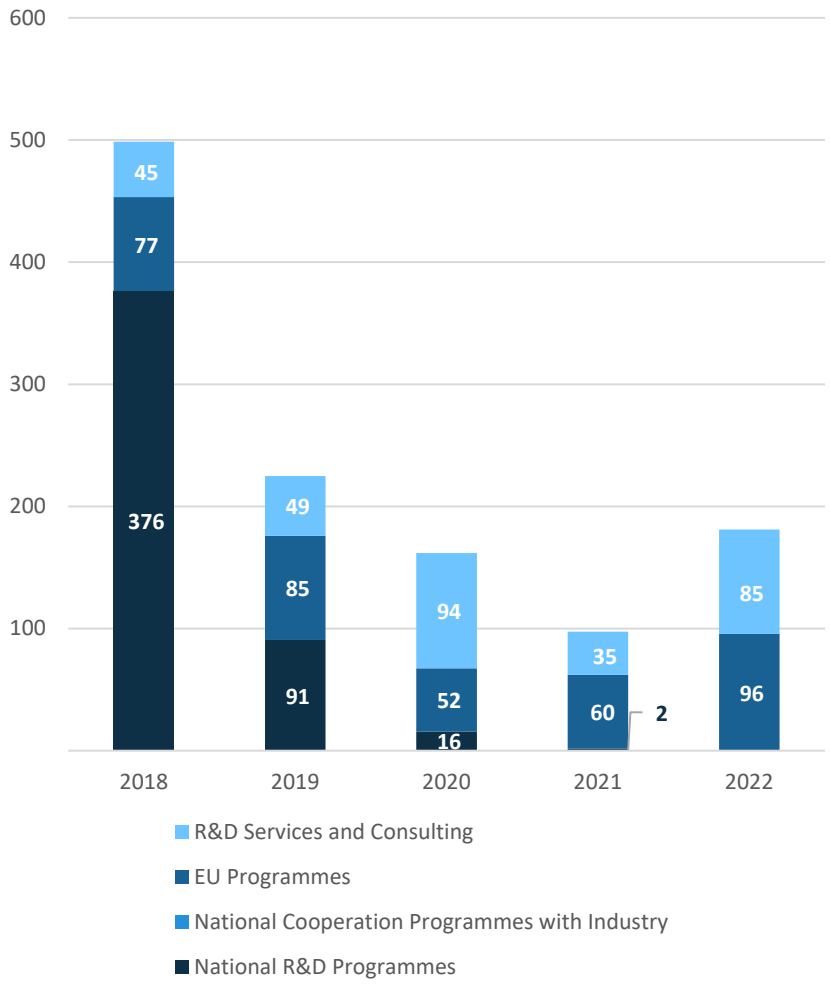


Figure 6.12.3 - CRACS - Project funding evolution (k€)

6.13 HASLAB – HIGH-ASSURANCE SOFTWARE LABORATORY

Coordinators: Alcino Cunha and António Luís Sousa

Assistant to the Centre Coordination: Catarina Leones Fernandes

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's research focuses on:

- **Software Engineering** – methods, techniques, and tools for rigorous software development, that can be applied to both classical and the novel quantum computing architectures;
- **Distributed Systems** – improving the reliability and scalability of software, by exploring properties inherent to the distribution and replication of computer systems;
- **Information Security** – minimising 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 2022

In 2022 HASLab continued to produce high-quality research and pursue its collaborations with renowned international partners. In terms of scientific outputs, HASLab had 48 scientific publications, of which 30 were conference papers (including 2 CORE A* and 6 CORE A) and 12 journal articles (including 9 Q1).

In terms of research outcomes, we would like to highlight the following achievements:

- The Software Engineering group continued its long-term research on formal specification languages and code quality. Concerning the former, the group developed a new extension to the Alloy language to address quantitative problems, a work that was published at ESEC/FSE, one of the top CORE A* conferences in the area. Concerning the latter, a paper that presents a method and tool for testing robotic systems developed with ROS won the Best Paper Award at the ENASE conference. The group also continued to research techniques to improve quantum programming, and in particular proposed the concept of quantamorphisms, a recursive quantum circuit combinator that aims to simplify the programming of quantum computers. This work was published in IEEE Transactions on Software Engineering, the top journal in the software engineering area.
- The Distributed Systems group saw its long term research collaboration with CPES internationally acknowledged, by publishing the paper "Towards a Cross-domain Semantically Interoperable Ecosystem" at WSDM, a CORE A* conference addressing the topics of web-search and data mining. A researcher of this group also explored the versatility of partitioned Bloom filters in the design of data structures, a work that was published in IEEE Transactions on Computers, one of the top journals in computer science.
- The Information Security group continued its research on formally proven structures and cryptographic protocols, and in particular concluded the first complete formal correctness proof of Kyber, one of the post-quantum cryptographic algorithms recently selected by NIST for standardisation. This ground-breaking work was conducted in collaboration with the Max Planck Institute for Security and Privacy and with INRIA.

In 2022, HASLab kicked-off three new FCT funded national projects: Ibex, focused on developing mathematical methods for modelling and analysing flaws in cyber-physical software; FLEXCOMM, that aims to reduce the energy impact of communication networks; and SpecRep, that aims to develop techniques to ease the learning

of formal specification languages. During this year, several FCT funded research projects were also concluded with very positive evaluation, namely the Malpis, HADES, DaVinci and Passcert projects.

The RISC2 European project, which aims to promote and improve the relationship between research and innovation communities in Europe and Latin America, won the HPCwire Editor's Choice Award in the category of Best HPC Collaboration. This award was presented at the annual HPCwire Readers' and Editors' Choice Awards, at the ACM/IEEE Supercomputing conference held in Dallas, USA.

Regarding internalisation, a few HASLab researchers participated in international exchange programs: one researcher did an internship at the Texas Advanced Computing Center, in Austin; and three researchers went to Tokyo for internships at the National Institute of Informatics, with which INESC TEC has a Memorandum of Understanding. HASLab also organised some scientific sessions with international invited researchers in Portugal. We highlight: the visits of Haim Levkowitz, a leading expert in the field of computing, and Oana Balmau, a researcher at the Data-Intensive Storage and Computer Systems Lab; the co-organisation of MUG 2022, a MACC event that aims to promote the adoption of advanced computing techniques and engagement with its operational team; and the Spring School on formal methods for reactive and quantum systems organised by the DaVinci project.

HASLab also continued with the internship programme to attract young researchers, namely MSc students, funded by BII grants. In 2022 this initiative involved 11 students, 2 of which will pursue a PhD in the centre. With 3 students concluding their PhD in 2022, the centre currently has 23 PhD students.

6.13.3 Innovation outcomes in 2022

In terms of innovation, the main highlight of 2022 was the start of two new European projects: BeFlexible, which aims to increase the flexibility of the energy system, improve cooperation between Distribution System Operators and Transmission System Operators, and facilitate communication between all energy stakeholders; and ENERSHARE, which will develop a reference architecture that facilitates data sharing in the energy sector. These projects result from the long-term collaboration between HASLab and CPES.

The SIS^1 project (Smart Insurance System), a collaboration between INESC TEC and the company NAU21, was one of the finalists in the 2022 edition of the Portugal Digital Awards, in the "Best Insurance Project" category. SIS^1 proposes a new collaborative and transparent approach for the management of the traditional business processes of the insurance sector.

The DigiLightRail project was successfully concluded in 2022. This consultancy for EFACEC aimed to develop tools and techniques to help verify infrastructure safety rules in railway network models. The main outcome of the project, the EVEREST tool, was described in a paper published at MODELS, a renowned CORE A conference addressing modelling and model-driven software and systems.

In 2022, HASLab has registered two new invention disclosures as result of the work done in collaboration with CPES in EU projects. Also, in the context of this collaboration, HASLab researchers participated in several international innovation events, such as, IoTWeek 2022 - Towards of Interoperable Energy Ecosystem of the Future - an event organised by the InterConnect project under the scope of the Sustainable Energy Week, an initiative promoted by the European Commission.

6.13.4 Activity Overview

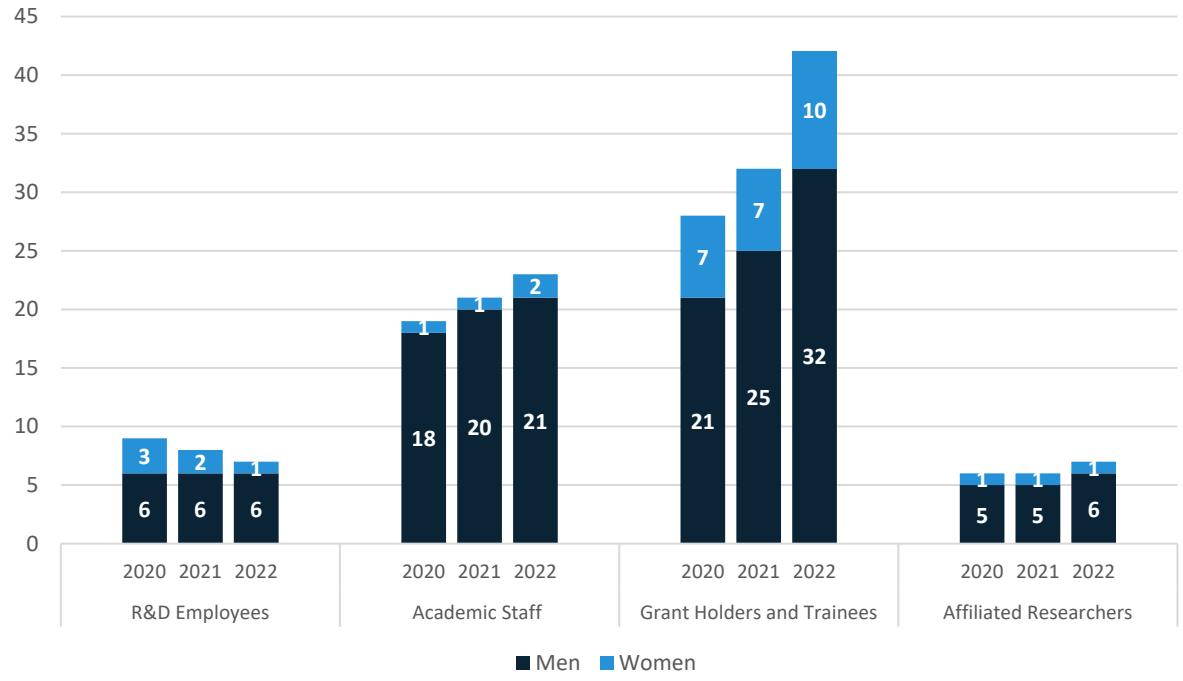


Figure 6.13.1 - HASLab - Research team evolution

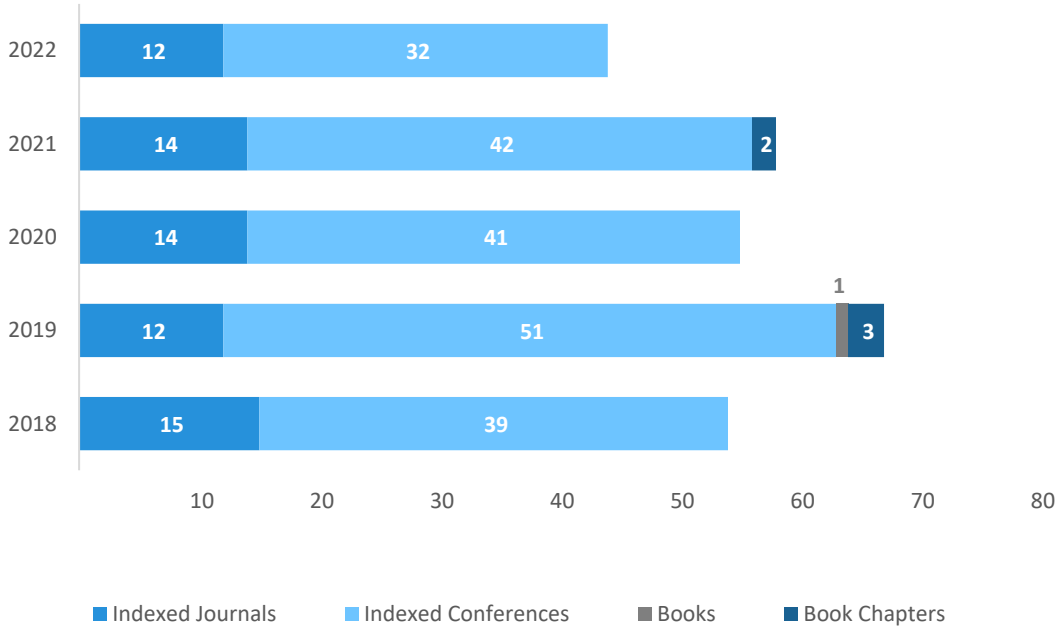


Figure 6.13.2 - HASLab - Evolution of publications by members of the Centre

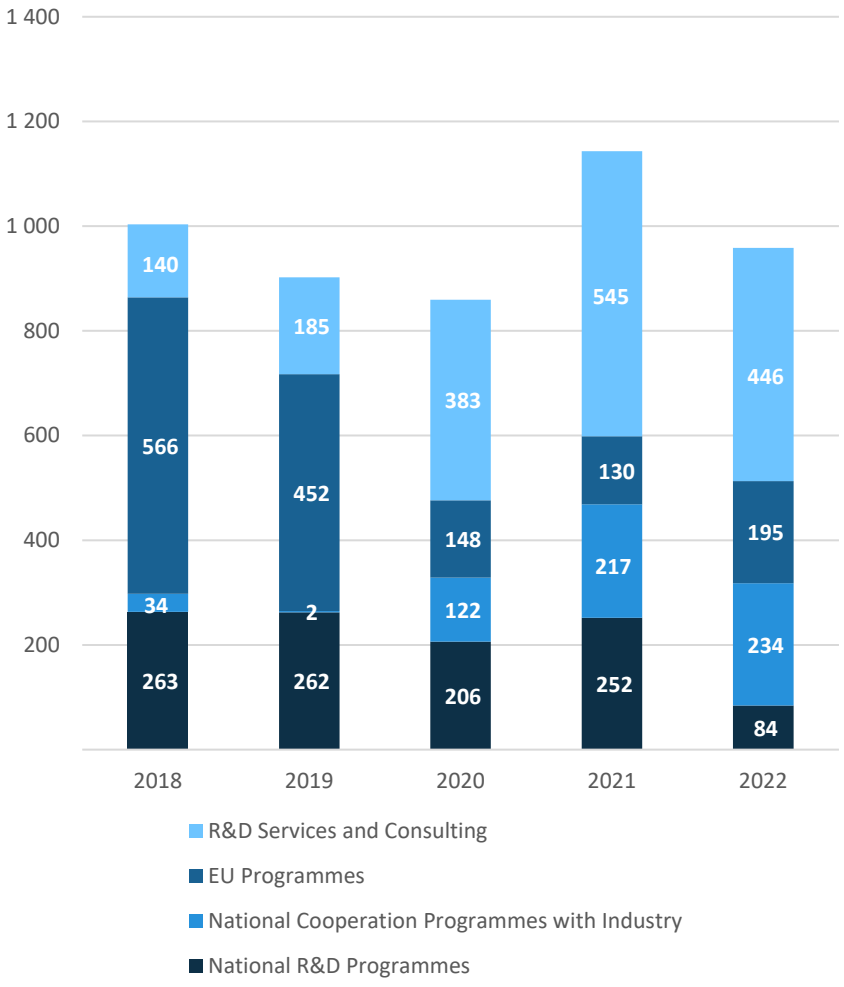


Figure 6.13.3 - HASLab - Project funding evolution (k€)

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), 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 first implementation phase was finished in the end of 2022 and was coordinated by Paulo Mónica as Principal Investigator. The implementation management team also included Eduardo Silva, António Silva, Aníbal Matos, José Almeida, Nuno Cruz, Carlos Pinho, Diana Viegas, Luís Pessoa, Bruno Ferreira, Maria Graça Barbosa, and Marta Barbas.

7.1.2 Main achievements in 2022

The research vessel Mar Profundo was tested during the REP(MUS)22 naval exercise in September 2022. In that exercise, Mar Profundo was used to test and deploy several underwater systems (Turtle Lander, EGIM, EVA and IRIS AUVs) during two weeks. This showed the potential of the vessel as a mobile laboratory at sea, hosting a team of researchers on board, and providing excellent working areas and infrastructure conditions for field research.

During 2022, the support facilities in the Leixões harbour had also been completed, providing a local laboratory and command centre to support research and developments activities in the harbour area.

The update of back-office labs (Sensors, Telecommunications, and Ocean Engineering) had all been completed during 2022. 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 acquisition of the underwater relocatable landers and buoys.

It should also be mentioned that while still in its implementation phase, in 2022, the existence of the Tec4Sea infrastructure already constituted 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.

The research vessel Mar Profundo has already supported two international and two national R&D projects, and it has already provided services to an international client, that rented the vessel for operation in 3 multi days missions.

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

7.2.1 Mission and positioning

EMSO-PT is a research infrastructure led by IPMA (Instituto Português do Mar e da Atmosfera) and involving 15 other research institutions working on ocean science or technology, including INESC TEC.

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

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

So far, the Portuguese participation in EMSO has been focused on the Azores and Cadiz nodes, in cooperation with France (Azores) and Italy (Cadiz) using two of the few available technological solutions for long term seafloor monitoring (ASSEM and GEOSTAR). Within the scope of EMSO-PT two sites will be considered close to the mainland: a deep water one, located in the Gulf of Cadiz, and another shallow water, located off North Portugal. The later one will also be a test bench for emerging monitoring strategies.

EMSO-PT observatories will merge “off-the-shelf” technology, which will ensure that they will meet the international standards, with novel approaches (based on networked, autonomous observation platforms) that will contribute to more sustainable monitoring operations and will create the basis for the development of new marine products and services, creating value and qualified jobs.

INESC TEC involvement in EMSO-PT addresses the establishment of long-term non-fixed observatories. Such work is organised along two complementary lines: relocatable nodes and long-endurance mobile platforms. In the first case, INESC TEC is building an EGIM (EMSO Generic Instrument Module) for integration and use in a Turtle relocatable node. In the second one, INESC TEC is implementing a network of underwater gliders for collection of oceanographic data.

While the goal of the EMSO-PT infrastructure is the implementation of a network of ocean observatories for data gathering, the underlying activities are aligned with CRAS research line associated with long term deployments.

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

7.2.2 Main achievements in 2022

The main achievements of EMSO-PT during 2022 were:

- INESC TEC’s developed EGIM was tested integrated in a Turtle lander, to make a mobile EMSO-PT node, during the REP(MUS)22 Naval robotic exercise with unmanned maritime systems, and had been deploy at Cabo Espichel near shore;
- The developed EGIM system was deployed from IPMA Mario Ruivo Research Vessel, in September 2022, on Madeira-Tore campaigns at Lion seamount, and was registering data for 4 days at 700m depth;
- The acquisition of two new 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 has dimensions 10mx6m and is 5m deep, and a workshop for prototyping. The laboratory infrastructure includes a large set of robotics platforms (underwater, surface, aerial, and terrestrial), most of them ready to operate in real environments. It also includes a large number of sensors and auxiliary equipment that can be operated independently or integrated into larger systems. Such assets contribute to a great operationality and have been fundamental for the establishment of partnerships.

7.3.2 Main achievements in 2022

The main achievement of the Robotics and Autonomous Systems Laboratory in 2022 were the following:

- Reorganisation of the physical space at the FEUP campus, setting up specific bench areas for specific projects and subsystems in the Systems Integration areas.
- Reorganisation of physical space at the ISEP campus, adding tools carts by working areas and adding elevation platforms for robot maintenance.
- Upgrade of robotic platforms taking advantage of ongoing projects:
    - Integration of 4G communications in EVA AUV, upgrading the thrusters for sea operation and increasing the depth rating of EVA AUV components for 1000m.
    - Improving the exploration software in UX1Neo AUV adding some capabilities for autonomous exploration of some confined environments with simpler topologies;
    - Development of software and a landing platform for autonomous landing of UAV in vessels;
    - Integration of Multibeam Echosounders in the MARES AUV and DART deep water AUV, adding the capability to perform small scale, close range bathymetric surveys;
    - Upgrade of the propulsion system of the MARES AUV, reducing the drag of the vertical thrusters and improving the efficiency in the horizontal propulsion;
    - Improving the ROV automatic behaviours (e.g auto depth).
- Development of a synchronised multi receiver acoustic localisation system, for standalone operation or for integration in robotic vehicles.
- Integration of a local underwater observatory in an underwater communications cable (SMART Cable), with multiple sensors and an AUV docking station.
- Continuing the upgrade of the scientific instruments available with new development equipment, navigation systems, LiDARS, Multibeam sonars, thermal cameras, and several underwater sensors;
- Continue the training of technicians to operate workshop facilities and provide support to field operations.

7.4 Laboratory of Microfabrication

7.4.1 Mission and positioning

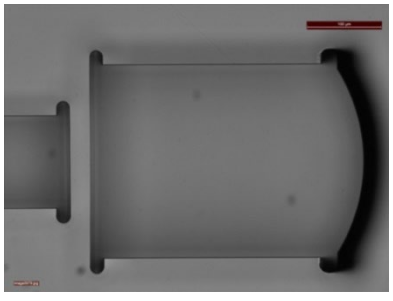
The Microfabrication Laboratory explores the femtosecond laser direct writing capabilities to support the activities on integrated optics and optofluidics and to provide support to other areas of research within CAP and INESC TEC. For example, microfluidics and optofluidics chips are produced to implement 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:

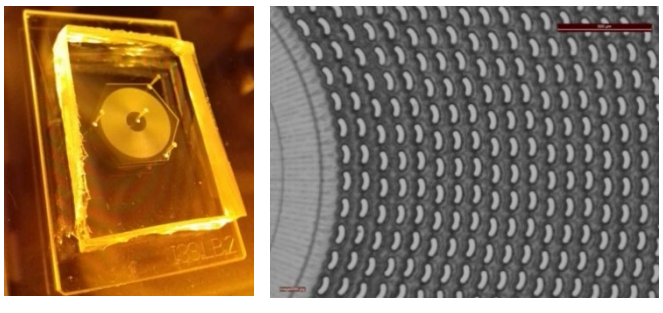
- Three-dimensional direct inscription of waveguides and complex integrated optical devices;
- Fabrication of Bragg and long period gratings (first and higher order structures);
- Fabrication of microfluidic devices using FLICE techniques (exposure followed by etching);
- Fabrication of optofluidic devices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

7.4.2 Main achievements in 2022

- Characterisation of laser direct writing in Ultra Low Expansion (ULE) glass; this includes direct writing of waveguides plus the possibility of glass micromachining. While waveguide writing proved unsuccessful due to photodarkening effects leading to high losses, the results on glass machining where like those of fused silica;
- The progress on ULE machining allowed the fabrication of reference cavities which are insensitive to temperature variations. These cavities were employed in the fabrication of high-resolution temperature sensors for applications in space;
- The glass micromachining capabilities were employed on the fabrication of long, uniform and glass embedded 3D metallic electrodes. Additionally, large area microfluidic devices for biomedical research where produced. These found application in liquid biopsy applications.



Reference interferometric cavity made in ULE glass by femtosecond laser micromachining. The smaller cavity on the left will house the optical fibre feeding the optical signal into the cavity.



Microfluidic device fabricated on the surface of a fused silica substrate. The device is sealed off using a PDMS layer in which holes are punched for liquid input/output. The image on the right shows a detailed view of the filtering section. Vesicles will be absorbed at the functionalized surfaces being removed from the liquid flowing through the device.

7.5 Smart Grids and Electric Vehicles Laboratory (SGEVL)

7.5.1 Mission and positioning

The Smart Grids and Electric Vehicle Laboratory (SGEVL) offers a distinctive 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. The lab is an important Research Infrastructure (RI) providing testing and validation capabilities to the research activities carried out within CPES scientific and innovation developments.

Recognised by FCT as part of the National Roadmap for Research Infrastructures of Strategic Interest, the SGEVL has a professional management that guarantees the implementation of an action plan, that encompasses: an efficient and transparent internal management of resources; a clear, well defined and widely advertised policy of conditions for access by researchers that are external to the infrastructure (national and international) and how the RI relates with, and provides services to, the scientific, educational, business and industrial community. The different projects (within INESC TEC activity) and services (to business and industrial community) guarantee the generation of revenue to support the overall maintenance of the RI.

SGEVL provides an advanced microgrid-based laboratorial framework, with the integration of self-developed and integrated technologies (e.g., inverters, EV chargers), as well as supporting technologies (e.g., real-time digital simulators for power systems). It hosts a team of experienced researchers to carry out activities involving advanced modelling, prototyping and testing, ensuring the support to wide variety of projects (e.g., EU, national, contracts with industry).

The SGEVL is currently headed by Justino Rodrigues that is responsible for the management of the activities and the implementation of the research and innovation plan set by CPES.

7.5.2 Main achievements in 2022

The main achievements of the RI for the year 2022 were the following:

- Implementation of a laboratory scale validation facility including hydrogen producing electrolysers (Horizon 2020 GREENH2ATLANTIC). A PEM electrolyser was commissioned, and its delivery is expected to 2023;
- Implementation of a hybrid AC+DC microgrid with very low EMI content, as part of an energy supply solution for a novel telescope infrastructure (Portugal 2020 SmartGlow). The hardware structure of the electronic power converter prototypes was already commissioned, and its delivery is expected to 2023;
- Implementation of a realistic and comprehensive V2G testbed to implement and validate new control strategies composed by EV chargers deployed in the field (H2020 POCITYF);
- Configuration of laboratory setup for MV feeder protection and automation testing, considering digital protection units (P2020 SCALE project);
- Implementation of a grid automation and protections testbed (Portugal 2020 SCALE). A pair of DOBLE F6350e linear V/I amplifiers were installed and tested, and its integration with the PHIL via OP5600 real-time digital simulator, using PTP (precision time protocol) and IEEE 1588 transparent clock;
- Development and implementation of interoperable solutions for EV charging, smart appliance, and energy management, using realistic microgrid testbed (Horizon 2020 InterConnect);
- Support and validation of novel fault detection and prediction methods (pre-commercial product from ENEIDA) for low voltage grids, based on real-time simulation and PHIL co-simulation (SGEVL service contracted by ENEIDA.io);
- Expansion of the SGEVL microgrid, consisting in the installation and successful testing of three additional resistive loads and two cable simulators, was successfully completed.

7.6 Neuro-Engineering Lab – BRAIN Lab

7.6.1 Mission and positioning

Neuro-Engineering laboratory, named of BRAIN (Biomedical Research And INnovation) has a strong focus on researching new biomedical engineering methods for neurological diseases (e.g., Parkinson's, Alzheimer's, Autism and Epilepsy) namely neuroimaging, quantified movement semiology, Gait impairment analysis, Deep Brain Stimulation (DBS), brain connectivity, neuro-robotics, among others. This lab has largely contributed to some pioneering research achievements, being the most relevant:

1. Neurokinect installation at University of Munich Medical Center, managing around 7TB/day of data, leading to the creation of a unique labelled dataset. To the best of our knowledge, it is the world-largest and unique 3Dvideo-EEG dataset of epileptic seizures.
2. The creation of the start-up InSignals Neurotech focused on the intra-op real-time motor symptoms monitoring to support neurosurgical procedures of deep brain stimulation. After a 4 year of development with CHUSJ, a family of patents and relevant high-impact papers, the start-up has raised $120,000 to extend the number of clinical trials in Europe and initiate the medical device road to the market.
3. The iLoF (intelligent-Lab-on-Fiber) technology was born from this lab that joined forces with CAP center to explore novel ML approaches to photonics signals obtained from optical fiber tweezers usage on biofluids[3]. It generated high-impact papers, a patent family and a spin-off startup that has raised $8.2M seed funding so far and focused in Alzheimer's neurologic disease.

BRAIN Lab also has a Stim-BRAIN Lab which we have an f-MRI simulator fully equipped with 64ch EEG medical systems from Micromed, wearable EEG devices, video cameras and pads MRI compatible and audio system to simulate f-MRI experiences and prepare stimulation sessions before going to a MRI at the CHUSJ or any other clinical center. We also have a strong research line in the area of Brain-Computer Interfaces, in the area of psychophysiological states, among others (Figure 7.6.1).

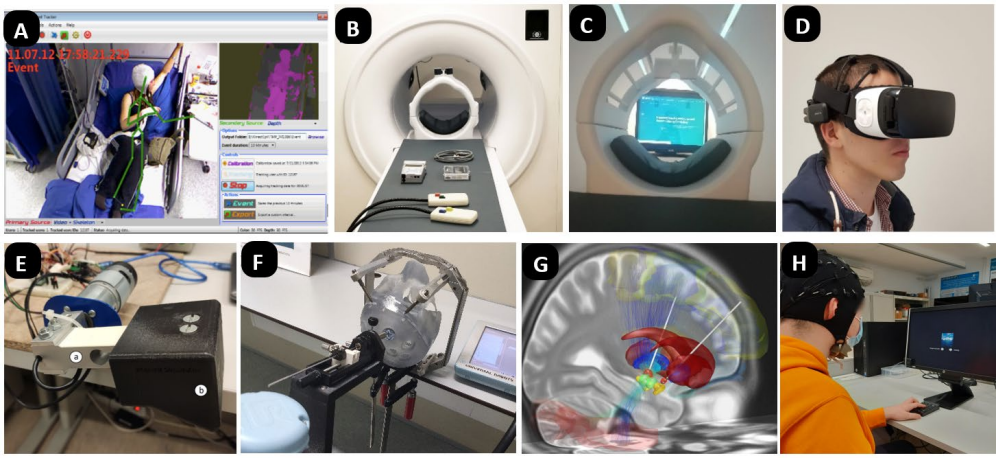


Figure 7.6.1: BRAINLab infrastructure and research projects examples. A- Neurokinect System interface; B/C- fMRI simulator for experimental design and training; D- Combination of EEG-wearable devices and Virtual reality to study psychophysiological states; E- Robotic wrist for wrist rigidity simulation; F- Surgical robot simulating automatic DBS electrodes precise adjustment based on real-time iHandU wrist rigidity quantification; G- 3Dmodel of brain structures and DBS stimulation electrodes position analysis to study electrodes position and brain stimulation connectivity; H- Experimental paradigm to correlate neuronal activity with memory recognition.

7.6.2 Main achievements in 2022

BRAIN Lab research group in 2022 counted with 3 interns, 8 MSc completed Theses, one PhD was completed in July and 3 undergoing PhD theses. The main achievements in 2022 were:

- Expand and share our knowledge and network at a European level in order to pursuit our research and innovative ideas in the Neuro-Engineering area;
- Pursuit the creation of a more advanced infrastructure to conduct new research projects and clinical trials, bringing researchers from different fields together with clinicians.

7.7 iiLAB - Industry and Innovation Lab

7.7.1 Mission and positioning

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

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

7.7.2 Main achievements in 2022

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. Conclusion of a document with the iiLab internal regulations.

- Training: Kaizen Institute: Form I4.0 (training on I4.0 technologies); Confacts (EIT-M Projects): Training digital contents creation on the topic "Machine Learning in Manufacturing" to be delivered virtually, through Skills.move platform; Workshop and demonstration event - SAP 4.0 project: Qualification and Aggregation of the Advanced Production Systems Sector and I4.0 Technologies Adoption; Workshop i4.0: Foundry Sector; Advanced Program in Industry 4.0 - INESC TEC, INEGI: Advanced training covering the topics of "Architectures and Systems Integration", and simulation, among others;
- Events: Demo4Green & EIT RIS Hub: Roundtable - digital and green technologies and Presentation and Demonstration of the technologies and companies supported by the project; SotecIn Factory (European project): Kick-off meeting and general assembly; Mari4_Yard: Human Centred Robotic Solutions - Public Workshop to present project results;
- Project Demonstrators: Produtech4S&C: collaborative robotic cell for complex parts assembly, combined with augmented reality for operator support; Mari4_Yard: Mobile Manipulator for kitting operations; PAC: artificial vision based inspection of aluminium parts;
- Support: Demo4Green: Flow-M (Portuguese open call winner) - Support activities in the scope of the D4G project;
- Visits: AVANTEK: Presentation of SIEMENS Solutions portfolio for the iiLab.

Additionally, during 2022, a considerable effort was dedicated to planning the new iiLab, namely in the execution of the activities such as layouts definition, as well as planning, selection, ordering and reception of material and equipment for the several technologies/concepts/demonstrators to be installed in the new iiLab. Moreover, in 2022, the design and planning of the implementation of a dedicated 5G network in the new iiLab also took place (Testbed).

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

7.8.1 Mission and positioning

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

Research Team: Filipe Neves Santos (PhD), Tatiana Pinho (PhD), António Paulo Moreira (Prof. PhD), Mário Cunha (Prof. PhD), Ricardo Braga (Prof. PhD), José Boaventura (Prof. PhD), António Valente (Prof. PhD), Manuel Silva (Prof. PhD), Héber Sobreira (PhD), André Aguiar (PhD), Luís Santos (PhD), Pedro Moura (MSc), Sandro Magalhães (PhD candidate), André Aguiar (PhD candidate), Daniel Silva (PhD candidate), Vítor Tinoco (MSc), Francisco Terra (MSc), Ricardo Neves (MSc), Humberto Rocha (MSc), Isabel Pinheiro (PhD Candidate), Miguel Marques (PhD Candidate), José Sarmento (PhD Candidate), Mafalda Pereira (PhD Candidate), Renan Tosin (PhD Candidate).

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

7.8.2 Main achievements in 2022

In 2022, our laboratory participated in five H2020 projects, including NOVATERRA, SCORPION, DEMETER, and AgRoboFood (DIH). The SCORPION project, coordinated by INESC TEC, is a 2.5M€ project with 11 European partners. Additionally, we are contributing to 10 national ongoing projects and have won more than 6 new projects.

As the only Portuguese laboratory fully devoted to the agriculture and forest sector, we have maintained our position and expanded our team to over 20 permanent members. Our dedication has led us to further research and develop 28 software and hardware prototypes that have achieved higher TRLs. Among them are Weta and Modular-E, two robots built from scratch to simplify the process of technology transfer and meet end-users' needs.

We have also made significant progress on various projects. The PRYSM spraying robot has upgraded its Manufacturing Readiness Level from level 4 to level 7, while the Agro navigation stack has been tested and validated in several ongoing projects. Our AgIoT module features (TRL7) have been enhanced, and we have reached V3.0 for SmartTrap (based on AgIoT solution), which will enable faster and more cost-effective detection of agricultural diseases vector.

Our laboratory has also made notable contributions to the academic community with 12 scientific publications in international and indexed peer review journals, 5 master theses, and 12 PhD works. We have garnered more than 40 references in mass media and technical magazines. We were honoured to participate in the 2022 FIRA World Agricultural Robotics Forum, showcasing the Scorpion project and WETA robot.

Overall, we are proud of our achievements in 2022 and look forward to continuing our mission of advancing Robotics and IoT for the agriculture and forest sector.

7.9 Computer Graphics and Virtual Environments Lab

7.9.1 Mission and positioning

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

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

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

- Studies in human augmentation for enhanced performance in professional and personal activities;
- Multisensory virtual environments to 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;
- 3D multimodal interaction in immersive environments, including haptics and pseudo-haptics.

Reference Laboratory

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

7.9.2 Main achievements in 2022

- Extended 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;
- Core research and prototyping in 3D multimodal interaction in immersive environments, including:
    - Shape-changing haptic devices;
    - DeskVR interaction;
    - Immersive visualisation.
- Conclusion of projects:
    - PAINTER;
    - M2S.
- 4 concluded PhD theses and 31 concluded MSc dissertations;
- 16 publications in journals and 15 publications in conferences;
- 3 activities of dissemination for schools;
- 3 activities of dissemination for industry.

7.10 CLOUDinha Laboratory

7.10.1 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/i5 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).

7.10.2 Main achievements in 2022

In 2022, the laboratory provided the computational infrastructure to develop, optimise and test the software prototypes being developed by HASLab researchers in topics such as:

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

These software prototypes were developed under the scope of HASLab's research and innovation projects, as well as PhD and MSC theses.

In particular, during this year, 19 MSc theses used the CLOUDinha Laboratory as computational infrastructure for the research work. Work done on 3 of these theses resulted in 4 scientific articles: "Cloud-Based Privacy-Preserving Medical Imaging System Using Machine Learning Tools", presented at the 21st EPIA Conference on Artificial Intelligence (EPIA 2022); "Accelerating Deep Learning Training Through Transparent Storage Tiering", presented at the 22nd IEEE/ACM International Symposium on Cluster, Cloud and Internet Computing (CCGRID 2022); "AIDA-DB: A Data Management Architecture for the Edge and Cloud Continuum", presented at the 19th IEEE Annual Consumer Communications and Networking Conference (CCNC 2022); and "Adaptive database synchronization for an online analytical cloud-to-edge continuum", presented at the 37th ACM/SIGAPP Symposium on Applied Computing (SAC 2022).

8 SPECIAL PROJECTS

8.1 UT AUSTIN PORTUGAL PROGRAM

Coordinators: José Manuel Mendonça and Rui Oliveira

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

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

8.1.1 Main Achievements in 2022

At the end of every year, the Program takes time to reflect on its activities and achievements between January and December and prepare for the year ahead. It is a joint exercise that builds on the contributions of many stakeholders and shows the Program's commitment to self-accountability, self-improvement, transparency, and excellence. It couldn't be any other way, especially when one bears the responsibility of preserving fifteen years of remarkable accomplishments and must stay up to the expectations of a loyal yet demanding transatlantic community.

2022 was a year of celebration for the Program turned 15 years old, and it was also a year to go deeper in discussing the Partnership's future as the current funding cycle is nearing its end. Such discussion was also held at the highest level, first with the former Minister of Science, Technology and Higher Education, Manuel Heitor - a long-standing champion of FCT's International Partnerships - and later with the newly appointed Minister, Elvira Fortunato and the new President of FCT, Madalena Alves.

Past, Present and Future, all packed into a year which started with the feeling that the COVID-19 pandemic would soon be under control and people could resume their lives as they knew before the pandemic. For the Program, this ray of hope meant getting its researchers to travel again between Portugal and Texas in the frame of ongoing research projects or short-term internships.

It also meant resuming onsite networking and training activities in parallel with online activities, which had proven effective during the pandemic. However, other challenges would come about. The impact of the price increase that followed the Ukraine war breakout and the subsequent energy crisis, aggravated by the budget cut for the Program's Portuguese office in 2022, should not be underestimated. With a return to onsite events and the reopening of borders that increased global mobility, the Program had to be even more careful with selecting suppliers to ensure sound management of its budget while keeping its high standards and sticking to the 2022 Activity Plan as much as possible. Some ongoing projects bearing the Program's seal were faced with stockouts, which inevitably led to project delays. Nevertheless, the energy crisis that came along with the war, and the acknowledgement that the transition to a non-fossil-based economy was more urgent than ever, gave the Program a chance to step forward and explain how it could contribute towards a cleaner and more sustainable energy future, building on its community's knowledge capital, trustful relationships, and advanced infrastructures in Nanotechnologies, Advanced Computing and Space-Earth Interactions both in Portugal and at UT Austin. Our Annual Conference brought this leadership potential to the foreground.

Our Main Highlights in 2022

Eight new Exploratory Research Projects (ERPs) were added to the Program's portfolio in early 2022, strengthening the Program's contribution to the cancer fight, energy transition, climate adaptation and the digital society through disruptive science. A new call to fund eight more Exploratory Research Projects was opened in the last quarter of the year, with its results due to be announced in April 2023. This instrument of the Program is expected to have funded 24 transatlantic teams by the end of Phase 3. As we learned at the 2022 External Review Committee Meeting, the ERPs have been allowing younger researchers a head start - the coordination of an international project for the first time, a key achievement for ascending in their professional

careers. The Strategic Research Projects selected at the end of 2019 kept progressing and reporting their outcomes to the Program. As they are closer to completing their 3-year work plans, they look for opportunities to leverage further funds and intensify their participation in closer-to-the-market and dissemination activities. By closely monitoring the project it supports, the Program can track the impact of its funding choices. In 2022, the Program worked on mapping new research initiatives from projects championed or funded during Phase 3.

After two years of travel restrictions, the Program finally launched a new call to provide ten researchers affiliated with Portuguese institutions with the opportunity to cross the Atlantic for short-term research internships at the University of Texas at Austin. Several training activities were organised throughout the year, engaging various stakeholders in training design and delivery. For the first time since 2018, the Program included an ECTS awarding course in its training offer. Being a Program targeted primarily to Portuguese institutions, 64% of our registered participants came from Portugal, 10% from the USA and the remainder from 55 countries. Academia and research institutions remain the primary recipients of our training portfolio (81% of registered participants).

The Annual Conference International Science & Technology Partnerships as Platforms for Science Diplomacy was the culmination of the Partnership's 15th-anniversary Program. It provided a venue for taking stock of UT Austin Portugal's entrepreneurship and technology commercialisation legacy, its disruptive contributions to the biomedical field, and its (future) role in society's energy transition.

9 SUPPORT SERVICES

9.1 LEGAL SUPPORT SERVICE

Manager: Rita Barros

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 2022

The service maintained its support to the activity developed by the institution, whether in terms of research and development, in public procurement, in intellectual property or in labour matters, ensuring the compliance with the rules applicable in each area and tacking in account the evolution of European Law in these several areas. In this sense, the Legal Support Service maintained a demanding pace of work, diversifying its activities. The main highlights are as follows:

- Support to the human resources service, taking into account the diversity of contractual employment relationships existing in the institution and the inherent idiosyncrasies;
- Study of the various ways of exercising the employment relationship and their respective implications, whether in person, teleworking or working abroad;
- Presence of an AJ element in the Ethics Committee, ensuring the necessary convergence between the various issues at play, guaranteeing compliance with legal obligations;
- Support to management control service, whether in the legal framework of expenses in funded projects, or in the various iterations with funding institutions;
- Increase in contractual activity, both within the scope of financed projects and in direct contracting with national and foreign companies and institutions;
- 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 Memoranda of Understanding and Collaboration Agreements with national and international entities, in order to create pathways for future collaborations;
- Start of the preparation of the Consortium Agreements for European projects TRIDENT, TERRAMETA and CONVERGE, being INESC TEC the coordinator. Similarly, INESC TEC was also a partner in several European projects, with intense contractual negotiation, namely in the ERA_FABRIC, interSTORE, PRIVATEER, WATSON, CINDERELLA projects;
- Legal support to the drafting and negotiation of Consortium Agreements for the approved projects of the Recovery and Resilience Plan;
- EIT Manufacturing - involvement in the negotiation of the Digital Content Agreement for the TECH2Market , AI SOV , ConFacts projects.

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;
- Legal support to the drafting and negotiation of applications and other contractual instruments concerning the Recovery and Resilience Plan;
- Intense activity in public procurement, both as contracting authority, especially in the implementation of large infrastructure projects, and as contracting entity;
- Study and development of the Plan for the Prevention of Risks of Corruption and Related Infractions and intervention in the institutional discussions for its implementation.

9.2 ACCOUNTING AND FINANCE SERVICE

Manager: Paula Faria

Assistant Manager: Libânia Caetano

Employees
2 Men
7 Women

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, managing INESC TEC´s cash flow and ensure the availability of enough funds to meet the payments due time. 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 2022

The year 2022 was marked by a large increase in activity, with a growth in the number of accounting documents that required greater organisation, updating and improving some of the service's processes.

According to the main actions planned for 2022 and the goals of the Accounting and Finance services, the main highlights during this year were:

- Implementation of the tax requirement regarding the ATCUD code in the invoice form;
- Improvement of the fixed assets process and write-off of unused fixed assets at INESC TEC;
- Improvement of the payment information in the purchasing process, so those involved in the process are informed of the steps of each purchase;
- Document Management Policy – first document elimination act of INESC TEC;
- Negotiation of special conditions with banks, with the aim of providing benefits to employees;
- Elaboration of a catalogue with all Accounting and Finance services, to make them known to all users (Administration, Research Centres and other services);
- Reinforce continuous improvement activities and practices through internal training sessions on different subjects;
- Assistance in developing an instrument to account HR accruals in the first two years of the contract;
- Participation in the identification of requirements and procurement of a new ERP system to replace SAP (currently in use);
- Improvement in the invoice entry process to speed up the consultation process of the already issued invoices;
- Intranet now integrates incoming supplier invoices with a direct link to the incoming invoice map;
- Updating the information in the travel process regarding the updates in the travel allowance and travel insurance.

9.3 MANAGEMENT CONTROL SERVICE

Manager: Vanda Ferreira

Assistant Manager: Bárbara Maia

Employees
2 Men
10 Women

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 2022

During 2022 the service supported the financial management of 217 funded projects, having submitted 225 financial reports to the respective funding entities, representing more than 17 million euros of expenses. In addition to funded projects, the service monitored 136 projects providing direct services to companies, which in 2022 represented more than 3.7 million euros in sales.

Among these, 75 projects were funded by H2020 European Union framework programme and Horizon Europe, 8 of which were coordinated by INESC TEC, all with multiple partners, and one of them with almost 50 partners. The service also reported 21 projects funded by other European programs, such as INTERREG. The expenses reported throughout the year amounted to 4.8 million euros.

Regarding national projects, the service supported 48 projects funded by FCT (Fundação para a Ciência e a Tecnologia), reporting more than 3 million euros of expenses, and 49 projects in cooperation with companies, funded by Agência Nacional de Inovação (ANI), reporting 3.8 million euros of expenses. In 2022, 9 of the almost 30 PRR projects approved in the meantime began, although with a very low amount of expenses in 2022.

There were also a set of large-scale strategic projects such as FCT's Multiannual funding, regional (CCDRN) funding for highly qualified human resources, the large infrastructures and funding for technology and innovation centres funded by ANI. All of these large strategic projects required a huge effort from the service (38 financial reports), representing more than 4.5 million euros of reported expense.

As to internal control matters, the service also proceeded with its work on the continuous improvement of information systems, in collaboration with other services and was present at several demonstration sessions of the new ERP, which will be implemented to replace the current SAP implementation.

9.4 HUMAN RESOURCES SERVICE

Manager: Luís Seca

Assistant Manager: Margarida Gonçalves

Employees
2 Men
7 Women

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 development and implementation of HR related policies, according to the applicable law, internal regulations and guidelines provided by the Board.

Activities in the service are divided into **operational** (Payroll Administration, Benefits Administration, Recruitment, HR Technology Support Services, Workplace Safety, etc.) and **development** (reconceiving and reconfiguring HR management strategies, policies and practices).

9.4.2 Highlights in 2022

In 2022, the main highlights of the service were:

STRATEGY AND DEVELOPMENT

- **Job descriptions and competences policy:**
  - Meetings with several stakeholders (Executive Bord (EB), Centre coordinations, TEC4 coordinators, DPO) in order to present the job structure, content and specific competencies;
  - Status meetings with the EB to present the job description matrix of INESC TEC;
  - Preparation of competencies framework workshop to be presented to the EC.
- **Career policy:**
  - Consolidation of EB inputs to the document “Guidelines for INESC TEC's new Career Policy”.
- **Performance appraisal policy (PA)**:
  - Consolidation of EB inputs to the document “Guidelines for INESC TEC's new PA Policy”.
- **Welcoming and onboarding policy**:
  - Revision of the existing institutional welcoming model;
  - Preparation of the documentation (e.g: Onboarding manual) and welcome kit.
- **Training policy:**
  - Revision of INESC TEC training model and design of a new training policy, with the elaboration of a final deliverable “Guidelines for INESC TEC's new Training Policy”;
  - Support the design of an internal training pilot on Machine Learning (ML).
- **Recruitment and selection policy**:
  - Gathering and analysis of relevant information in recruitment process; employee branding benchmark; KPIs regarding the current recruitment process.
- **Interviews skills training**
  - Development of an interview skills training to promote and develop these skills in collaborators who directly perform job interviews;
  - Delivery of 5 sessions to 36 trainees.

OPERATIONAL

- **Process internal reorganisation:**
  - Reorganisation of document repository to allow better interaction with other services.
- **Improvement of the intranet HR processes to reduce workload, processing time and error rates:**

- Upload of the grant contracts in the respective MLs and NCs;
- Time reduction of contract signature;
- Revision of automatic emails in order to generate clearer messages;
- Integration with SRI, by providing automatic notification every time a foreign candidate is selected, allowing a closer support to the candidate;
- Improvement of dissemination routines in websites (internal and external);
- Improvement on performance evaluation, allowing multiple assessments in the case of an employee that has more than one manager;
- Review of the necessary fields / information for the reception of external students and the appropriate changes in the platforms (ML and NC).

- **Revision and creation of news HR documents:**
  - Implementation of permanence pacts;
  - Implementation of Telework agreement for people going to work abroad;
  - Creation of two new forms when the employee is leaving: "Probation_assessment_form" (to get the responsible person's opinion about the outgoing employee and share it with the other centres and find out if they are interested in it) and "Exit Form" to be filled by the employee.
- **New Programmes:**
  - Reception and award of 32 grants to students under the Summer with Science Programme;
  - Support for the UTAustin Programme, ERCIM Programme, International Mobility Support, namely advance payment, contracts (…).
- **New Platform:**
  - Automatic mechanism to upload our Team on the new FCT platform.
- **Insurance:**
  - Negotiation of new conditions for health insurance;
  - Revision of the territorial extension of health insurance and occupational accidents.
- **Internal Information addressed to the Coordinators, Board and Secretariat:**
  - Articulation meetings with centre coordinations to support the transition to permanent contracts;
  - Harmonisation of entry salaries and bandwidth definition according to professional experience;
  - Clarifications on fixed and uncertain contracts and their implications.
- **Resumption of INESC TEC cards emission**

9.5 MANAGEMENT SUPPORT SERVICE

Manager: Isabel Macedo

Employees
1 Man
1 Woman

9.5.1 Presentation of the Service

The Management Support Service facilitates effective decision-making in the following governing bodies of INESC TEC: General Council, Board of Directors, Executive Board and Council of R&D Centres. In addition to its operational focus, it also assists the Board of Directors and the Executive Board in streamlining internal strategic initiatives.

With a cross-cutting perspective, it ensures institution-wide coordinated information management, and seeks to improve current processes and procedures, namely by developing data-driven recommendations and solutions.

9.5.2 Highlights in 2022

Besides its regular operational activities that have intensified significantly in line with the increase in the institution's activity, the main highlights of the Service are:

Direct support to Management

- Coordination of the institutional planning and reporting to INESC TEC's various stakeholders;
- Ensure compliance with the rules of transparency and disclosure of information within the new framework of public utility status;
- Support and mediation to INESC TEC's accession to the associations 6G-IA, RAIL Colab, EASTRO and EBRAINS and to the company CEO – Companhia de Energia Oceânica, S.A.;

Information Management:

- Continuous document management support of INESC TEC Support Services as part of the reorganisation of the institutional archives;
- Fostering and monitoring the standardisation of information management practices within INESC TEC Support Services in accordance with the Document Management Policy;
- Assistance and guidance in the newly implemented disposal process of accumulated institutional documentation in accordance with the conservation periods established in the Document Management Policy while ensuring legal compliance with the GDPR;
- Publication of the fourth and fifth issues of the INESC TEC Science & Society magazine in digital format;
- Data publication at INESC TEC´s RDM (Research Data Repository) with 63 DOI´s minted, complemented with the creation of the INESC TEC´s Zenodo community and the registry of the RDM on the Re3data.org directory;
- Contributions to the development of several Data Management Plans, namely through direct support in their elaboration, recommendations of good practices, document review and ongoing support, while leading the management of the FIRE-RES project's DMP.

Continuous improvement:

- Participation and contributions to the strategic HR Workgroup on Performance Appraisal.

9.6 SECRETARIAL COORDINATION

Managers: Ana Isabel Oliveira and Grasiela Almeida

Employees
19 Women

9.6.1 Presentation of the Service

The Secretarial team is responsible for effectively executing the tasks required for the development of the activities of the Board of Directors, Research Centres and Services they support, in accordance with INESC TEC´s internal rules and processes.

In 2022, the team was composed by 19 employees, developing their work directly under the responsibility of a coordinator within a structure, being also coordinated by one of the managers: Ana Isabel Oliveira managing the team of Executive Assistants of the Board of Directors, and Grasiela Almeida managing the team of Assistants that support Research Centres and Services.

Each manager supervises its corresponding team (conducting regular meetings, assuring procedure compliance, providing training, giving feedback on performance, providing information on established partnerships and anticipating needs), while combining efforts to develop both teams along with the institution, with focus on continuous improvement.

9.6.2 Highlights in 2022

Apart from the regular operational activities mentioned above, the main highlights in 2022 were:

- Designing training on “Emotional Intelligence and Well-being” with AUDAZ, resulting in initiatives applied to teams, allowing a better performance and stronger relations and ties. Some examples: publicly birthday celebration, complimentary fruit, periodic walks around campus, regular 1-1 meetings, team lunches, organising healthy games/competitions on lunch breaks, gratitude email/chat messages, organising team events to celebrate achievements, share perspectives/plan the future and relax;
- Reorganisation of the INESC TEC Assistants team – needs assessment, solution design and implementation, along with recruiting 2 new assistants (1 in Braga and 1 in Porto): recruitment/selection process, full-time training of the assistant in Porto and close collaboration to this process in Braga, and follow up through the whole process;
- Management of the transition between suppliers: 4 travel agencies in the course of 5 months (along with several public procurement processes) and 4 car rental suppliers;
- In cooperation with HR, survey of secretariat’s functions and skills towards a future revision;
- Definition of indicators for the secretariat team, with a perspective of implementation for 2023;
- Developing a Training Course for assistants on Advanced Microsoft Excel, to be implemented in 2023;
- Elaboration of the structure and definition of the migration phases of institutional contacts to the CRM (ongoing);
- Implementation of the digital archive in compliance with GDPR (ongoing).

9.7 FUNDING OPPORTUNITIES OFFICE

Manager: Marta Barbas

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 2022

From all the activities developed we shall highlight, for its relevance, the information sessions and support regarding FCT call for "R&D Project in All Scientific Domains" and "Individual Call to Scientific Employment Stimulus", the monitoring of several proposals to national Recovery and Resilience Plan (RRP) and finally the support provided to the high volume of submissions of Horizon Europe and also several meetings with H. Europe National Contact Points and principal researchers of coordinated proposals.

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

- FCT Call for R&D Project in All Scientific Domains 2022: 94 proposals;
- FCT call for exploratory international cooperation projects UT Austin Portugal – 2022: 1 proposal;
- FCT call for exploratory international cooperation projects MIT Portugal – 2021: 2 proposals;
- FCT call for exploratory international cooperation projects CMU Portugal – 2021: 8 proposals;
- ERASMUS + KA2: 1 proposal;
- ERANET Biodiversa + Call: 1 proposal;
- ERANET Water4All: 1 proposal;
- Individual Call to Scientific Employment Stimulus - 6th Edition: 16 proposals;
- Agendas Mobilizadoras e Pactos de Inovação Verdes (PRR): 25 proposals;
- Agendas Mobilizadoras Bioeconomia (PRR): 3 proposals;
- Agendas de Investigação e Inovação IFAP (PRR): 5 proposals;
- Hub Azul, Rede de Infraestruturas para a Economia Azul (PRR): 1 proposal;
- HORIZON Europe: 107 proposals were submitted; we highlight 3 successful proposals coordinated by INESC TEC whose submissions were strongly supported by the service: TRIDENT (HORIZON-CL4-2022-RESILIENCE-01-02), CONVERGE (HORIZON-INFRA-2022-TECH-01-01) and TERRAMETA (HORIZON-JU-SNS-2022-STREAM-B-01-02) submitted in March and April;
- Digital Europe Programme: 10 Proposals, 9 to EDIH and 1 EUROHPC;
- European Defence Fund: 1 proposal;
- Interregional Innovation Investments Instrument (I3): 1 proposal;
- EIT Manufacturing - Call 2023: 27 proposals;
- Cascade Funding: 2 proposals;
- European Tenders: 4 proposals.

9.8 TECHNOLOGY LICENSING OFFICE

Manager: Daniel Marques de Vasconcelos

Employees
3 Men

Grant holders
1 Woman

9.8.1 Presentation of the Service

The INESC TEC Technology Licensing Office (TLO) aims **to boost the societal impact of the R&D results** generated at the institution. The TLO is a key player at both national and European levels with a **world-class practice in Intellectual Property (IP) Strategy and Technology Transfer.**

9.8.2 Highlights in 2022

As planned in 2022, SAL consolidated its new internal organisation expanding its team to a new tech manager dedicated to the Industry and Digital markets. The systematic strategic scouting was initiated, the interaction with commercial partners was intensified, and many internal processes were reviewed to improve INESC TEC efficiency. Following the main objectives stated in the Plan for 2022, the achievements and highlights are briefly presented:

1. **Formalise and promote INESC TEC exploitable outputs:**

   1.1. **Proactive and strategic R&D results scouting launched in March 2022,** which comprises biannual meetings with principal investigators of top R&D projects for mapping new and expected R&D results and for Intellectual Property Clinics. Top 94 out of 490 projects monitored (19%), representing 40M€ out of 100M€ INESC TEC budget in EU, national and contract research projects;

   1.2. **Acceleration in the new R&D disclosures** with 2x the KPI registered in 2021 and more 65% than the planned number of disclosures for 2022 (29);

   1.3. **New General Agreement on joint IP was signed with the University of Porto**, which defined the rules on the management of the current and future joint patents and boosts the collaboration between the two TLOs.

2. **Adopt a market-driven IP portfolio management:**

   2.1. New monthly and internal meetings for portfolio management to optimise priorities and actions considering the overall INESC TEC portfolio. These meetings are key to sharing knowledge and best practices among the team, refining sectorial IP strategies, assessing the competitive landscape, and improving engagement with both regional and international deep tech companies;

   2.2. Growing IP portfolio comprising 76+ different technologies and 96 patents.

3. **More transparent and user-friendly internal TLO procedures for results and technology disclosure:**

   3.1. New IP database at the TLO Office with more robust data, which quickly can provide insights and statistics on IP management to the whole institution with details at Centre level also supporting individual performance assessment in tech transfer;

   3.2. A new flowchart explaining the whole process from the disclosure of new R&D results to their protection, management, and commercialisation was prepared and will be made available in early 2023;

   3.3. Internal physical Board at the TLO office to show the overall tasks and progress on project scouting, IP portfolio management and commercialisation, which also contributes for the improved morale of the team;

   3.4. Benchmark vs other European RTOs and Universities using the ASTP annual report to assess and compare INESC TEC performances in major tech transfer KPIs.

4. Raise IP awareness and promote new IP-related KPIs and incentives

4.1. Improved KPIs for knowledge transfer by increasing the number of points attributed to R&D Centres for commercialisation (options, licenses, and assignments) and alignment of the KPIs with the ones used by international references such as ASTP and the European Commission to reflect best practices;

4.2. A more present TLO exploiting synergies with the strategic scouting initiative where the regular contact with R&D teams brings new opportunities to clarify issues regarding IP strategy and commercialisation.

5. A new market-driven team organisation

5.1. New tech manager in the TLO team dedicated to multimedia, manufacturing, and digital technologies;

5.2. Advanced training of team members in emerging topics such as digital, spin-off, IP valuation and knowledge (and not just tech) transfer;

5.3. Closer collaboration with TEC4 initiative by participating in monthly meetings and promoting regular discussion and contributions between TEC4 and TLO managers assigned to the same market;

5.4. More intense customer discovery activities by contacting relevant players in the market in an early stage to validate the need and market gap and identify critical requirements for the solution to maximise the likelihood of successful commercialisation of the generated R&D results.

9.9 INTERNATIONAL RELATIONS OFFICE

Manager: Andreia Passos

Employees
1 Man
4 Women

9.9.1 Presentation of the Service

The International Relations Service (SRI) was created in 2020 to assist INESC TEC's Board of Directors and R&D Centers in maximising global opportunities, reach and reputation through tailored support to international mobility, development of high-level international partnerships and promotion of intercultural awareness and understanding. Additionally, the Service accommodates the INESC Brussels Hub with an independent management framework.

9.9.2 Highlights in 2022

At the end of 2021, the SRI set several goals for the following year, aligning with the three pillars the Service stands on: helping move from individual-led initiatives to institutional opportunities, valuing human interaction in mobility services and embedding intercultural understanding in the working culture for successful international cooperation.

What goals did the Service set itself in 2022	Highlights – How well did the Service live up to its goals
Implementation of a survey to map active and (prospective) international research collaborations	The survey was conducted, but the response rate was low for the team to infer sound conclusions. Nevertheless, the data collected allowed the Service to expand its contact base and use it to disseminate the INESC TEC International Visiting Researcher Programme and prepare the ground for more institutional contacts. In addition to this, the SRI carried on working and fine-tuning a framework to help the Board of Directors lay down its Vision for Internationalisation while allowing room for bottom-up internationalisation action. The framework should be ready for deployment in 2023.
Carry on assisting in bilateral and multilateral cooperation	In 2022, the SRI established itself as an advisory service for international cooperation, backing the organisation and its internationalisation champions in MoU negotiation, monitoring and renewal and planning and hosting of visiting delegations, including high-ranking visitors. The SRI was committed to levelling up the standards of these specific activities in the organisation by drafting guidelines for safe international collaboration and a policy for hosting visiting delegations or embedding intercultural awareness into delegation planning. These two drafts have been recently submitted for top-level perusal and should be made available to the whole INESC TEC community if authorised for publication. Finally, the Service continued managing, at an executive level, the UT Austin Portugal Program, which was credited for its outstanding performance last year by the Program's External Review Committee.
Promote the institution's international profile through refreshed internal and external communication and new and improved indicators to best capture its performance in a global setting	Collaboration with the Communications Service was remarkably consistent. The SRI used all possibilities to promote widespread visibility of the institution's international engagement both at home and abroad. The team worked with SCOM on videos about the attraction of international talent and international mobility, news stories about international partners and visitors, communication campaigns on the 1st edition of INESC TEC International Visiting Researcher Programme or an editorial on BIP. Regarding indicators, the SRI put in place a dashboard of indicators to monitor and report its performance, particularly in inbound mobility.

What goals did the Service set itself in 2022	Highlights – How well did the Service live up to its goals
Carry on supporting inbound and outbound research mobility processes	The SRI kept on assisting incoming foreign staff and visiting researchers in relocation and mobility processes. The demand for SRI's support in this area increased by 60% compared with the previous year, with more Centres reaching out to our team throughout the year not only for us to help foreign newcomers settle in but also to advise staff on short-term mobility opportunities abroad (e.g., the OpenInnoTrain project; US opportunities through FLAD). The SRI organised a short-term training activity on the new Aliens Act delivered by the High Commission for Migrations and open to HR and Admin Assistants at INESC TEC. Additionally, two breakthrough initiatives were launched: the 1st edition of the INESC TEC International Visiting Researcher Programme, which features INESC TEC as a high-profile venue for international scientific cooperation through short-term research mobility, and the INESC TEC Intercultural Ambassadors Network, which demonstrates the institution's commitment to improved intercultural awareness and literacy across the organisation and in its relationship with external actors.

9.10 COMMUNICATION SERVICE

Manager: Joana Coelho

9.10.1 Presentation of the Service

The Communication Service collaborates with the Board of Directors in the definition of the institution's communication strategies. 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, and helping the institution in terms of brand positioning as a solid and reputable R&D institution. To reach these objectives, the communication service divides its activities into five main components - contents, design and multimedia, events, projects leadership in communication and dissemination working groups and translation -, in a mission focused entirely on highlighting the role of science communication. The activities conducted by the Communication Service follow an integrated marketing communication (IMC) approach.

9.10.2 Highlights in 2022

External Communication

- Science communication
    - INESC TEC Science & Society Magazine – two editions in 2022 (Digital (R)evolution in Agro-Food and Forestry and The Energy Transition), with a total number of views higher that 5 400 (more than the double compared with 2021). The English version of the magazine has more page visualisations than the Portuguese one (3660 VS 1744).
    - Spotlight – a long story format – published on BIP - that seeks to deepen themes that researchers of the institution are working on. In 2022, this section had more than 1 600 total page visualisations. Spotlight featured 6 editions in 2022, energy transition piece achieving the highest number of readers: more than 230 visualisations (both in Portuguese and English).
    - Science Bits – a podcast format, only available in Portuguese, and produced in partnership with Engenharia Rádio. There were 5 episodes in 2022, and the number of downloads was higher than 2 590.
    - SCOM carried out different campaigns to promote the science and technology developed at INESC TEC. One of those campaigns was about the International Day of Women & Girl in Science, taking into consideration the principles of an IMC approach, involving advertisement (design and multimedia), and digital marketing (social media, website) actions.
- Public Relations
    - **National Press Relations** – in 2022, 1 025 news pieces were published in the national media, with an Automatic Advertising Value of more than 4.2M€. The Communication Service released 22 press releases to the media throughout the year; in addition, it obtained exclusives with Agência Lusa and other national media, thanks to editorial proposals.
    - **International Press Relations** – in 2022, the Communication Service had a higher investment in terms of activity in this area. 11 Press Releases were launched via Alpha Galileo, a platform that allow us to reach international journalists. These PRs led to 87 news pieces published on the international media. In 2022, the Medium portal also continued to serve as a media to publish opinion pieces written by INESC TEC researchers, with two pieces published, leading to more than 110 visualisations.
    - **Events** – in 2022, the Communication Service was involved in 42 events, even though the level of involvement was different. 11 of said events were organised with the objective of disseminating the science and technology activities of the institution, namely Encontro Ciência, Mostra U. Porto, Semana Profissão Engenheiro, etc. Similarly, 11 of these events were coorganised by the Communication Service, meaning that the team supported the event in different ways (e.g., visual identity, dissemination, video, news pieces, etc.); examples include the CTM Open Day, PSCC 2022, Women in STEM workshop, etc. SCOM supported the organisation of 20 events, such as the VISUM conference, QSP Summit, Hannover

Messe, etc. From all these events, it is important to highlight "INESC TEC Autumn Forum", that occurs every year, with the Communication Service responsible for the organisation. In 2022, 238 people were present at the event and 175 watched it online.

- Digital Marketing
  - **Website –** in 2022, INESC TEC website translated into a total of 54 272 visits. The most visited page – in both languages – were the "Opportunities" and "People". The English version of the website featured more visits than the Portuguese (90 325 total views VS 87 669).
  - **BIP** – regarding INESC TEC's newsletter, in 2022, there was a total page visualisation of 40 030. The news section is the one with a higher number of visualisations – both in English and Portuguese, followed by the Homepage and the "Partners" section.
  - **Social media** – the numbers of followers on the five social media channels increased in 2022. On Twitter the number of followers is 9 362 (+532 than 2021), on LinkedIn 17 235 (+2372), on Facebook 7 717 (+334), on Instagram 2 554 (+288) and on YouTube 1 250 (+135).
- Advertising
  - **Design and Multimedia –** a work that is mainly divided into three main aspects: institutional communication – such as supporting design works like INESC TEC Science & Society Magazine or the illustrations developed for each of the Spotlight's editions, or multimedia works like Intercultural Corner section on BIP or other types of activities that are spread on the social media channels -; visual identities and other multidisciplinary visual works – that are mainly used in events in which the institution is involved (e.g., XIII Symposium on Bioengineering, SOE'22, PSCC'22, etc.) – and improvement/maintenance of visual identities – in which the work relies on identities that already exist, yet require the development of other types of material, such as flyers, videos, stands, etc.
- Translation
  - In 2022, every news piece, institutional document, video or even scientific publications were either translated or proofread by the Communication Service.
- Dissemination and Communication of project results
  - In 2022, the Communication Service supported 7 project proposals, being responsible for writing sections like impact, dissemination and communication plan, and work package structure and objectives definition. Three of these proposals failed, three were approved and one is still waiting for results. Moreover, in 2022, the Communication Service continued to support eight projects (European and national), playing a key-role in terms of work package leadership.

Internal Communication

- Organisation of four events – INESC TEC on foot, Strategic Meeting, Roasted Chestnuts Party and BIP Anniversary, and INESC TEC season party –, that involved not only organisation tasks, but also design and multimedia support work;
- Ongoing dynamisation of "News and Events" and "Kit Kat time" channels on Mattermost;
- Production and distribution of new merchandise elements (e.g., at events);
- Support in terms of translation and proofreading of internal institutional documents.

9.11 NETWORKS AND COMMUNICATIONS SERVICE

Manager: Gil Coutinho

Employees
5 Men

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 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 Networks, namely at headquarters and other labs located at Asprela;
- External connectivity (e.g. RCTS, peer institutions, service providers);
- Network security (e.g. access control, threat and intrusion prevention/detection, incident response);
- Core mail system (e.g. mail transfer agents, anti-virus, anti-spam);
- Remote-access VPN and site-to-site VPNs;
- Underlying network services (e.g. DNS, DHCP, RADIUS)
- Datacenter facility management;
- VoIP infrastructure;
- Video-conferencing systems and solutions;
- Audio/Video streaming and broadcasting;
- Printing and scanning systems;

9.11.2 Highlights in 2022

In 2022 we witnessed, as expected, an intensification of the hybrid working model, which led to a significant increase in the number of hybrid videoconferencing sessions, each of which having its own requirements and topology. The setup of these sessions, which involves reconfiguration of sound and video systems as well as providing technical support throughout them, was a particularly time-consuming activity for the (few) elements of the team. Besides this, the majority of the remaining tickets solved by the team mainly concerned access control (e.g. new systems or virtual machines, opening of network ports) or specific network topology requests (e.g. VPNs for external users);

Despite the little time remaining after these daily tasks, thorough attention was still given to important activities like close monitorisation of the infrastructure, preventive and corrective maintenance, security upgrades and occasional improvements.

Some planned and unplanned highlights for 2022 include:

- The operationalisation of the redundant connection to the Portuguese national research and education network (RCTS) via UMinho. This not only enables a disaster recovery and off-site backup location, but also a second connection to the internet, thus improving resilience in case of failure at headquarters or even at FCCN's point of presence (FEUP);
- The adoption by the team of a maintenance window (6:00 to 8:00), partially coincidental to the one assumed by FCCN (Wednesdays 6:00 to 8:30), during which all network interventions with a reasonable degree of risk are undertaken. This has allowed for a number of afore- and below-mentioned activities to be accomplished with minimal impact to the end-users;
- The total decommissioning of the small datacenter located at the basement of headquarters building A, by leveraging both server virtualisation and the existence of two other datacenters (buildings A and B), with significant savings in terms of climatisation, maintenance, energy, etc.;

- Significant upgrade and restructuring of the datacenters' switching infrastructure, with an increase of capacity and scale: the core now operates at 100 gigabit/s, and more than 150 ports are available for connecting servers (roughly a 50/50 mix of 25 and 10 gigabit/s ports);
- Close participation and support in the design and implementation processes of laboratories networking infrastructures, in particular but not exclusively iiLab; integration of the labs located at FEUP in INESC TECs central network;
- Continuous improvement of infrastructure monitorisation and alerting procedures, both from internal and external points of view and using different media, as well as a consolidation of the use of the centralised logging platform;
- Participation in the development of an intranet module being undertaken by SIG, which aims to integrate SRC's database and user interface in the intranet;
- Articulation with cybersecurity entities like RCTS CERT and CERT.PT (CNCS), towards a continuous improvement of cybersecurity and cyber resilience mechanisms and procedures, as well as incident reporting.

9.12 MANAGEMENT INFORMATION SYSTEMS SERVICE

Manager: José Carlos Sousa

Employees
5 Men

Grant holders
2 Men
2 Women

9.12.1 Presentation of the Service

The Management Information Systems Service oversees 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 CRM system, the Institutional Repository, the Website, and the European projects management system UOne Connect. SIG also supports the several services in their interaction with the financial ERP system.

9.12.2 Highlights in 2022

The main new functionalities added to the intranet system were:

- New Ethics form associated with project proposals;
- Follow-up of the Internal Seed Project process;
- Enhanced integration of Electronic Invoicing with internal ERP;
- Improvements in the Conflicts of Interest management system;
- Enhanced Car Booking system.

The IRIS kept growing through the addition of more modules:

- New module to manage and report cost specialisation in contract research projects;
- New module to manage the sharing of human resources among different structures.

A new CRM system has been established, interoperable with the INESC TEC information system. The main developments focus on:

- New dashboards templates;
- Improvements based on feedback from collaborators.

The system uONEConnect fully supports the European projects management needs. It is now used as the default European project management platform. New features developed in 2022:

- New set of charts in the financial reports, dedicated to third party partners;
- Improved version control comparisons;
- New financial correction reports;
- New module to manage the partner payment requests (pre-financing and interim payment);
- Support to Horizon Europe projects.

9.13 SYSTEM ADMINISTRATION SERVICE

Manager: Jaime Dias

Employees
4 Men

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 2022

The transition to hybrid work and the gradual change from desktops to laptops that begun in 2021, continued in 2022, and so did the need of a broader system administration and remote helpdesk availability from SAS to all INESC TEC users.

Security and resiliency tasks have taken up a significant portion of the SAS effort on system administration. SAS kept improving preventive and reactive measures, assist users in determining if their accounts may have been compromised or perform forensic analysis of potentially compromised machines. Despite users being more aware of email phishing attacks, 2022 saw an increase of spear phishing, much more difficult to distinguish from legitimate emails. SAS changed the INESC TEC antivirus solution (endpoint security) which contributed for a better protection, helped users verify suspect emails and gave feedback to SRC so that it could improve email's MTAs malware/phishing filtering.

Next are listed the highlights in 2022:

- **Storage and computing infrastructures.**
    - Six new servers were acquired and integrated into the CCloud computing cluster, which increased the cluster computing capacity to over 700 virtual CPUs and 6 Tbytes of RAM.
    - CCloud was improved to enabled selected centres' users to create and manage VMs directly on the management interface.
- **Resource usage monitoring.** A monitoring platform was deployed to track down CCloud virtual machines' potentially unused resources so that these can be made available to others.
- **Disaster recovery.** SAS continued the provision of the hot site at the University of Minho with new application services along with SRC, which provides the network part of the DR.
- **Collaborative applications.** The Gitlab, Chat and Drive services were improved with new functionalities. This was done gradually, with minimal downtimes outside working hours, to guarantee the continuous operation of the services during working hours. Besides on-premises collaborative services, SAS manages INESC TEC Office365 services, such as Teams, OneDrive, Sharepoint Online, and MS Office Online, to INESC TEC users.
- **DevOps.** DevOps are evolving rapidly, but there are still many possible solutions, not compatible with the adoption of a single platform for INESC TEC. To deal with this, 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 different cluster does not disrupt others.
- **Security.**
    - SAS deployed two patching solutions for Windows and Linux systems, which will be used to automate the patching of VMs and computers at INESC TEC.
    - SAS changed the INESC TEC Antivirus solution (endpoint security) and migrated the endpoints in 2022. All three main Operating Systems are supported (Windows, Linux and macOS).

- **Helpdesk.** A new first line support SAS member helped to reduce support response times and assisted with the implementation of measures to reduce new helpdesk issues.
- **Digital certificates.** After having migrated all the services to HTTPS in 2021, SAS proceeded with the yearly renewal of the digital certificates, adding this to the group of security tasks handled by SAS to increase the INESC TEC overall security, such as systems and websites patching and periodic system vulnerability assessment.
- **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.

9.14 INFRASTRUCTURE MANAGEMENT SERVICE

Manager: Jorge Couto

Employees
6 Men

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 and infrastructures.

9.14.2 Highlights in 2022

As referred in the 2022 activity plan, the focus of the service was to reorganise and improve the overall condition of workspaces, bearing in mind the increase of comfort to all INESC TEC co-workers and the availability of the proper conditions for the foreseen hybrid model (face to face and remote work) to be adopted.

Following the objectives described in the activity plan, the following actions were put in place:

- **Increase energy efficiency of buildings:**
  - Converting traditional lighting to controllable LED in 4 additional rooms, emergency paths and common spaces;
  - Complete reformulation of the KNX system, with the implementation of a centralised web-based control, that allows real time visualisation and control of all lighting devices in headquarters buildings;
  - Reformulation of HVAC control systems, to increase visibility on consumption and foster the adoption of corrective set points according to weather conditions;
  - Planning and design of an electrical alternative (heat pump with inertia reservoir) to reduce the use of natural gas, by pre-heating the water circuit;
  - Overall cleaning of all solar panels on the rooftop;
  - Improve the performance of the CADU system in both headquarter buildings;
  - Installation of submetering to allow energy audits, that allowed identifying an error of configuration in the intensity transformer by the DSO, which led to a relevant reduction in the electricity bill;
  - Preventive and corrective maintenance of the various security, electrical and mechanical equipment installed in the buildings.

- **Security of people**
  - AED defibrillator equipment was placed in the groundfloor of Building A, to allow as immediate life support in case of heart disease; its installation included adequate training to different co-workers in the buildings;
  - Reformulation of emergency and evacuation plans and their installation;
  - Preventive and corrective maintenance of the various fire control devices installed in all the buildings;
  - Change of the smoke escape window opening in building A staircases.

- **Workspace improvement**
  - Conclusion of studies for changing spaces in the lunchroom of building A and open space on 2nd floor of Building B;
  - Furniture replacement in several rooms and workspaces;
  - Soundproofing of Board of Directors meeting room;
  - Start of building renovation works at Portic (new iiLab facilities);
  - Installation of Video Wall in Building A;
  - M&S to MAssive Laboratory at UTAD;

- Reformulation of bar/cafeteria to improve the circulation of people inside and to reduce service time.

- **Other activities**
  - Start of activity of the security company ND, that required the reformulation of several support documentation and procedures;
  - Replacement of cleaning company, with a very delicate process after several labour and legal infringements by the previous company;
  - Following the strategy of reducing carbon footprint of mobility for INESC TEC co-workers, a new local pay-per-use car rental system was put in place, together with a new reserve system that chooses the most adequate vehicle according to the mission and distance.

10 ANNEX I

10.1 CTM – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	10	9	9	
		Academic Staff	14	13	14	1
		Grant Holders and Trainees	52	45	49	4
		Total Core Researchers	**76**	**67**	**72**	**5**
		Total Core PhD	**26**	**21**	**22**	**1**
	Affiliated Researchers		9	8	10	2
	Administrative and Technical Employees		1	1	1	
	Total Integrated HR		**86**	**76**	**83**	**7**
	Total Integrated PhD		**35**	**29**	**29**	

Table 10.1.2 - CTM – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	470	396	113	-284
PN-PICT	National R&D Programmes - S&T Integrated Projects		4	77	73
PN-COOP	National Cooperation Programmes with Industry	322	150	277	127
PUE-FP	EU Framework Programmes	240	205	244	39
PUE-DIV	EU Cooperation Programmes – Other	-3		11	11
SERV-NAC	R&D Services and Consulting – National	295	708	625	-83
SERV-INT	R&D Services and Consulting – International	123	37	21	-15
OP	Other Funding Programmes	51	59	74	15
Total Funding		**1 498**	**1 559**	**1 443**	**-116**

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

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	41	45	41
Indexed Conferences	44	48	33
Books			
Book Chapters	1	3	1
Concluded PhD Theses - Members	3	4	5
Concluded PhD Theses – Supervised	3	7	6

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

Type of Result	2020	2021	2022
Pre-Disclosures (PDF)		2	4
Technology Disclosures (TDF)	1		1
First Priority Patent Applications (New Inventions)		1	1
First Patents Internationalisation			
First Patents Granted		2	1
Commercial Contracts (Licences, Options, Assignments)	1	1	
Spin-offs established			
Spin-offs in development			

Table 10.1.5 - CTM - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	13
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	6
International events in which INESC TEC members participate in the program committees	37
Participation in events such as fairs, exhibitions or similar	5
Conferences, workshops and scientific sessions organised by the Centre	11
Participants in the conferences, workshops and scientific sessions organised by the Centre	800
Advanced training courses organised by the Centre	2

Table 10.1.6 - CTM - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	TEC4SEA-1	Rui Lopes Campos	01/09/2017	31/12/2022
PN-FCT	ENDURANCE	Luís Manuel Pessoa	01/07/2018	29/12/2020
PN-FCT	PEPCC	João Canas Ferreira	01/10/2018	31/12/2021
PN-FCT	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	MATinMOL	Maria Inês Carvalho	01/03/2021	29/02/2024
PN-FCT	CIRCUMSTANCE	Hélder Filipe Oliveira	01/01/2022	31/12/2024
PN-PICT	DECARBONIZE-1	Rui Lopes Campos	01/01/2021	30/06/2023
PN-COOP	STRx	Luís Manuel Pessoa	01/05/2019	30/10/2022
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
PN-COOP	Continental FoF	Luís Manuel Pessoa	01/07/2020	30/06/2023
PN-COOP	Produtech R3-3	Rui Lopes Campos	01/09/2022	31/12/2025
PN-COOP	SUSTAINABLE PLASTICS	Pedro Miguel Carvalho	01/09/2022	30/08/2025
PUE-DIV	OpenMinds	Gilberto Bernardes Almeida	30/12/2021	29/12/2023
PUE-FP	TERAPOD	Luís Manuel Pessoa	01/09/2017	31/05/2021
PUE-FP	RESPONDRONE	Rui Lopes Campos	01/05/2019	30/04/2022
PUE-FP	InterConnect-1	Filipe André Ribeiro	01/10/2019	31/03/2024
PUE-FP	DivaX-1	Filipe André Ribeiro	01/04/2022	31/10/2022
PUE-FP	CINDERELLA	Jaime Cardoso	01/06/2022	31/05/2026
SERV-NAC	STRx_Licenciamento	Filipe André Ribeiro	11/05/2020	31/03/2023
SERV-NAC	SLID	Luís Manuel Pessoa	01/11/2019	30/09/2022
SERV-NAC	5GforUtilities	Filipe André Ribeiro	01/01/2021	31/12/2022
SERV-NAC	CholdaDigital-1	Rui Lopes Campos	17/06/2021	11/04/2022
SERV-NAC	CadPath	Filipe André Ribeiro	01/06/2021	30/11/2022
SERV-NAC	vCardID4	Filipe André Ribeiro	01/09/2021	31/10/2022
SERV-NAC	THEIA	Luís Manuel Pessoa	03/01/2022	31/12/2023
SERV-NAC	ABIS	Filipe André Ribeiro	01/04/2022	01/01/2023
SERV-NAC	Vision2Control-1	Pedro Miguel Carvalho	01/10/2022	01/01/2023
SERV-NAC	AURORA	Filipe André Ribeiro	01/10/2022	30/11/2024
SERV-INT	SMART	Rui Lopes Campos	31/03/2021	31/07/2022
SERV-INT	IWOW2022	Filipe André Ribeiro	19/06/2022	19/07/2022
OP	Inphinit	Paula Viana	01/12/2019	01/12/2022
OP	VISUM2022	Sara Isabel Oliveira	01/11/2021	30/09/2022

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

10.1.2 List of Publications

International Journals with Scientific Referees

1. Albuquerque, T, Cruz, R, Cardoso, JS, "Quasi-Unimodal Distributions for Ordinal Classification", MATHEMATICS, vol.10, pp.980, 2022
2. Beco, SC, Pinto, JR, Cardoso, JS, "Electrocardiogram lead conversion from single-lead blindly-segmented signals", BMC MEDICAL INFORMATICS AND DECISION MAKING, vol.22, 2022
3. Caetano, F, Carvalho, P, Cardoso, J, "Deep Anomaly Detection for In-Vehicle Monitoring—An Application-Oriented Review", APPLIED SCIENCES-BASEL, vol.12, pp.10011, 2022
4. Capozzi, L, Barbosa, V, Pinto, C, Pinto, JR, Pereira, A, Carvalho, PM, Cardoso, JS, "Towards vehicle occupant-invariant models for activity characterisation", IEEE ACCESS, pp.1-1, 2022
5. Carvalho, G, Pereira, ME, Silva, C, Deuermeier, J, Kiazadeh, A, Tavares, V, "Characterization and modelling of resistive switching phenomena in IGZO devices", AIP ADVANCES, vol.12, 2022
6. Clement, A, Bernardes, G, "Assessing the Influence of Multimodal Feedback in Mobile-Based Musical Task Performance", MULTIMODAL TECHNOLOGIES AND INTERACTION, vol.6, pp.68, 2022
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8. Correia, A, Tavares, VG, Barquinha, P, Goes, J, "All-Standard-Cell-Based Analog-to-Digital Architectures Well-Suited for Internet of Things Applications", JOURNAL OF LOW POWER ELECTRONICS AND APPLICATIONS, vol.12, 2022
9. Costa, A, Rodrigues, D, Castro, M, Assis, S, Oliveira, HP, "The effect of augmentation and transfer learning on the modelling of lower-limb sockets using 3D adversarial autoencoders", DISPLAYS, vol.74, pp.102190, 2022
10. Costa, DG, Peixoto, JPJ, Jesus, TC, Portugal, P, Vasques, F, Rangel, E, Peixoto, M, "A Survey of Emergencies Management Systems in Smart Cities", IEEE ACCESS, vol.10, pp.61843-61872, 2022
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12. Descalzi, O, Carvalho, MI, Facao, M, Brand, HR, "Dissipative solitons stabilized by nonlinear gradient terms: Time-dependent behavior and generic properties", CHAOS, vol.32, 2022
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14. Fonseca, J, Liu, XY, Oliveira, HP, Pereira, T, "Learning Models for Traumatic Brain Injury Mortality Prediction on Pediatric Electronic Health Records", FRONTIERS IN NEUROLOGY, vol.13, 2022
15. Frade, J, Pereira, T, Morgado, J, Silva, F, Freitas, C, Mendes, J, Negrao, E, de Lima, BF, da Silva, MC, Madureira, AJ, Ramos, I, Costa, JL, Hespanhol, V, Cunha, A, Oliveira, HP, "Multiple instance learning for lung pathophysiological findings detection using CT scans", MEDICAL & BIOLOGICAL ENGINEERING & COMPUTING, 2022
16. Goncalves, T, Rio-Torto, I, Teixeira, LF, Cardoso, JS, "A survey on attention mechanisms for medical applications: are we moving towards better algorithms?", IEEE ACCESS, pp.1-1, 2022
17. Jesus, TC, Costa, DG, Portugal, P, Vasques, F, "A Survey on Monitoring Quality Assessment for Wireless Visual Sensor Networks", FUTURE INTERNET, vol.14, pp.213, 2022
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27. Peixoto, PS, Carvalho, PH, Machado, A, Barreiros, L, Bordalo, AA, Oliveira, HP, Segundo, MA, "Development of a Screening Method for Sulfamethoxazole in Environmental Water by Digital Colorimetry Using a Mobile Device", CHEMOSENSORS, vol.10, pp.25, 2022

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32. Pinto, JP, Viana, P, Teixeira, IN, Andrade, MT, "Improving word embeddings in Portuguese: increasing accuracy while reducing the size of the corpus", PeerJ Comput. Sci., vol.8, pp.964, 2022

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Machine Learning-Aided Lung Cancer Clinical Routines: Approaches and Open Challenges", JOURNAL OF PERSONALIZED MEDICINE, vol.12, pp.480, 2022

37. Silva, HBGE, Ricardo, M, "5G and governance through technology", EPTIC, vol.24, pp.7-21, 2022
38. Sousa, J, Pereira, T, Neves, I, Silva, F, Oliveira, HP, "The Influence of a Coherent Annotation and Synthetic Addition of Lung Nodules for Lung Segmentation in CT Scans", SENSORS, vol.22, pp.3443, 2022
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41. Viana, P, Andrade, MT, Carvalho, P, Vilaca, L, Teixeira, IN, Costa, T, Jonker, P, "Photo2Video: Semantic-Aware Deep Learning-Based Video Generation from Still Content", JOURNAL OF IMAGING, vol.8, pp.68, 2022

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2. Almeida, EN, Campos, R, Ricardo, M, "Traffic-Aware UAV Placement Using a Generalizable Deep Reinforcement Learning Methodology", IEEE Symposium on Computers and Communications, ISCC 2022, Rhodes, Greece, June 30 - July 3, 2022, vol.abs/2203.08924, 2022
3. Almeida, EN, Rushad, M, Kota, SR, Nambiar, A, Harti, HL, Gupta, C, Waseem, D, Santos, G, Fontes, H, Campos, R, Tahiliani, MP, "Machine Learning Based Propagation Loss Module for Enabling Digital Twins of Wireless Networks in ns-3", WNS3 2022: 2022 Workshop on ns-3, Virtual Event, USA, June 22 - 23, 2022, vol.abs/2205.04284, 2022
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5. Carvalho, P, Freitas, D, Machado, T, Viana, P, "Enhancing Photography Management Through Automatically Extracted Metadata", INTELLIGENT SYSTEMS DESIGN AND APPLICATIONS, ISDA 2021, vol.418, pp.956-964, 2022
6. Costa, P, Gaudio, A, Campilho, A, Cardoso, JS, "Explainable Weakly-Supervised Cell Segmentation by Canonical Shape Learning and Transformation", International Conference on Medical Imaging with Deep Learning, MIDL 2022, 6-8 July 2022, Zurich, Switzerland., vol.172, pp.250-260, 2022
7. Dumont, M, Correia, C, Sauvage, JF, Schwartz, N, Gray, M, Beltramo-Martin, O, Cardoso, J, "Deep learning for space-borne focal-plane wavefront sensing", SPACE TELESCOPES AND INSTRUMENTATION 2022: OPTICAL, INFRARED, AND MILLIMETER WAVE, vol.12180, 2022
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9. Finich, S, Salgado, HM, Pinho, P, "Substrate Integrated Waveguide Cavity Backed Slot Antennas for Millimeter-Wave Applications", 2022 16TH EUROPEAN CONFERENCE ON ANTENNAS AND PROPAGATION (EUCAP), 2022
10. Friedrich, M, Lieb, TJ, Temme, A, Almeida, EN, Coelho, A, Fontes, H, "ResponDrone - A Situation Awareness Platform for First Responders", AIAA/IEEE Digital Avionics Systems Conference - Proceedings, 2022

11. Goncalves, R, Ferreira, I, Godina, R, Pinto, P, Pinto, A, "A Smart Contract Architecture to Enhance the Industrial Symbiosis Process Between the Pulp and Paper Companies - A Case Study", BLOCKCHAIN AND APPLICATIONS, vol.320 LNNS, pp.252-260, 2022

12. Huber, M, Boutros, F, Luu, AT, Raja, K, Ramachandra, R, Damer, N, Neto, PC, Goncalves, T, Sequeira, AF, Cardoso, JS, Tremoco, J, Lourenco, M, Serra, S, Cermeno, E, Ivanovska, M, Batagelj, B, Kronovsek, A, Peer, P, Struc, V, "SYN-MAD 2022: Competition on Face Morphing Attack Detection Based on Privacy-aware Synthetic Training Data", 2022 IEEE INTERNATIONAL JOINT CONFERENCE ON BIOMETRICS (IJCB), vol.abs/2208.07337, 2022

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14. Maia, D, Coelho, A, Ricardo, M, "Obstacle-aware On-demand 5G Network using a Mobile Robotic Platform", International Conference on Wireless and Mobile Computing, Networking and Communications, vol.2022-October, 2022

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18. Mosiichuk, V, Viana, P, Oliveira, T, Rosado, L, "Automated Adequacy Assessment of Cervical Cytology Samples Using Deep Learning", PATTERN RECOGNITION AND IMAGE ANALYSIS (IBPRIA 2022), vol.13256, pp.156-170, 2022

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INTERNATIONAL JOINT CONFERENCE ON COMPUTER VISION, IMAGING AND COMPUTER GRAPHICS THEORY AND APPLICATIONS (VISAPP), VOL 5, 2022

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29. Silva, P, Pereira, T, Teixeira, M, Silva, F, Oliveira, HP, "On the way for the best imaging features from CT images to predict EGFR Mutation Status in Lung Cancer", 44th Annual International Conference of the IEEE Engineering in Medicine & Biology Society, EMBC 2022, Glasgow, Scotland, United Kingdom, July 11-15, 2022, pp.2659-2662, 2022
30. Silva, W, Carvalho, M, Mavioso, C, Cardoso, MJ, Cardoso, JS, "Deep Aesthetic Assessment and Retrieval of Breast Cancer Treatment Outcomes", PATTERN RECOGNITION AND IMAGE ANALYSIS (IBPRIA 2022), vol.13256, pp.108-118, 2022
31. Sousa, LM, Paulino, N, Ferreira, JC, Bispo, J, "A Flexible HLS Hoeffding Tree Implementation for Runtime Learning on FPGA", 2022 IEEE 21ST MEDITERRANEAN ELECTROTECHNICAL CONFERENCE (IEEE MELECON 2022), vol.abs/2112.01875, 2022
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Books

Blank

Chapter/Paper in Books

1. Rodrigues, ASF, Lopes, RP, Teixeira, LF, “Classification of Facial Expressions Under Partial Occlusion for VR Games", Optimization, Learning Algorithms and Applications, pp.804-819, 2022

Publications (Editor)

1. Pinho, AJ, Georgieva, P, Teixeira, LF, Sánchez, JA, "Pattern Recognition and Image Analysis - 10th Iberian Conference, IbPRIA 2022, Aveiro, Portugal, May 4-6, 2022, Proceedings", IbPRIA, vol.13256, 2022
2. Reyes, M, Abreu, PH, Cardoso, JS, "Interpretability of Machine Intelligence in Medical Image Computing - 5th International Workshop, iMIMIC 2022, Held in Conjunction with MICCAI 2022, Singapore, Singapore, September 22, 2022, Proceedings", iMIMIC@MICCAI, vol.13611, 2022

Dissertations (PhD)

1. Gomes, R., "Digital Polar Transmitters for Emerging Wireless Communications”
2. Pinto, J., “Seamless Multimodal Biometrics for Continuous Personalised Wellbeing Monitoring"
3. Pires de Oliveira, S., “Cancer diagnosis in digital pathology: learning from label scarcity”
4. Silva, W., “Deep Aesthetic Assessment of Breast Cancer Surgery Outcomes”
5. Teixeira, J., “An anatomical breast atlas: automatic segmentation of key points in multiple radiological modalities”

10.2 CAP – ACTIVITY RESULTS IN 2022

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 2022 participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-2022
Integrated HR	Core Research Team	Employees	10	11	15	4
		Academic Staff	8	8	8	
		Grant Holders and Trainees	18	11	19	8
		Total Core Researchers	**36**	**30**	**42**	**12**
		Total Core PhD	**15**	**16**	**19**	**3**
	Affiliated Researchers		5	5	3	-2
	Administrative and Technical Employees		1	1	1	
		Total Integrated HR	**42**	**36**	**46**	**10**
		Total Integrated PhD	**20**	**20**	**20**	

Table 10.2.2 - CAP - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	289	191	120	-71
PN-PICT	National R&D Programmes - S&T Integrated Projects	22	1		-1
PN-COOP	National Cooperation Programmes with Industry		46	201	154
PUE-FP	EU Framework Programmes	211	260	206	-54
PUE-DIV	EU Cooperation Programmes - Other	38	47	5	-42
SERV-NAC	R&D Services and Consulting - National	46	-3	43	46
SERV-INT	R&D Services and Consulting - International	4	17	64	47
OP	Other Funding Programmes		9	21	12
	Total Funding	**610**	**567**	**659**	**92**

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

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	20	42	25
Indexed Conferences	4	8	13
Books			
Book Chapters			
Concluded PhD Theses - Members		2	1
Concluded PhD Theses – Supervised		4	1

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

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		2	1
Technology Disclosures (TDF)	2	1	2
First Priority Patent Applications (New inventions)	2	3	1
First Patents Internationalisation		1	2
First Patents Granted		1	
Commercial Contracts (Licences, Options, Assigments)			1
Spin-offs established			
Spin-offs in development	1	1	1

Table 10.2.5 - CAP - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	4
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	1
Participation in events such as fairs, exhibitions or similar	0
Conferences, workshops and scientific sessions organised by the Centre	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	20
Advanced training courses organised by the Centre	0

Table 10.2.6 - CAP - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	FLAPSYS	Pedro Jorge	01/03/2018	28/02/2022
PN-FCT	ENDOR	Orlando Frazão	01/06/2018	31/12/2021
PN-FCT	GreenNanoSensing	Ariel Guerreiro	01/07/2018	30/06/2022
PN-FCT	MYTAG	Pedro Jorge	01/01/2022	01/01/2025
PN-COOP	SMARTFARM40-1	Rui Costa Martins	01/07/2020	30/06/2023
PN-COOP	CorkSurf	Pedro Jorge	01/07/2020	30/06/2023
PN-COOP	CaVaLi	Nuno Azevedo Silva	01/07/2020	30/06/2023
PUE-FP	INSite-1	Pedro Jorge	01/01/2020	31/12/2022
PUE-FP	WiPTherm	Orlando Frazão	01/11/2019	30/06/2023
PUE-FP	EUSCORES-1	Luís Carlos Coelho	01/09/2021	31/08/2025
SERV-NAC	OpTweezers	Ireneu Dias	01/11/2019	31/03/2022
SERV-NAC	DFOSREN	Ireneu Dias	01/10/2021	01/10/2022
SERV-NAC	GREENPEG2	Ireneu Dias	01/10/2022	31/12/2022
SERV-INT	LIRA	Orlando Frazão	01/11/2021	01/05/2023
OP	SMARTCAP	Orlando Frazão	01/02/2022	01/02/2025

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. Arcadio, F, Seggio, M, Del Prete, D, Buonanno, G, Mendes, J, Coelho, LCC, Jorge, PAS, Zeni, L, Bossi, AM, Cennamo, N, "A Plasmonic Biosensor Based on Light-Diffusing Fibers Functionalized with Molecularly Imprinted Nanoparticles for Ultralow Sensing of Proteins", NANOMATERIALS, vol.12, pp.1400, 2022
2. Cardoso, MP, Silva, AO, Romeiro, AF, Giraldi, MTR, Costa, JCWA, Santos, JL, Baptista, JM, Guerreiro, A, "Tunable Plasmonic Resonance Sensor Using a Metamaterial Film in a D-Shaped Photonic Crystal Fiber for Refractive Index Measurements", APPLIED SCIENCES-BASEL, vol.12, pp.2153, 2022
3. Cardoso, VHR, Caldas, P, Giraldi, MTR, Fernandes, CS, Frazao, O, Costa, JCWA, Santos, JL, "A Simple Optical Sensor Based on Multimodal Interference Superimposed on Additive Manufacturing for Diameter Measurement", SENSORS, vol.22, pp.4560, 2022
4. Cardoso, VHR, Caldas, P, Giraldi, MTR, Frazao, O, Costa, JCWA, Santos, JL, "Optical Strain Gauge Prototype Based on a High Sensitivity Balloon-like Interferometer and Additive Manufacturing", SENSORS, vol.22, pp.7652, OCT, 2022
5. Dias, B, Carvalho, J, Mendes, JP, Almeida, JMMM, Coelho, LCC, "Analysis of the Relative Humidity Response of Hydrophilic Polymers for Optical Fiber Sensing", POLYMERS, vol.14, pp.439, 2022

6. Dias, B, de Almeida, JMMM, Coelho, LCC, "Long-Period Fiber Gratings Coated with Poly(ethylene glycol) as Relative Humidity Sensors", U.Porto Journal of Engineering, vol.8, pp.2-6, 2022
7. Dias, B, Mendes, JPS, de Almeida, JMMM, Coelho, LCC, "Simple Optical Fiber Interferometer for Dynamic Measurement of Refractive Index and Thickness of Polymer Films", IEEE SENSORS JOURNAL, vol.22, pp.11732-11739, 2022
8. Dos Santos, PSS, de Almeida, JMMM, Coelho, LCC, "Study of LSPR Spectral Analysis Techniques on SPR Optical Fiber Sensors", U.Porto Journal of Engineering, vol.8, pp.12-17, 2022
9. Ferreira, MFS, Capela, D, Silva, NA, Goncalves, F, Lima, A, Guimaraes, D, Jorge, PAS, "Comprehensive comparison of linear and non-linear methodologies for lithium quantification in geological samples using LIBS", SPECTROCHIMICA ACTA PART B-ATOMIC SPECTROSCOPY, vol.195, SEP, 2022
10. Ferreira, MFS, Silva, NA, Guimarães, D, Martins, RC, Jorge, PAS, "Effects of Pulse Duration in Laser-induced Breakdown Spectroscopy", U.Porto Journal of Engineering, vol.8, pp.7-11, 20224. Cardoso, VHR, Caldas, P, Giraldi, MTR, Frazao, O, Costa, JCWA, Santos, JL, "Optical Strain Gauge Prototype Based on a High Sensitivity Balloon-like Interferometer and Additive Manufacturing", SENSORS, vol.22, pp.7652, OCT, 2022
11. Ferreira, TD, Rocha, V, Silva, D, Guerreiro, A, Silva, NA, "Towards the experimental observation of turbulent regimes and the associated energy cascades with paraxial fluids of light", NEW JOURNAL OF PHYSICS, 2022
12. Ferreira, TD, Silva, NA, Guerreiro, A, "Nematic Liquid Crystals as a Tabletop Platform for Studying Turbulence", U.Porto Journal of Engineering, vol.8, pp.42-47, 2022
13. Ivanov, OV, Caldas, P, Rego, G, "High Sensitivity Cryogenic Temperature Sensors Based on Arc-Induced Long-Period Fiber Gratings", SENSORS, vol.22, pp.7119, OCT, 2022
14. Maia, JM, Viveiros, D, Amorim, VA, Marques, PVS, "Femtosecond laser micromachining of suspended silica-core liquid-cladding waveguides inside a microfluidic channel", OPTICS AND LASERS IN ENGINEERING, vol.154, 2022
15. Martins, RC, Barroso, TG, Jorge, P, Cunha, M, Santos, F, "Unscrambling spectral interference and matrix effects in Vitis vinifera Vis-NIR spectroscopy: Towards analytical grade 'in vivo' sugars and acids quantification", COMPUTERS AND ELECTRONICS IN AGRICULTURE, vol.194, pp.106710, 2022
16. Mendes, JP, Coelho, LCC, Jorge, PAS, Pereira, CM, "Differential Refractometric Biosensor for Reliable Human IgG Detection: Proof of Concept", BIOSENSORS-BASEL, vol.12, pp.515, JUL, 2022
17. Perez-Herrera, RA, Soares, L, Silva, S, Frazao, O, "Ring Cavity Erbium-Doped Fiber for Refractive Index Measurements", SENSORS, vol.22, pp.9315, 2022
18. Robalinho, P, Melo, M, Frazao, O, Ribeiro, ABL, "Temperature-Monitored Fibre Optic Current Sensor Using Channelled-Spectrum Analysis", IEEE PHOTONICS TECHNOLOGY LETTERS, pp.1-1, 2022
19. Rodrigues, AV, Monteiro, C, Silva, SO, Linhares, C, Mendes, H, Tavares, SMO, Frazão, O, "Brief Review on Optical Fiber Sensing for the Power Grid", U.Porto Journal of Engineering, vol.8, pp.18-23, 2022
20. Rodrigues, AV, Reis, J, Martins, AJM, Monteiro, CS, Silva, SO, Caridade, CMR, Tavares, SO, Frazao, O, "Cavity length dependence on strain sensitivity for Fabry-Perot sensors", MICROWAVE AND OPTICAL TECHNOLOGY LETTERS, 2022Monteiro, CS, Raposo, M, Ribeiro, PA, Silva, SO, Frazao, O, "Tuning of Fiber Optic Surface Reflectivity through Graphene Oxide-Based Layer-by-Layer Film Coatings", Photonics, vol.7, pp.11, 2020
21. Silva N.A., Capela D., Ferreira M., Gonçalves F., Lima A., Guimarães D., Jorge P.A.S., "Towards robust calibration models for laser-induced breakdown spectroscopy using unsupervised clustered regression techniques", Results in Optics, pp.100245, 2022
22. Silva, D, Monteiro, CS, Silva, SO, Frazao, O, Pinto, JV, Raposo, M, Ribeiro, PA, Serio, S, "Sputtering Deposition of TiO2 Thin Film Coatings for Fiber Optic Sensors", PHOTONICS, vol.9, pp.342, 2022

23. Soares, B, Robalinho, P, Guerreiro, A, Frazao, O, "Resilience to Passive Attacks of a Secure Key Distribution System Based on an Ultra-Long Fiber Laser Using a Bi-Directional EDFA", PHOTONICS, vol.9, pp.825, 2022

24. Tosin, R, Martins, R, Pocas, I, Cunha, M, "Canopy VIS-NIR spectroscopy and self-learning artificial intelligence for a generalised model of predawn leaf water potential in Vitis vinifera", BIOSYSTEMS ENGINEERING, vol.219, pp.235-258, 2022

25. Vasconcelos, HCASG, de Almeida, JMMM, Mendes, JP, Dias, B, Jorge, PAD, Saraiva, CMT, Coelho, LCC, "Optical Biosensor for the Detection of Biogenic Amines", IEEE SENSORS JOURNAL, pp.1-1, 2022

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1. Araújo, JCC, Dias, B, Dos Santos, PSS, De Almeida, JMMM, Coelho, LCC, "Development of a Low-Cost Interrogation System Using a MEMS Fabry-Pérot Tunable Filter", Journal of Physics: Conference Series, vol.2407, pp.012008, 2022

2. Cavaco, R, Rodrigues, P, Lopes, T, Capela, D, Ferreira, MFS, Jorge, PAS, Silva, NA, "Listening plasmas in Laser-Induced Breakdown Spectroscopy", Journal of Physics: Conference Series, vol.2407, pp.012018, 2022

3. Coutinho, F, Teixeira, J, Rocha, V, Oliveira, J, Jorge, PAS, Silva, NA, "Autonomous Optical Tweezers: From automatic trapping to single particle analysis", Journal of Physics: Conference Series, vol.2407, pp.012025, 2022

4. Da Silva, PM, Mendes, JP, Coelho, LCC, De Almeida, JMMM, "Optical fiber sensors for monitoring cement paste carbonation", Journal of Physics: Conference Series, vol.2407, pp.012038, 2022

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7. Ferreira, TD, Silva, NA, Silva, D, Rosa, CC, Guerreiro, A, "Reservoir computing with nonlinear optical media", Journal of Physics: Conference Series, vol.2407, 2022

8. Lopes, T, Cavaco, R, Rodrigues, P, Ferreira, J, Capela, D, Ferreira, MFS, Jorge, PAS, Silva, NA, "Multimodal approach to mineral identification: Merging Laser-induced breakdown spectroscopy with Hyperspectral imaging", Journal of Physics: Conference Series, vol.2407, pp.012053, 2022

9. Mendes, JP, Coelho, LCC, Pereira, CM, Jorge, PAS, "Differential Refractometric Platform for Reliable Biosensing based on Long-period Gratings and Molecular Imprinting", Optics InfoBase Conference Papers, 2022

10. Rodrigues, P, Lopes, T, Cavaco, R, Capela, D, Ferreira, MFS, Jorge, PAS, Silva, NA, "Integrating Laser-induced breakdown spectroscopy and photogrammetry towards 3D element mapping", Journal of Physics: Conference Series, vol.2407, pp.012046, 2022

11. Teixeira, J, Rocha, V, Oliveira, J, Jorge, PAS, Silva, NA, "Towards real-time identification of trapped particles with UMAP-based classifiers", Journal of Physics: Conference Series, vol.2407, pp.012043, 2022

12. Vasconcelos, H, De Almeida, JMMM, Mendes, J, Dias, B, Jorge, PAS, Saraiva, C, Coelho, LCC, "Optical Fiber Sensor for the Detection of Decarboxylation Products of Amino Acids", Optics InfoBase Conference Papers, 2022

13. Vasconcelos, H, Matias, A, Mendes, J, Arahjo, J, Dias, B, Jorge, PAS, Saraivaa, C, Coelho, LCC, de Almeida, JMMM, "Optical biosensor for the detection of low concentrations of hydrogen peroxide in milk samples", OPTICAL SENSING AND DETECTION VII, vol.12139, 2022

Books

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Chapter/paper in Books

Blank

Publications (Editor)

Blank

Dissertations (PhD)

1. Vasconcelos, H., " Development of optical biosensors for monitoring the deterioration of fresh meat and fish”

10.3 CRAS – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	18	20	24	4
		Academic Staff	12	12	12	
		Grant Holders and Trainees	32	38	35	-3
		Total Core Researchers	**62**	**70**	**71**	**1**
		Total Core PhD	**16**	**16**	**17**	**1**
	Affiliated Researchers				1	1
	Administrative and Technical Employees		3	4	3	-1
	Total Integrated HR		**65**	**74**	**75**	**1**
	Total Integrated PhD		**16**	**16**	**16**	

Table 10.3.2 - CRAS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	507	355	543	188
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	210	328	469	141
PUE-FP	EU Framework Programmes	767	950	1 791	841
PUE-DIV	EU Cooperation Programmes – Other	124	262	149	-113
SERV-NAC	R&D Services and Consulting – National	73	30	89	59
SERV-INT	R&D Services and Consulting - International	222	312	128	-185
OP	Other Funding Programmes	28	1		-1
	Total Funding	**1 932**	**2 239**	**3 169**	**930**

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

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	11	16	18
Indexed Conferences	21	21	22
Books		1	1
Book Chapters	2	1	4
Concluded PhD Theses - Members	1		
Concluded PhD Theses – Supervised	1		1

Table 10.3.4 - CRAS - Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		3	1
Technology Disclosures (TDF)			1
First Priority Patent Applications (New Inventions)			1
First Patents Internationalisation			
First Patents Granted			1
Commercial Contracts (Licences, Options, Assigments)			
Spin-offs established		1	
Spin-offs in development	1		

Table 10.3.5 - CRAS - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	15
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	16
Participation in events such as fairs, exhibitions or similar	14
Conferences, workshops and scientific sessions organised by the Centre	10
Participants in the conferences, workshops and scientific sessions organised by the Centre	370
Advanced training courses organised by the Centre	0

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	31/12/2022
PN-FCT	EMSO-PT	Aníbal Matos	01/07/2017	30/06/2023
PN-FCT	DIIUS	Andry Maykol Pinto	26/07/2018	25/07/2022
PN-FCT	QuALTOS	Nuno Cruz	01/01/2020	31/12/2022
PN-FCT	Connect2Oceans	Alfredo Martins	20/03/2021	19/03/2024
PN-COOP	HiperSea	Eduardo Silva	01/07/2018	30/09/2022
PN-COOP	NESSIE	Aníbal Matos	01/01/2019	31/05/2023
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
PN-COOP	Drivolution	André Dias	01/09/2022	01/09/2025
PN-COOP	NewSpacePortugal	Diana Viegas	01/10/2022	31/12/2025
PN-COOP	NEXUS-1	José Miguel Almeida	01/10/2022	31/12/2025
PUE-DIV	PROTOATLANTIC	Eduardo Silva	01/11/2017	30/06/2023
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	SHIELD	Hugo Miguel Silva	01/09/2020	30/04/2023
PUE-DIV	FLYPASS	Bruno Miguel Ferreira	06/06/2022	01/01/2024
PUE-DIV	SEAWINGS	José Miguel Almeida	01/12/2022	31/05/2026
PUE-FP	SPRING	Aníbal Matos	01/08/2019	31/07/2023
PUE-FP	DEEPFIELD	Hugo Miguel Silva	01/10/2019	30/09/2023
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	MAGPIE-2	Diana Viegas	01/10/2021	01/10/2026
PUE-FP	FIRELOGUE	Hugo Miguel Silva	01/11/2021	31/10/2025
PUE-FP	TIMREX	Ana Cristina Pires	01/01/2022	31/12/2024
PUE-FP	OVERWATCH	Hugo Miguel Silva	01/11/2022	31/10/2025
SERV-NAC	EDIDPMiricle	José Miguel Almeida	01/09/2022	01/11/2023
SERV-NAC	ASM_research2022	Alfredo Martins	01/12/2022	28/02/2023
SERV-INT	PORT XXI	Aníbal Matos	15/11/2020	31/05/2022
SERV-INT	KRISO_2022	José Miguel Almeida	01/01/2022	01/01/2023
SERV-INT	SUMO_PPI_072022	José Miguel Almeida	01/09/2022	31/12/2022
SERV-INT	AECUD_2	José Miguel Almeida	01/12/2022	28/02/2023

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

10.3.2 List of Publications

International Journals with Scientific Referees

1. Agostinho, LR, Ricardo, NM, Pereira, MI, Hiolle, A, Pinto, AM, "A Practical Survey on Visual Odometry for Autonomous Driving in Challenging Scenarios and Conditions", IEEE ACCESS, vol.10, pp.72182-72205, 2022
2. Campos, DF, Matos, A, Pinto, AM, "Modular Multi-Domain Aware Autonomous Surface Vehicle for Inspection", IEEE ACCESS, vol.10, pp.113355-113375, 2022
3. Campos, TD, Barbosa, MLS, Olmos, AAR, Martins, M, Pereira, FAM, De Moura, MFSF, Zille, A, Dourado, N, "Fracture characterisation of bone-cement bonded joints under mode I loading", THEORETICAL AND APPLIED FRACTURE MECHANICS, vol.120, pp.103404, 2022
4. Carneiro, JF, Pinto, JB, de Almeida, FG, Cruz, NA, "Design and Experimental Tests of a Buoyancy Change Module for Autonomous Underwater Vehicles", ACTUATORS, vol.11, pp.254, SEP, 2022
5. Dinis, H, Rocha, J, Matos, T, Goncalves, LM, Martins, M, "The Challenge of Long-Distance Over-the-Air Wireless Links in the Ocean: A Survey on Water-to-Water and Water-to-Land MIoT Communication", APPLIED SCIENCES-BASEL, vol.12, pp.6439, 2022
6. Duarte, DF, Pereira, MI, Pinto, AM, "Multiple Vessel Detection in Harsh Maritime Environments", MARINE TECHNOLOGY SOCIETY JOURNAL, vol.56, pp.58-67, 2022
7. Faria, CL, Martins, MS, Matos, T, Lima, R, Miranda, JM, Goncalves, LM, "Underwater Energy Harvesting to Extend Operation Time of Submersible Sensors", SENSORS, vol.22, pp.1341, FEB, 2022
8. Fernandes, RDV, Melro, L, Padrao, J, Ribeiro, AI, Mehravani, B, Monteiro, F, Pereira, E, Martins, MS, Dourado, N, Zille, A, "Active Neutralizing Mats for Corrosive Chemical Storage", GELS, vol.8, pp.489, AUG, 2022
9. Ferreira, A, Almeida, J, Martins, A, Matos, A, Silva, E, "3DupIC: An Underwater Scan Matching Method for Three-Dimensional Sonar Registration", SENSORS, vol.22, pp.3631, 2022
10. Freitas, S, Silva, H, Silva, E, "Hyperspectral Imaging Zero-Shot Learning for Remote Marine Litter Detection and Classification", REMOTE SENSING, vol.14, pp.5516, 2022
11. Garcia-Mendez, S, Leal, F, Malheiro, B, Burguillo-Rial, JC, Veloso, B, Chis, AE, Gonzalez-Velez, H, "Simulation, modelling and classification of wiki contributors: Spotting the good, the bad, and the ugly", SIMULATION MODELLING PRACTICE AND THEORY, pp.102616, 2022
12. Leal, F, Veloso, B, Malheiro, B, Burguillo, JC, Chis, AE, Gonzalez Velez, H, "Stream-based explainable recommendations via blockchain profiling", INTEGRATED COMPUTER-AIDED ENGINEERING, vol.29, pp.105-121, 2022
13. Matos, T, Rocha, JL, Faria, CL, Martins, MS, Henriques, R, Goncalves, LM, "Development of an automated sensor for in-situ continuous monitoring of streambed sediment height of a waterway", SCIENCE OF THE TOTAL ENVIRONMENT, vol.808, pp.152164, 2022
14. Padrao, J, Nicolau, T, Felgueiras, HP, Calcada, C, Veiga, MI, Osorio, NS, Martins, MS, Dourado, N, Taveira-Gomes, A, Ferreira, F, Zille, A, "Development of an Ultraviolet-C Irradiation Room in a Public Portuguese Hospital for Safe Re-Utilization of Personal Protective Respirators", INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH, vol.19, pp.4854, APR, 2022
15. Pereira, PNDAD, Campilho, RDSG, Pinto, AMG, "Application of a Design for Excellence Methodology for a Wireless Charger Housing in Underwater Environments", MACHINES, vol.10, pp.232, APR, 2022
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2. Caruso, BC, Stenstkie, C, van Duivenboden, D, Starosta, J, Hoernschemeyer, J, Peytard, S, Malheiro, B, Ribeiro, C, Justo, J, Silva, MF, Ferreira, P, Guedes, P, "Smart Pedestrian Crossing - An EPS@ISEP 2020 Project", MOBILITY FOR SMART CITIES AND REGIONAL DEVELOPMENT - CHALLENGES FOR HIGHER EDUCATION, VOL 1, vol.389 LNNS, pp.141-152, 2022
3. Carvalho, D, Martins, A, Almeida, JM, Silva, E, "A SMACC based mission control system for autonomous underwater vehicles", Oceans Conference Record (IEEE), 2022
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7. Gaspar, AR, Nunes, A, Matos, A, “Limit Characterization for Visual Place Recognition in Underwater Scenes”, ROBOT 2022, 2022
8. Graça, PA, Alves, JC, Ferreira, BM, "Multi-Objective optimization of Sensor Placement in a 3D Body for Underwater Localization", Oceans Conference Record (IEEE), vol.2022-October, 2022
9. Leal, F, Garcia-Mendez, S, Malheiro, B, Burguillo, JC, "Explanation Plug-In for Stream-Based Collaborative Filtering", INFORMATION SYSTEMS AND TECHNOLOGIES, WORLDCIST 2022, VOL 1, pp.42-51, 2022
10. Lima, AP, Hernandez, HM, Giannoumis, J, O'Suilleabhain, D, OReilly, A, Heward, M, Presse, P, Santana, M, Falcon, JG, Silva, E, "ProtoAtlantic: Innovation in the Marine Environment in the Atlantic Area Region", OCEANS 2022, 2022
11. Martins M.S., Cruz N.A., Silva A., Ferreira B., Zabel F., Matos T., Jesus S.M., Pinto A., Pereira E., Matos A., Faria C., Tieppo M., Goncalves L.M., Rocha J., Faria J., "Network nodes for ocean data exchange through submarine fiber optic cable repeaters", Oceans Conference Record (IEEE), vol.2022-October, 2022
12. Matos T., Rocha J.L., Dinis H., Faria C.L., Martins M.S., Henriques R., Goncalves L.M., "A low-cost, low-power and low-size multi-parameter station for real-time and online monitoring of the coastal area", Oceans Conference Record (IEEE), vol.2022-October, 2022
13. Oliveira, AJ, Ferreira, BM, Cruz, NA, "Real-time Wall Identification for Underwater Mapping using Imaging Sonar", Oceans Conference Record (IEEE), vol.2022-October, 2022
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Chapter/Paper in Books

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Publications (Editor)

Blank

Dissertations (PhD)

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10.4 C-BER – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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 – C-BER - Research team composition

Type of Human Resources			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	5	4	4	
		Academic Staff	6	5	6	1
		Grant Holders and Trainees	11	14	15	1
		Total Core Researchers	**22**	**23**	**25**	**2**
		Total Core PhD	**9**	**8**	**8**	
	Affiliated Researchers		1	1	1	
	Administrative and Technical Employees		1	1	1	
		Total Integrated HR	**24**	**25**	**27**	**2**
		Total Integrated PhD	**9**	**9**	**9**	

Table 10.4.2 – C-BER - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes - FCT	153	95	76	-19
PN-PICT	National R&D Programmes - S&T Integrated Projects				0
PN-COOP	National Cooperation Programmes with Industry	28	98	80	-18
PUE-FP	EU Framework Programmes			38	38
PUE-DIV	EU Cooperation Programmes - Other				0
SERV-NAC	R&D Services and Consulting - National	35	24	23	-1
SERV-INT	R&D Services and Consulting - International			21	21
OP	Other Funding Programmes		2	6	4
	Total Funding	**216**	**218**	**244**	**26**

Table 10.4.3 – C-BER - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	28	23	31
Indexed Conferences	18	34	20
Books			
Book Chapters			1
Concluded PhD Theses - Members		2	1
Concluded PhD Theses – Supervised		2	

Table 10.4.4 – C-BER - Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		3	3
Technology Disclosures (TDF)	3	3	5
First Priority Patent Applications (New inventions)	2	1	2
First Patents Internationalisation		1	
First Patents Granted	1	2	
Commercial Contracts (Licences, Options, Assignments)		3	
Spin-offs established			
Spin-offs in development	2	2	2

Table 10.4.5 – C-BER - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	5
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	
International events in which INESC TEC members participate in the program committees	14
Participation in events such as fairs, exhibitions or similar	
Conferences, workshops and scientific sessions organised by the Centre	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	50
Advanced training courses organised by the Centre	

Table 10.4.6 – C-BER - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	THOR	Miguel Coimbra	01/03/2021	29/02/2024
PN-FCT	CAGED	Miguel Coimbra	01/03/2021	29/02/2024
PN-COOP	TAMI-1	Aurélio Campilho	01/04/2020	31/03/2023
PN-COOP	AgWearCare	Duarte Filipe Dias	01/08/2021	30/06/2023
PUE-FP	FIRE_RES-1	Duarte Filipe Dias	01/12/2021	01/12/2025
SERV-NAC	iHandU_v2	João Paulo Cunha	28/07/2021	31/03/2022
SERV-NAC	iHandUApp	Duarte Filipe Dias	01/09/2021	30/11/2022
SERV-NAC	Bio_Support	Duarte Filipe Dias	01/08/2021	30/11/2022
SERV-INT	iProcureSecurity	Duarte Filipe Dias	01/10/2022	01/05/2024
OP	C4MiR_BIP_Proof	Miguel Velhote Correia	01/09/2020	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

10.4.2 List of Publications

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Books

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Chapter/Paper in Books

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Blank

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10.5 CPES – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	28	39	50	11
		Academic Staff	9	10	10	
		Grant Holders and Trainees	42	33	39	6
		Total Core Researchers	**79**	**82**	**99**	**17**
		Total Core PhD	**25**	**25**	**29**	**4**
	Affiliated Researchers		7	7	5	1
	Administrative and Technical Employees		3	2	3	1
		Total Integrated HR	**64**	**88**	**107**	**19**
		Total Integrated PhD	**32**	**29**	**29**	

Table 10.5.2 - CPES – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	246	179	117	-62
PN-PICT	National R&D Programmes - S&T Integrated Projects		44	77	32
PN-COOP	National Cooperation Programmes with Industry	25	367	527	161
PUE-FP	EU Framework Programmes	1 693	1 648	2 034	385
PUE-DIV	EU Cooperation Programmes – Other		8	60	52
SERV-NAC	R&D Services and Consulting – National	802	850	956	106
SERV-INT	R&D Services and Consulting - International	131	123	27	-96
OP	Other Funding Programmes	157	11	180	168
	Total Funding	**3 055**	**3230**	**3 978**	**748**

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

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	113	97	112
Indexed Conferences	60	85	31
Books	1		
Book Chapters	7	3	2
Concluded PhD Theses - Members	3	4	3
Concluded PhD Theses – Supervised	4	6	4

Table 10.5.4 - CPES – Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		5	2
Technology Disclosures (TDF)	12		
First Priority Patent Applications (New inventions)	2		
First Patents Internationalisation	2	1	
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			

Table 10.5.5 - CPES – Summary of participation in dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	9
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	5
International events in which INESC TEC members participate in the program committees	6
Participation in events such as fairs, exhibitions or similar	3
Conferences, workshops and scientific sessions organised by the Centre	10
Participants in the conferences, workshops and scientific sessions organised by the Centre	1 156
Advanced training courses organised by the Centre	2

Table 10.5.6 – CPES - List of projects

List of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	SGEVL	Luís Seca	01/07/2017	31/03/2022
PN-PICT	DECARBONIZE	David Emanuel Rua	01/01/2021	30/06/2023
PN-COOP	NEXTSTEP	Clara Sofia Gouveia	01/12/2016	30/11/2021
PN-COOP	GPDER	Ricardo Jorge Bessa	01/08/2019	30/06/2023
PN-COOP	BATERIAS2030	Clara Sofia Gouveia	01/07/2020	30/06/2023
PN-COOP	CITYCATALIST	Filipe Joel Soares	01/07/2020	30/06/2023
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	01/01/2021	30/06/2023
PN-COOP	SmartGlow	Clara Sofia Gouveia	01/04/2021	30/06/2023
PN-COOP	RN21	Zenaida Mourão	01/07/2022	31/12/2025
PUE-DIV	ASPRELASUSTENTAVEL	Alexandre Lucas	15/05/2021	15/05/2024
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	01/06/2023
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	31/03/2024
PUE-FP	POCITYF	Justino Miguel Rodrigues	01/10/2019	30/09/2024
PUE-FP	ATTEST	Filipe Joel Soares	01/03/2020	31/08/2023
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	OpenInnoTrain	Luís Seca	01/01/2019	30/06/2024
PUE-FP	EUSCORES	Bernardo Silva	01/09/2021	31/08/2025
PUE-FP	MAGPIE	Zenaida Mourão	01/10/2021	01/10/2026
PUE-FP	GREENH2ATLANTIC	João Peças Lopes	01/12/2021	30/11/2027
PUE-FP	ENERSHARE	Ricardo Jorge Bessa	01/07/2022	30/06/2025
PUE-FP	BeFlex	Ricardo Jorge Bessa	01/09/2022	31/08/2026
PUE-FP	Every1	Alexandre Lucas	01/11/2022	30/04/2026
SERV-NAC	EFACEC-DMS	Jorge Correia Pereira	15/04/2001	31/12/2030
SERV-NAC	INFRA_PT	João Peças Lopes	20/07/2017	31/12/2022
SERV-NAC	AO_Perdas	Luís Seca	01/01/2018	31/03/2022
SERV-NAC	SmartClima	David Emanuel Rua	15/01/2020	07/03/2022
SERV-NAC	IoT4Distribuicao	Clara Sofia Gouveia	04/01/2021	28/02/2023
SERV-NAC	Telemetry4Water	Eric Zanghi	06/10/2021	22/07/2022
SERV-NAC	MORADIST	Leonel Magalhães Carvalho	01/02/2021	31/12/2025
SERV-NAC	TapadaOuteiroH2	João Peças Lopes	15/04/2021	30/03/2022
SERV-NAC	iELFOS	Ricardo Jorge Bessa	01/05/2021	18/03/2022
SERV-NAC	ContFreq_ServSis	João Peças Lopes	01/06/2021	07/09/2022
SERV-NAC	FaultPredict	Justino Miguel Rodrigues	01/06/2021	30/11/2022
SERV-NAC	Perfis_Perdas_2022	José Nuno Fidalgo	31/05/2021	10/02/2022
SERV-NAC	GridImp_PV_AO	Bernardo Silva	01/09/2021	24/02/2022
SERV-NAC	redesISOL_AO	Bernardo Silva	30/09/2021	24/02/2022
SERV-NAC	Pontas_Modelo	José Nuno Fidalgo	01/09/2021	15/10/2022
SERV-NAC	PV_BESS_Sizing	Carlos Moreira	01/09/2021	25/03/2022
SERV-NAC	LossPD_MT	José Nuno Fidalgo	01/09/2021	18/05/2022
SERV-NAC	Liga_CVER	Carlos Moreira	01/10/2021	06/06/2022

List of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	Fin_Losses	Filipe Joel Soares	01/10/2021	31/12/2023
SERV-NAC	WF_OVER_EQUIP	Bernardo Silva	01/10/2021	27/04/2022
SERV-NAC	CampusREN2022	João Peças Lopes	01/12/2021	30/09/2022
SERV-NAC	SGMRVFX	Jorge Correia Pereira	15/01/2022	08/08/2022
SERV-NAC	PV_Lagoa2	Bernardo Silva	01/03/2022	30/12/2022
SERV-NAC	PV_LAJES_PICO	Bernardo Silva	01/02/2022	30/12/2022
SERV-NAC	PV_VELAS_SJorge	Bernardo Silva	15/02/2022	30/12/2022
SERV-NAC	PV_Horta_Faial	Bernardo Silva	15/02/2022	30/12/2022
SERV-NAC	RAA_SA_2023_2033	Leonel Magalhães Carvalho	01/02/2022	01/11/2022
SERV-NAC	PERSA_2022	Ricardo Jorge Bessa	01/05/2022	27/06/2022
SERV-NAC	CSF_PESSEGUEIRO	Bernardo Silva	01/04/2022	01/10/2022
SERV-NAC	Wind_curteil_soft_3	Leonel Magalhães Carvalho	01/03/2022	30/09/2022
SERV-NAC	SmartGas	João Peças Lopes	20/03/2022	20/09/2023
SERV-NAC	Pinhal_Perdas	Filipe Joel Soares	01/04/2022	01/08/2022
SERV-NAC	TechMeter	David Emanuel Rua	18/04/2022	18/01/2023
SERV-NAC	WIND_FARM_REPOWER	Leonel Magalhães Carvalho	01/06/2022	01/11/2022
SERV-NAC	H2IND	Zenaida Mourão	01/07/2022	31/12/2023
SERV-NAC	Tarif_Ref_Mad	João Tomé Saraiva	02/05/2022	13/07/2022
SERV-NAC	CER_Reg	José Villar	27/06/2022	22/09/2022
SERV-NAC	WF_Terceira	Bernardo Silva	01/09/2022	01/01/2023
SERV-NAC	ConsultGrid4Water	Eric Zanghi	20/07/2022	21/09/2022
SERV-NAC	EEDIMarinha	Luís Seca	07/04/2022	31/10/2022
SERV-NAC	Perfis_Perdas_2023	José Nuno Fidalgo	23/05/2022	31/01/2023
SERV-NAC	ELFOS_maintenance	José Ricardo Andrade	01/10/2022	01/10/2023
SERV-NAC	PROTEnerN	João Peças Lopes	02/07/2022	30/05/2023
SERV-INT	PV_Pombal_ENER	Bernardo Silva	01/02/2021	01/04/2022
SERV-INT	CleanEU_Island	João Peças Lopes	01/03/2021	01/05/2023
SERV-INT	PV_POMBAL_REQUIP	Bernardo Silva	15/07/2022	15/11/2022
SERV-INT	VIATEXT	Ricardo Jorge Bessa	01/11/2021	23/03/2022
SERV-INT	Helas_ExtremeRES	Ricardo Jorge Bessa	06/10/2022	30/05/2023
OP	Sustainable HPC	Ricardo Jorge Bessa	01/07/2021	30/06/2023
OP	PSCC2022	João Peças Lopes	01/06/2020	31/01/2023
INT	Lab_redes_eletricas	Justino Miguel Rodrigues	01/01/2014	

Type of Project:

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

10.5.2 List of publications

International Journals with Scientific Referees

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10.6 CESE – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	21	22	27	5
		Academic Staff	4	4	6	2
		Grant Holders and Trainees	16	14	11	-3
		Total Core Researchers	**41**	**40**	**44**	**4**
		Total Core PhD	**13**	**14**	**16**	**2**
	Affiliated Researchers		9	8	9	1
	Administrative and Technical Employees		2	2	2	
		Total Integrated HR	**52**	**50**	**55**	**5**
		Total Integrated PhD	**21**	**22**	**22**	

Table 10.6.2 - CESE - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	159	126	130	4
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	388	521	918	397
PUE-FP	EU Framework Programmes	473	440	533	93
PUE-DIV	EU Cooperation Programmes – Other			1	1
SERV-NAC	R&D Services and Consulting – National	342	272	347	75
SERV-INT	R&D Services and Consulting - International	2	40	37	-3
OP	Other Funding Programmes		1		-1
	Total Funding	**1 363**	**1 400**	**1 967**	**567**

Table 10.6.3 - CESE - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	17	15	19
Indexed Conferences	20	39	31
Books		1	
Book Chapters		6	2
Concluded PhD Theses - Members	2		
Concluded PhD Theses – Supervised	2	1	

Table 10.6.4 - CESE - Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		4	1
Technology Disclosures (TDF)	2	1	8
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)	2		
Spin-offs established			
Spin-offs in development			

Table 10.6.5 – CESE - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	3
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	8
Participation in events such as fairs, exhibitions or similar	4
Conferences, workshops and scientific sessions organised by the Centre	8
Participants in the conferences, workshops and scientific sessions organised by the Centre	200
Advanced training courses organised by the Centre	1

Table 10.6.6 – CESE - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	opti-MOVES	Tânia Daniela Fontes	26/07/2018	31/01/2022
PN-FCT	StoSS	Ana Maria Rodrigues	15/10/2018	14/10/2022
PN-FCT	FuturePharma	Jorge Pinho de Sousa	29/03/2021	28/03/2024
PN-FCT	eLOG	Tânia Daniela Fontes	01/01/2022	30/06/2023
PN-COOP	PRODUTECH_SIF	António Correia Alves	01/10/2017	30/09/2022
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	Reinaldo Silva Gomes	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	01/05/2021	30/06/2023
PN-COOP	SADCoPQ	António Correia Alves	22/05/2021	30/06/2023
PN-COOP	OnlineAIOps	Hugo Miguel Ferreira	18/01/2021	30/06/2023
PN-COOP	Zypho 4.0	Paulo Sá Marques	01/05/2021	30/06/2023
PN-COOP	DEO	Filipa Rente Ramalho	01/07/2021	30/06/2023
PN-COOP	BE@T-1	César Toscano	01/07/2022	31/12/2025
PN-COOP	BioShoes4All	Rui Diogo Rebelo	01/07/2022	31/12/2025
PUE-DIV	MANUFACTUR4.0-1	Ana Cristina Barros	17/04/2017	31/12/2020
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	CircThread	António Lucas Soares	01/06/2021	31/05/2025
PUE-FP	EIT_RIS_Hubs_2021	Vasco Bernardo Teles	01/01/2021	31/12/2022
PUE-FP	iFishCan	Rui Correia Dias	01/01/2021	31/12/2022
PUE-FP	MAGPIE-1	António Henrique Almeida	01/10/2021	01/10/2026
PUE-FP	ConFacts	Ana Cristina Simões	01/01/2022	31/12/2022
PUE-FP	IESMA_SSchool	Ana Cristina Simões	01/01/2022	31/12/2022
PUE-FP	GreenAPS	Gustavo Dalmarco	01/01/2022	31/12/2022
PUE-FP	SoTecInFactory	Gustavo Dalmarco	01/06/2022	31/05/2025
PUE-FP	Demo4Green	Ana Cristina Simões	01/01/2022	31/12/2022
PUE-FP	TECH2MARKET-1	Vasco Bernardo Teles	01/01/2022	31/12/2022
PUE-FP	ReSChape	Ricardo Augusto Zimmermann	01/10/2022	30/09/2025
PUE-FP	TF_Competition-1	Ana Cristina Simões	01/10/2022	31/12/2022
SERV-NAC	MESPARTNERSHIP	Luís Guardão	25/11/2020	25/01/2026
SERV-NAC	APSPARTNERSHIP	Luís Guardão	15/11/2020	15/01/2026
SERV-NAC	GBYPLN_EVO	Luís Guardão	01/03/2021	30/03/2022
SERV-NAC	OptiLog	Rui Diogo Rebelo	12/04/2021	28/03/2022

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	BCSSelection	Luís Guardão	18/05/2021	27/05/2022
SERV-NAC	Observador_AUTO	António Lucas Soares	01/04/2021	15/06/2022
SERV-NAC	SSPM	Luís Guardão	04/02/2021	30/09/2022
SERV-NAC	JCRroadmap	António Correia Alves	30/09/2021	30/01/2022
SERV-NAC	SIACEDV_A_OAZEMEIS	Rui Diogo Rebelo	29/09/2021	29/03/2023
SERV-NAC	CORKMES2	Rui Diogo Rebelo	15/11/2021	15/03/2022
SERV-NAC	ACCAGCI2	Filipe David Ferreira	12/10/2021	12/01/2022
SERV-NAC	ACCDS	Filipe David Ferreira	12/10/2021	12/01/2022
SERV-NAC	SIACEDV_A_FEIRA	Rui Diogo Rebelo	29/09/2021	29/03/2023
SERV-NAC	DTNARR	Filipe David Ferreira	14/01/2022	10/05/2022
SERV-NAC	FORM_I40	Rui Diogo Rebelo	10/03/2022	31/03/2022
SERV-NAC	ECOSSISTEMA	Rui Diogo Rebelo	28/02/2022	28/02/2023
SERV-NAC	DTNARR3PROC	Rui Diogo Rebelo	01/07/2022	01/03/2023
SERV-NAC	Fundicao4	Rui Diogo Rebelo	15/06/2022	15/07/2022
SERV-NAC	PFAI4_3ed	Américo Azevedo	04/05/2022	04/07/2022
SERV-NAC	VOXPOP	Jorge Pinho de Sousa	10/05/2022	31/12/2022
SERV-NAC	KT2022	Filipe David Ferreira	15/08/2022	31/12/2022
SERV-NAC	DIGI4PLAST	António Correia Alves	01/10/2022	01/04/2023
SERV-INT	DT4PV-1	Luís Lima	22/03/2021	31/12/2022
OP	EurOMA Grant 2020	Ricardo Augusto Zimmermann	01/12/2020	31/12/2022

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

10.6.2 List of publications

International Journals with Scientific Referee

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2. Fernandes, JMRC, Homayouni, SM, Fontes, DBMM, "Energy-Efficient Scheduling in Job Shop Manufacturing Systems: A Literature Review", SUSTAINABILITY, vol.14, pp.6264, MAY, 2022
3. Fontes, DBMM, Homayouni, SM, Resende, MGC, "Job-shop scheduling-joint consideration of production, transport, and storage/retrieval systems", JOURNAL OF COMBINATORIAL OPTIMIZATION, vol.44, 2022
4. Guimaraes, LR, de Sousa, JP, Prata, BD, "Variable fixing heuristics for the capacitated multicommodity network flow problem with multiple transport lines, a heterogeneous fleet and time windows", Transportation Letters-The International Journal of Transportation Research, pp.1-10, 2022

5. Marchisotti, G, Filho, J, Franca, S, Domingos, M, Junior, V, Toledo, R, Alves, C, Castro, H, Putnik, G, "THE SOCIAL REPRESENTATION OF THE GOVERNANCE SYSTEM THROUGH KEY DESCRIPTORS: MUTE ZONE?", INTERNATIONAL JOURNAL FOR QUALITY RESEARCH, vol.16, pp.595-612, 2022
6. Marchisotti, G, Rodrigues, J, Franca, S, Toledo, R, Castro, H, Alves, C, Putnik, G, "HYBRID GOVERNANCE SYSTEM VALUE PERCEPTION MODEL", INTERNATIONAL JOURNAL FOR QUALITY RESEARCH, vol.16, pp.261-278, 2022
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9. Pais, A, Ferreira, C, Pires, V, Silva, V, Alves, JL, Bastos, J, Belinha, J, "3D printed devices to avoid hand contact with commonly shared surfaces", INTERNATIONAL JOURNAL OF INTERACTIVE DESIGN AND MANUFACTURING - IJIDEM, 2022
10. Paiva, S, Amaral, A, Goncalves, J, Lima, R, Barreto, L, "Image Recognition-Based Architecture to Enhance Inclusive Mobility of Visually Impaired People in Smart and Urban Environments", SUSTAINABILITY, vol.14, pp.11567, 2022
11. Petropoulos, F, Apiletti, D, Assimakopoulos, V, Babai, MZ, Barrow, DK, Ben Taieb, S, Bergmeir, C, Bessa, RJ, Bijak, J, Boylan, JE, Browell, J, Carnevale, C, Castle, JL, Cirillo, P, Clements, MP, Cordeiro, C, Oliveira, FLC, De Baets, S, Dokumentov, A, Ellison, J, Fiszeder, P, Franses, PH, Frazier, DT, Gilliland, M, Gonul, MS, Goodwin, P, Grossi, L, Grushka Cockayne, Y, Guidolin, M, Guidolin, M, Gunter, U, Guo, XJ, Guseo, R, Harvey, N, Hendry, DF, Hollyman, R, Januschowski, T, Jeon, J, Jose, VRR, Kang, YF, Koehler, AB, Kolassa, S, Kourentzes, N, Leva, S, Li, F, Litsiou, K, Makridakis, S, Martin, GM, Martinez, AB, Meeran, S, Modis, T, Nikolopoulos, K, Onkal, D, Paccagnini, A, Panagiotelis, A, Panapakidis, I, Pavia, JM, Pedio, M, Pedregal, DJ, Pinson, P, Ramos, P, Rapach, DE, Reade, JJ, Rostami Tabar, B, Rubaszek, M, Sermpinis, G, Shang, HL, Spiliotis, E, Syntetos, AA, Talagala, PD, Talagala, TS, Tashman, L, Thomakos, D, Thorarinsdottir, T, Todini, E, Arenas, JRT, Wang, XQ, Winkler, RL, Yusupova, A, Ziel, F, "Forecasting: theory and practice", INTERNATIONAL JOURNAL OF FORECASTING, vol.38, pp.705-871, 2022
12. Pinto, A, Sousa, S, Simoes, A, Santos, J, "A Trust Scale for Human-Robot Interaction: Translation, Adaptation, and Validation of a Human Computer Trust Scale", HUMAN BEHAVIOR AND EMERGING TECHNOLOGIES, vol.2022, 2022
13. Santos, AD, Castro, H, "Housing and Setting Constraints: The Portuguese Evidence", SUSTAINABILITY, vol.14, pp.11720, 2022
14. Senna, PP, Ferreira, LMDF, Barros, AC, Roca, JB, Magalhaes, V, "Prioritizing barriers for the adoption of industry 4.0 technologies", COMPUTERS & INDUSTRIAL ENGINEERING, pp.108428, 2022
15. Silva, MTDE, Azevedo, A, "Self-adapting WIP parameter setting using deep reinforcement learning", COMPUTERS & OPERATIONS RESEARCH, vol.144, 2022
16. Simoes, AC, Pinto, A, Santos, J, Pinheiro, S, Romero, D, "Designing human-robot collaboration (HRC) workspaces in industrial settings: A systematic literature review", JOURNAL OF MANUFACTURING SYSTEMS, vol.62, pp.28-43, JAN, 2022
17. Sousa, C, Teixeira, D, Carneiro, D, Nunes, D, Novais, P, "Knowledge-based decision intelligence in street lighting management", INTEGRATED COMPUTER-AIDED ENGINEERING, pp.1-19, 2022
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International Conference Proceedings with Scientific Referees

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2. Cardoso, JL, Rebentisch, E, Rhodes, DH, Soares, A, "Adapting Concept of Operations Analysis for Digital Transformation", Advances in Transdisciplinary Engineering, 2022
3. Castro, H, Costa, F, Ferreira, L, Avila, P, Putnik, GD, Cruz Cunha, M, "Data Science for Industry 4.0: A Literature Review on Open Design Approach", Procedia Computer Science, vol.204, 2022
4. Costa, D, Santos, AS, Bastos, JA, Madureira, AM, Brito, MF, "A Tool for Air Cargo Planning and Distribution", INNOVATIONS IN BIO-INSPIRED COMPUTING AND APPLICATIONS, IBICA 2021, vol.419, pp.78-87, 2022
5. Diniz, F, Duarte, N, Amaral, A, Pereira, C, "Industry 4.0: Individual Perceptions About Its Nine Technologies", Lecture Notes in Information Systems and Organisation, vol.53, pp.1-11, 2022
6. Duarte, N, Pereira, C, Carneiro, D, "DIGITAL MATURITY: AN OVERVIEW APPLIED TO THE MANUFACTURING INDUSTRY IN THE REGION OF TAMEGA E SOUSA, PORTUGAL", 12TH INTERNATIONAL SCIENTIFIC CONFERENCE BUSINESS AND MANAGEMENT 2022, pp.546-555, 2022
7. Enrique, DV, Soares, AL, "Cognitive Digital Twin Enabling Smart Product-Services Systems: A Literature Review", IFIP Advances in Information and Communication Technology, vol.662 IFIP, pp.77-89, 2022
8. Fagundes, PB, de Macedo, DDJ, Soares, AL, "Application and Evaluation of a Taxonomy in the Context of Software Requirements Management", Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST, vol.452 LNICST, pp.163-177, 2022
9. Faria, BS, Simoes, AC, Rodrigues, JC, "Impact of Governmental Support for the Implementation of Industry 4.0 in Portugal", INNOVATIONS IN INDUSTRIAL ENGINEERING, pp.108-120, 2022
10. Fernandes, G, Lucas, P, Simoes, AC, Dalmarco, G, "P2B Methodology: from patents to business", 2022 IEEE 28th International Conference on Engineering, Technology and Innovation, ICE/ITMC 2022 and 31st International Association for Management of Technology, IAMOT 2022 Joint Conference - Proceedings, 2022
11. Ferreira, AR, Soares, Â, Santos, AS, Bastos, JA, Varela, LR, "Analysis and Comparison of DABC and ACO in a Scheduling Problem", Lecture Notes in Mechanical Engineering, pp.203-215, 2022
12. Gama, LF, Simoes, AC, "Scrum's Methodology adaptations to meet the teleworking needs experienced by Software Development Teams", 2022 IEEE 28th International Conference on Engineering, Technology and Innovation, ICE/ITMC 2022 and 31st International Association for Management of Technology, IAMOT 2022 Joint Conference - Proceedings, 2022
13. Gomes, M, Oliveira, B, Sousa, C, "Enriching Legal Knowledge Through Intelligent Information Retrieval Techniques: A Review", PROGRESS IN ARTIFICIAL INTELLIGENCE, EPIA 2022, pp.119-130, 2022
14. Jorio, M, Amaral, A, Neto, T, "COMPARATIVE ANALYSIS OF BUILDING'S SUSTAINABLE ASSESSMENT SYSTEMS: AN OVERVIEW", TECHNOLOGIES, MARKETS AND POLICIES: BRINGING TOGETHER ECONOMICS AND ENGINEERING, pp.550-555, 2022
15. Jorio, M, Amaral, A, Neto, T, "THE IMPORTANCE OF CREATING SUSTAINABLE HABITATS TOWARDS ENSURING A SMOOTH TRANSITION TO A SUSTAINABLE CITY - RIO DE JANEIRO CASE STUDY", TECHNOLOGIES, MARKETS AND POLICIES: BRINGING TOGETHER ECONOMICS AND ENGINEERING, pp.518-523, 2022
16. Machado, F, Duarte, N, Amaral, A, Araujo, M, "DIGITAL TRANSFORMATION IN MANUFACTURING SMEs: A BIBLIOMETRIC ANALYSIS USING VOSviewer", 12TH INTERNATIONAL SCIENTIFIC CONFERENCE BUSINESS AND MANAGEMENT 2022, pp.627-633, 2022

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19. Öztürk, E, Rocha, P, Sousa, F, Lima, M, Rodrigues, AM, Ferreira, JS, Nunes, AC, Lopes, C, Oliveira, C, "An Application of Preference-Inspired Co-Evolutionary Algorithm to Sectorization", Lecture Notes in Mechanical Engineering, pp.257-268, 2022

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21. Rebentisch E.S., Soares A.L., Rhodes D.H., Zimmermann R.A., Cardoso J.L.F.P., "On the use of sociotechnical systems design in industry: digital transformation processes and artifacts", CEUR Workshop Proceedings, vol.3239, pp.85-98, 2022

22. Ribeiro, J, Tavares, J, Fontes, T, "Real-Time Detection of Vehicle-Based Logistics Operations", INTELLIGENT TRANSPORT SYSTEMS (INTSYS 2021), pp.192-205, 2022

23. Romanciuc, V, Lopes, C, Teymourifar, A, Rodrigues, AM, Ferreira, JS, Oliveira, C, Ozturk, EG, "An Integer Programming Approach to Sectorization with Compactness and Equilibrium Constraints", INNOVATIONS IN INDUSTRIAL ENGINEERING, pp.185-196, 2022

24. Sequeiros, JA, Silva, R, Santos, AS, Bastos, J, Varela, MLR, Madureira, AM, "A Novel Discrete Particle Swarm Optimization Algorithm for the Travelling Salesman Problems", INNOVATIONS IN INDUSTRIAL ENGINEERING, pp.48-55, 2022

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26. Silva, H, Moreno, T, Almeida, A, Soares, AL, Azevedo, A, “A digital twin platform-based approach to product lifecycle management: Towards a transformer 4.0”, Lecture Notes in Mechanical Engineering, pp.14-25, JUN, 2022

27. Simoes, AC, Mendes, JT, Rodrigues, JC, "The Impact of Industry 4.0 Paradigm on the Pharmaceutical Industry in Portugal", INNOVATIONS IN INDUSTRIAL ENGINEERING, pp.406-419, 2022

28. Tavares, J, Ribeiro, J, Fontes, T, "Detection of vehicle-based operations from geolocation data", Transportation Research Procedia, vol.62, pp.341-349, 2022

29. Teymourifar, A, Rodrigues, AM, Ferreira, JS, Lopes, C, "A Comparison Between Optimization Tools to Solve Sectorization Problem", Lecture Notes in Networks and Systems, vol.363 LNNS, pp.40-50, 2022

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Books

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1. Homayouni, SM, Fontes, DBMM, "Energy-Efficient Scheduling of Intraterminal Container Transport", Springer Optimization and Its Applications, vol.181, 2022

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Dissertations (PhD)

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10.7 CRIIS – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	13	15	19	4
		Academic Staff	12	16	13	-3
		Grant Holders and Trainees	22	24	33	9
		Total Core Researchers	**47**	**55**	**65**	**10**
		Total Core PhD	**18**	**22**	**20**	**-2**
	Affiliated Researchers		6	2	3	1
	Administrative and Technical Employees		2	2	2	
		Total Integrated HR	**55**	**59**	**70**	**11**
		Total Integrated PhD	**23**	**24**	**24**	

Table 10.7.2 - CRIIS – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	269	-14	5	19
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	48	182	510	328
PUE-FP	EU Framework Programmes	535	604	780	176
PUE-DIV	EU Cooperation Programmes - Other	17	9	19	11
SERV-NAC	R&D Services and Consulting - National	113	365	236	-129
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	4	4	4	
	Total Funding	**986**	**1 149**	**1 554**	**405**

Table 10.7.3 – CRIIS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	37	50	42
Indexed Conferences	52	58	33
Books	1		
Book Chapters		2	2
Concluded PhD Theses - Members		2	
Concluded PhD Theses – Supervised	1	3	3

Table 10.7.4 - CRIIS – Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		7	1
Technology Disclosures (TDF)	7	3	
First Priority Patent Applications (New inventions)	1	1	
First Patents Internationalisation			1
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)	1		
Spin-offs established			
Spin-offs in development			

Table 10.7.5 - CRIIS – Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	7
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	4
International events in which INESC TEC members participate in the program committees	8
Participation in events such as fairs, exhibitions or similar	5
Conferences, workshops and scientific sessions organised by the Centre	7
Participants in the conferences, workshops and scientific sessions organised by the Centre	250
Advanced training courses organised by the Centre	

Table 10.7.6 - CRIIS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	COBOTIS	António Paulo Moreira	01/06/2018	31/05/2022
PN-FCT	OmicBots	Mário Cunha	16/01/2022	16/01/2025
PN-COOP	CrossLOG-2	Manuel Santos Silva	01/11/2019	30/06/2023
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	02/01/2021	30/06/2023
PN-COOP	SMARTCUT	Filipe Neves Santos	01/12/2020	30/06/2023
PN-COOP	InOlive-1	Filipe Neves Santos	01/09/2021	30/06/2023
PN-COOP	SMARTDRYING	Filipe Neves Santos	01/07/2021	30/06/2023
PN-COOP	Continental FoF-2	António Paulo Moreira	01/07/2020	30/06/2023
PN-COOP	Zypho 4.0-1	António Valente	01/05/2021	30/06/2023
PN-COOP	BE@T	Luís Freitas Rocha	01/07/2022	31/12/2025
PN-COOP	BioShoes4All-2	Luís Freitas Rocha	01/07/2022	31/12/2025
PN-COOP	Hi_reV	Luís Freitas Rocha	01/01/2022	31/12/2025
PN-COOP	GreenAuto	Manuel Santos Silva	03/10/2022	31/12/2025
PN-COOP	Vine & Wine PT	Filipe Neves Santos	11/10/2022	10/10/2025
PUE-DIV	MANUFACTUR4.0	Luís Freitas Rocha	17/04/2017	31/12/2020
PUE-FP	AgRoBoFood	Filipe Neves Santos	01/06/2019	31/05/2023
PUE-FP	DEMETER	Filipe Neves Santos	01/09/2019	31/08/2023
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	NOVATERRA	Filipe Neves Santos	01/10/2020	30/09/2024
PUE-FP	PRySM	Filipe Neves Santos	01/05/2020	10/02/2022
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	iFishCan-1	Rafael Lírio Arrais	01/01/2021	31/12/2022
PUE-FP	AI4RWeld	Luís Freitas Rocha	17/01/2022	17/10/2022
PUE-FP	Waste2BioComp	Germano Veiga	01/06/2022	31/05/2025
PUE-FP	IMMC	Marcelo Petry	01/01/2022	31/12/2022
PUE-FP	TF_Competition	Marcelo Petry	01/10/2022	31/12/2022
SERV-NAC	Smart-Fertilizers	Filipe Neves Santos	01/01/2019	31/01/2023
SERV-NAC	SMARTPVD	Hélio Mendonça	01/10/2019	31/03/2022
SERV-NAC	ROBOCARE	Filipe Neves Santos	01/03/2020	31/01/2023
SERV-NAC	RDH4COVID	Héber Miguel Sobreira	17/10/2020	31/12/2022
SERV-NAC	VINCI7D	Manuel Santos Silva	01/09/2020	01/09/2023
SERV-NAC	SIAP	Joaquim João Sousa	24/07/2020	30/06/2022
SERV-NAC	BRAINY	Luís Freitas Rocha	01/09/2021	01/10/2022
SERV-NAC	FORM_I40-2	Germano Veiga	10/03/2022	31/03/2022
SERV-NAC	Fundicao4-1	Germano Veiga	15/06/2022	15/07/2022
SERV-NAC	PFAI4_3ed-3	Germano Veiga	04/05/2022	04/07/2022
SERV-NAC	Vision2Control	Luís Freitas Rocha	01/10/2022	01/01/2023
SERV-NAC	FARO	António Paulo Moreira	01/10/2022	30/06/2023
SERV-NAC	Lever_AdDP	Joaquim João Sousa	07/12/2022	06/01/2023
OP	SAFE	António Valente	01/01/2019	31/05/2022

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

10.7.2 List of publications

International Journals with Scientific Referees

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2. Aguiar, AS, dos Santos, FN, Sobreira, H, Boaventura Cunha, J, Sousa, AJ, "Localization and Mapping on Agriculture Based on Point-Feature Extraction and Semiplanes Segmentation From 3D LiDAR Data", FRONTIERS IN ROBOTICS AND AI, vol.9, 2022
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4. Carneiro, PMR, Ferreira, JAF, Kholkin, AL, dos Santos, MPS, "Towards Self-Adaptability of Instrumented Electromagnetic Energy Harvesters", MACHINES, vol.10, JUN, 2022
5. Cerqueira, S, Campelos, MR, Leite, A, Pires, EJS, Pereira, LT, Diniz, H, Sampaio, S, Figueiredo, A, Alve, R, "How can we predict the kidney graft failure of Portuguese patients?", REVISTA DE NEFROLOGIA DIALISIS Y TRASPLANTE, vol.42, pp.189-198, 2022
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7. Coutinho, RM, Sousa, A, Santos, F, Cunha, M, "Contactless Soil Moisture Mapping Using Inexpensive Frequency-Modulated Continuous Wave RADAR for Agricultural Purposes", APPLIED SCIENCES-BASEL, vol.12, pp.5471, 2022
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9. Da Silva, DQ, dos Santos, FN, Filipe, V, Sousa, AJ, Oliveira, PM, "Edge AI-Based Tree Trunk Detection for Forestry Monitoring Robotics", ROBOTICS, vol.11, pp.136, 2022
10. de Souza, JPC, Amorim, AM, Rocha, LF, Pinto, VH, Moreira, AP, "Industrial robot programming by demonstration using stereoscopic vision and inertial sensing", INDUSTRIAL ROBOT-THE INTERNATIONAL JOURNAL OF ROBOTICS RESEARCH AND APPLICATION, vol.ahead-of-print, 2022
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12. Guo, YH, Chen, SZ, Li, XX, Cunha, M, Jayavelu, S, Cammarano, D, Fu, YS, "Machine Learning-Based Approaches for Predicting SPAD Values of Maize Using Multi-Spectral Images", REMOTE SENSING, vol.14, pp.1337, MAR, 2022
13. Jurado Rodriguez, D, Jurado, JM, Pauda, L, Neto, A, Munoz Salinas, R, Sousa, JJ, "Semantic segmentation of 3D car parts using UAV-based images", COMPUTERS & GRAPHICS-UK, vol.107, pp.93-103, 2022

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27. Padua, L, Bernardo, S, Dinis, LT, Correia, C, Moutinho Pereira, J, Sousa, JJ, "The Efficiency of Foliar Kaolin Spray Assessed through UAV-Based Thermal Infrared Imagery", REMOTE SENSING, vol.14, pp.4019, 2022

28. Padua, L, Matese, A, Di Gennaro, SF, Morais, R, Peres, E, Sousa, JJ, "Vineyard classification using OBIA on UAV-based RGB and multispectral data: A case study in different wine regions", COMPUTERS AND ELECTRONICS IN AGRICULTURE, vol.196, pp.106905, 2022

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2. Berger, GS, Júnior, AO, Braun, J, Lima, J, Pinto, MF, Valente, A, Pereira, AI, Cantieri, AR, Wehrmeister, MA, “Sensorial Testbed for High-Voltage Tower Inspection with UAVs”, ROBOT 2022: Fifth Iberian Robotics Conference - Advances in Robotics, Volume 1, Zaragoza, Spain, 23-25 November 2022, vol.590, pp.353-364, 2022

3. Boaventura-Cunha, J, Ferreira, J, "Dynamic Modelling of a Thermal Solar Heating System", INNOVATIONS IN BIO-INSPIRED COMPUTING AND APPLICATIONS, IBICA 2021, vol.419, pp.743-750, 2022

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21. Oliveira, PBD, Soares, F, Cardoso, A, "Pocket-Sized Portable Labs: Control Engineering Practice Made Easy in Covid-19 Pandemic Times", IFAC PAPERSONLINE, 2022
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32. Teixeira, AC, Ribeiro, J, Neto, A, Morais, R, Sousa, JJ, Cunha, A, "Using Deep Learning for Detection and Classification of Insects on Traps", International Geoscience and Remote Sensing Symposium (IGARSS), 2022
33. Ventuzelos, V, Leão, G, Sousa, A, “Teaching ROS1/2 and Reinforcement Learning using a Mobile Robot and its Simulation”, ROBOT 2022: Fifth Iberian Robotics Conference - Advances in Robotics, Volume 1, Zaragoza, Spain, 23-25 November 2022, vol.589, pp.566-598, 2022

Books

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Chapter/Paper in Books

1. de Castro Pereira, S, Solteiro Pires, EJ, B. de Moura Oliveira, P, "A Hybrid Approach GABC-LS to Solve mTSP", Optimization, Learning Algorithms and Applications, pp.520-532, 2022
2. Gomes, B, Torres, J, Sobral, P, Sousa, A, Reis, LP, "Stereo Based 3D Perception for Obstacle Avoidance in Autonomous Wheelchair Navigation", ROBOT2022: Fifth Iberian Robotics Conference - Lecture Notes in Networks and Systems, pp.321-332, 2022

Publications (Editor)

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Dissertations (PhD)

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10.8 CEGI – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	10	6	7	1
		Academic Staff	15	18	19	1
		Grant Holders and Trainees	28	24	24	
		Total Core Researchers	**53**	**48**	**50**	**2**
		Total Core PhD	**28**	**26**	**26**	
	Affiliated Researchers		7	6	5	-1
	Administrative and Technical Employees		1	1	1	
	Total Integrated HR		**61**	**55**	**56**	**1**
	Total Integrated PhD		**34**	**32**	**32**	

Table 10.8.2 – CEGI – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes - FCT	317	297	107	-190
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	23	39	98	60
PUE-FP	EU Framework Programmes	191	267	478	211
PUE-DIV	EU Cooperation Programmes - Other	20	3	11	8
SERV-NAC	R&D Services and Consulting - National	148	119	137	19
SERV-INT	R&D Services and Consulting - International	3			
OP	Other Funding Programmes		2		-2
Total Funding		**702**	**725**	**832**	**107**

Table 10.8.3 - CEGI – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	31	37	55
Indexed Conferences	20	8	11
Books		1	
Book Chapters	3	2	4
Concluded PhD Theses - Members	4	4	7
Concluded PhD Theses – Supervised	5	5	10

Table 10.8.4- CEGI – Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)			2
Technology Disclosures (TDF)	1		1
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)	1		
Spin-offs established			
Spin-offs in development			

Table 10.8.5 - CEGI – Summary of participation in dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	27
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	9
Participation in events such as fairs, exhibitions or similar	
Conferences, workshops and scientific sessions organised by the Centre	2
Participants in the conferences, workshops and scientific sessions organised by the Centre	28
Advanced training courses organised by the Centre	3

Table 10.8.6 - CEGI – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
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	opti-MOVES-1	Teresa Galvão	26/07/2018	31/01/2022
PN-FCT	PLASMA 4 COVID	Sofia Cruz Gomes	01/07/2020	01/06/2021
PN-FCT	BeFresh	Pedro Amorim	01/01/2022	31/12/2024
PN-COOP	TRF4p0-1	Luís Guimarães	01/07/2020	01/07/2023
PN-COOP	Replant-1	Pedro Amorim	01/07/2020	30/06/2023
PN-COOP	AI4PV-1	Luís Guimarães	01/07/2021	30/06/2023
PN-COOP	SmartPV	Luís Guimarães	01/01/2021	30/06/2023
PN-COOP	DIGITALCER-1	Mário Amorim Lopes	01/01/2021	30/06/2023
PN-COOP	Produtech R3-1	António Galrão Ramos	01/09/2022	31/12/2025
PUE-DIV	WINDEXT-1	Luís Guimarães	01/01/2020	31/12/2022
PUE-FP	MANU-SQUARE-1	Mário Amorim Lopes	01/01/2018	30/06/2021
PUE-FP	XFLEX_HIDRO-1	Armando Leitão	01/09/2019	31/08/2023
PUE-FP	POCITYF-1	Lia Patrício	01/10/2019	30/09/2024
PUE-FP	TRUSTAI	Gonçalo Reis Figueira	01/10/2020	31/03/2025
PUE-FP	EUSCORES-2	Luís Guimarães	01/09/2021	31/08/2025
PUE-FP	OpenInnoTrain-1	Ana Viana	01/01/2019	30/06/2024
SERV-NAC	BEST_ORDER_II	Mário Amorim Lopes	20/10/2021	25/03/2022
SERV-NAC	SolIM62010	Vera Miguéis	15/11/2021	14/06/2022
SERV-NAC	DRIVEN	Gonçalo Reis Figueira	15/12/2021	27/06/2022
SERV-NAC	FORM_I40-1	Gonçalo Reis Figueira	10/03/2022	31/03/2022
SERV-NAC	BestOrder3	Mário Amorim Lopes	01/03/2022	01/01/2023

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

10.8.2 List of publications

International Journals with Scientific Referees

1. Adot, E, Akhmedova, A, Alvelos, H, Barbosa Pereira, S, Berbegal Mirabent, J, Cardoso, S, Domingues, P, Franceschini, F, Domenech, D, Machado, R, Maisano, DA, Marimon, F, Mas Machuca, M, Mastrogiacomo, L, Melo, A, Migueis, V, Rosa, MJJ, Sampaio, P, Torrents, D, Xambre, AR, “SMART-QUAL: a dashboard for quality measurement in higher education institutions”, INTERNATIONAL JOURNAL OF QUALITY & RELIABILITY MANAGEMENT”, dez, 2022
2. Ali, S, Ramos, AG, Carravilla, MA, Oliveira, JF, "On-line three-dimensional packing problems: A review of off-line and on-line solution approaches", COMPUTERS & INDUSTRIAL ENGINEERING, vol.168, pp.108122, 2022

3. Barbosa, F, Rampazzo, PCB, de Azevedo, AT, Yamakami, A, "The impact of time windows constraints on metaheuristics implementation: a study for the Discrete and Dynamic Berth Allocation Problem", APPLIED INTELLIGENCE, 2022

4. Borges, J, "VisAC: An interactive tool for visual analysis of consanguinity in the ancestry of individuals", INFORMATION VISUALIZATION, pp.147387162210963, 2022

5. Boto, JM, Marreiros, A, Diogo, P, Pinto, E, Mateus, MP, "Health behaviours as predictors of the Mediterranean diet adherence: a decision tree approach", PUBLIC HEALTH NUTRITION, 2022

6. Boto, JM, Rocha, A, Migueis, V, Meireles, M, Neto, B, "Sustainability Dimensions of the Mediterranean Diet: A Systematic Review of the Indicators Used and Its Results", ADVANCES IN NUTRITION, 2022

7. Camanho, A, Barbosa, F, Henriques, A, "A system-level optimization framework for efficiency and effectiveness improvement of wastewater treatment plants", INTERNATIONAL TRANSACTIONS IN OPERATIONAL RESEARCH, 2022

8. Cambra-Fierro, J, Gao, L, Melero-Polo, I, Patricio, L, "Theories, constructs, and methodologies to study COVID-19 in the service industries", SERVICE INDUSTRIES JOURNAL, vol.42, pp.551-582, 2022

9. Carvalho, M, Lodi, A, Pedroso, JP, "Computing equilibria for integer programming games", EUROPEAN JOURNAL OF OPERATIONAL RESEARCH, 2022

10. Clavijo-Buritica N., Triana-Sanchez L., Escobar J.W., "A hybrid modeling approach for resilient agri-supply network design in emerging countries: Colombian coffee supply chain", Socio-Economic Planning Sciences, pp.101431, 2022

11. Cunha, NFT, Curcio, E, Amorim, P, Almada Lobo, B, Grunow, M, “Robust supply chain design with suppliers as system integrators: an aerospace case study”, INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH, vol.22, pp.1-22, 2022

12. Curcio, E, De Lima, VL, Miyazawa, FK, Silva, E, Amorim, P, “The integrated lot-sizing and cutting stock problem under demand uncertainty”, INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH, vol.27, pp.1-27, 2022

13. do Nascimento, DN, Cherri, AC, Oliveira, JF, "The two-dimensional cutting stock problem with usable leftovers: mathematical modelling and heuristic approaches", OPERATIONAL RESEARCH, 2022

14. Duarte, SP, de Sousa, JP, de Sousa, JF, "Rethinking Technology-Based Services to Promote Citizen Participation in Urban Mobility", International Journal of Decision Support System Technology, vol.15, pp.1-20, 2022

15. Ferreira, C, Figueira, G, Amorim, P, "Effective and interpretable dispatching rules for dynamic job shops via guided empirical learning", OMEGA-INTERNATIONAL JOURNAL OF MANAGEMENT SCIENCE, vol.111, SEP, 2022

16. Ferreira, MC, Costa, PD, Abrantes, D, Hora, J, Felicio, S, Coimbra, M, Dias, TG, "Identifying the determinants and understanding their effect on the perception of safety, security, and comfort by pedestrians and cyclists: A systematic review", TRANSPORTATION RESEARCH PART F-TRAFFIC PSYCHOLOGY AND BEHAVIOUR, vol.91, pp.136-163, NOV, 2022

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21. Goncalves, L, Patricio, L, "From smart technologies to value cocreation and customer engagement with smart energy services", ENERGY POLICY, vol.170, NOV, 2022

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23. Henriques, AA, Fontes, M, Camanho, AS, D'Inverno, G, Amorim, P, Silva, JG, "Performance evaluation of problematic samples: a robust nonparametric approach for wastewater treatment plants", ANNALS OF OPERATIONS RESEARCH, 2022

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30. Neves Moreira, F, Almada Lobo, B, Guimaraes, L, Amorim, P, "The multi-product inventory-routing problem with pickups and deliveries: Mitigating fluctuating demand via rolling horizon heuristics", TRANSPORTATION RESEARCH PART E-LOGISTICS AND TRANSPORTATION REVIEW, vol.164, pp.102791, 2022

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48. Santos, AG, Viana, A, Pedroso, JP, "2-echelon lastmile delivery with lockers and occasional couriers", TRANSPORTATION RESEARCH PART E-LOGISTICS AND TRANSPORTATION REVIEW, vol.162, pp.102714, JUN, 2022

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50. Saputro, TE, Figueira, G, Almada Lobo, B, "A comprehensive framework and literature review of supplier selection under different purchasing strategies", COMPUTERS & INDUSTRIAL ENGINEERING, vol.167, 2022

51. Silva M., Pedroso J.P., Viana A., "Stochastic crowd shipping last-mile delivery with correlated marginals and probabilistic constraints", European Journal of Operational Research, 2022

52. Silva, M, Pedroso, JP, "Deep Reinforcement Learning for Crowdshipping Last-Mile Delivery with Endogenous Uncertainty", MATHEMATICS, vol.10, OCT, 2022

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54. Tourinho, M, Santos, PR, Pinto, FT, Camanho, AS, "Performance assessment of water services in Brazilian municipalities: An integrated view of efficiency and access", SOCIO-ECONOMIC PLANNING SCIENCES, pp.101139, 2022

55. van Wees, M, Revilla, BP, Fitzgerald, H, Ahlers, D, Romero, N, Alpagut, B, Kort, J, Tjahja, C, Kaiser, G, Blessing, V, Patricio, L, Smit, S, "Energy Citizenship in Positive Energy Districts— Towards a Transdisciplinary Approach to Impact Assessment", BUILDINGS, vol.12, 2022

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1. Camanho, AS, Tourinho, M, Barbosa, F, Santos, PR, Pinto, FT, "A Non-convex Global Malmquist Index to Compare the Performance of Water Services Among Brazilian Macro-regions", Lecture Notes in Networks and Systems, vol.414 LNNS, pp.219-230, 2022
2. Duarte, P, De Sousa, JP, De Sousa, JF, "Designing urban mobility policies in a socio-technical transition context", Transportation Research Procedia, vol.62, pp.17-24, 2022
3. Felício, S, Hora, J, Ferreira, MC, Abrantes, D, Costa, PD, Dangelo, C, Silva, J, Galvão, T, "Handling OpenStreetMap georeferenced data for route planning", Transportation Research Procedia, vol.62, pp.189-196, 2022
4. Fulgêncio, R, Ferreira, MC, Abrantes, D, Coimbra, M, "Restart: A Route Planner to Encourage the Use of Public Transport Services in a Pandemic Context", Transportation Research Procedia, vol.62, pp.123-130, 2022
5. Lima, L, Pereira, AI, Vaz, C, Ferreira, O, "Mixture Design: Development of a Graphical User Interface for Determining Mixture Parameters", 2022 17TH IBERIAN CONFERENCE ON INFORMATION SYSTEMS AND TECHNOLOGIES (CISTI), vol.2022-June, 2022
6. Mendes, B, Ferreira, MC, Dias, TG, "Tourism as a Service: Enhancing the Tourist Experience", Transportation Research Procedia, vol.62, pp.1-8, 2022
7. Neves, J, Loureiro, A, d'Orey, PM, Migueis, V, Costa, A, Ferreira, M, "Empirical Evaluation of the Performance of Electric Vehicles for Taxi Operation", 2022 IEEE 95TH VEHICULAR TECHNOLOGY CONFERENCE (VTC2022-SPRING), vol.2022-June, pp.1-6, 2022
8. Rocha, P, Ramos, AG, Silva, E, "CrossLog: Automatic Mixed-Palletizing for Cross-Docking Logistics Centers", COMPUTATIONAL LOGISTICS (ICCL 2022), vol.13557, pp.351-365, 2022
9. Rodrigues, N, Sousa, A, Reis, LP, Coelho, A, “Intelligent Wheelchairs Rolling in Pairs Using Reinforcement Learning”, ROBOT 2022
10. Silva, FG, Sena, I, Lima, LA, Fernandes, FP, Pacheco, MF, Vaz, CB, Lima, J, Pereira, AI, "External Climate Data Extraction Using the Forward Feature Selection Method in the Context of Occupational Safety", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), pp.3-14, 2022
11. Vaz, CB, Ferreira, ÂP, "Dynamic Analysis of the Sustainable Performance of Electric Mobility in European Countries", Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), pp.15-28, 2022

Books

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Chapter/Paper in Books

1. Sangiorgi, D, Holmlid, S, Patricio, L, "The Multiple Identities of Service Design in Organizations and Innovation Projects", The Palgrave Handbook of Service Management, pp.497-529, 2022
2. Souza, MEB, Pacheco, AP, Teixeira, JG, "Systematizing experts' risk perception on rural fires resulting from traditional burnings in Portugal: A Mental Model approach", Advances in Forest Fire Research 2022, pp.1520-1525, 2022
3. Souza, MEB, Pacheco, AP, Teixeira, JG, Pereira, JMC, "Designing an effective risk communication plan as a tool to reduce the risk associated with traditional burning practices in Portugal", Advances in Forest Fire Research 2022, pp.1437-1442, 2022
4. Souza, MEB, Teixeira, JG, Pacheco, AP, "Mitigating rural fires through transformative service research: value cocreation with forest-related rural communities", Advances in Forest Fire Research 2022, pp.1709-1713, 2022

Publications (Editor)

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Dissertations (PhD)

1. Andrade, X., “Selecting fast-moving consumer goods product lines”
2. Dias, L., “Leveraging asset management policies with analytics for multi-dependent and heterogeneous multi-asset systems”
3. Falcão e Cunha, N., “Towards Sustainable Product and Supply Chain Development in the Aerospace Industry”
4. Ferreira, C., “Scheduling in Collaborative and Dynamic Environments”
5. Gonçalves, L., “Understanding the customer engagement and the value co-creation with Smart Energy Services”
6. Hora, J., “Public Transport Timetable Synchronization using Optimization Techniques”
7. Soares, R., “New models and methods for the Vehicle Routing Problem with Multiple Synchronisation Constraints”

10.9 CITE – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	5	5	5	
		Academic Staff	2	2	2	
		Grant Holders and Trainees	1	1	1	
		Total Core Researchers	**8**	**8**	**8**	
		Total Core PhD	**4**	**4**	**5**	**1**
	Affiliated Researchers		2	2	2	
	Administrative and Technical Employees					
		Total Integrated HR	**10**	**10**	**10**	
		Total Integrated PhD	**6**	**6**	**6**	

Table 10.9.2 – CITE – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	8			
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry		14	7	-7
PUE-FP	EU Framework Programmes	143	158	331	174
PUE-DIV	EU Cooperation Programmes - Other	19		45	45
SERV-NAC	R&D Services and Consulting - National	53	17	23	6
SERV-INT	R&D Services and Consulting - International		30		-30
OP	Other Funding Programmes				
	Total Funding	**224**	**218**	**406**	**188**

Table 10.9.3 - CITE – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	14	18	15
Indexed Conferences	6	4	6
Books			
Book Chapters	9	9	8
Concluded PhD Theses - Members		1	
Concluded PhD Theses – Supervised		1	

Table 10.9.4- CITE – Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)			
Technology Disclosures (TDF)			
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			

Table 10.9.5 - CITE - Summary of participation in dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	3
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	2
Participation in events such as fairs, exhibitions or similar	2
Conferences, workshops and scientific sessions organised by the Centre	3
Participants in the conferences, workshops and scientific sessions organised by the Centre	70
Advanced training courses organised by the Centre	2

Table 10.9.6 - CITE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-COOP	SMARTHEALTH4ALL	Cristina Machado Guimarães	01/11/2020	30/06/2023
PUE-DIV	EEN2022	Alexandra Xavier	15/01/2022	15/07/2025
PUE-FP	INCLUDING-1	Vasco Amorim	01/08/2019	31/07/2024
PUE-FP	SCORPION-1	Alexandra Xavier	01/01/2021	31/12/2023
PUE-FP	FIRE_RES	Alexandra Xavier	01/12/2021	01/12/2025
PUE-FP	EITJUMPSTART2021	Alexandra Xavier	21/04/2021	31/12/2022
PUE-FP	VR2Care-1	Cristina Machado Guimarães	01/01/2022	31/12/2023
PUE-FP	DivaX	Sara Correia Neves	01/04/2022	31/10/2022
PUE-FP	TECH2MARKET	Alexandra Xavier	01/01/2022	31/12/2022
PUE-FP	Demo4Green-1	Cristina Maria Barbosa	01/01/2022	31/12/2022
PUE-FP	TURING	José Coelho Rodrigues	01/01/2022	31/12/2022
PUE-FP	GreenMA	Alexandra Xavier	01/01/2022	31/12/2022
PUE-FP	EITJumpUkraine22	Cristina Maria Barbosa	01/10/2022	31/12/2023
SERV-NAC	IMSGIDI	Alexandra Xavier	15/03/2019	30/06/2022
SERV-NAC	SGIDI_agro	Alexandra Xavier	22/07/2021	30/06/2022
SERV-NAC	SIACEDV_A_OAZEMEIS-1	Alexandra Xavier	29/09/2021	29/03/2023

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

10.9.2 List of publications

International Journals with Scientific Referees

1. Almeida, F, "Human resource management practices at university spin-offs", International Journal of Organizational Analysis, 2022
2. Almeida, F, "Methods for identifying and evaluating disruptive technologies in university spinoffs", INTERNATIONAL JOURNAL OF ENTREPRENEURSHIP AND INNOVATION, pp.146575032110508, 2022
3. Almeida, F, "The Contribution of Local Agents and Citizens to Sustainable Development: The Portuguese Experience", SUSTAINABILITY, vol.14, pp.12696, 2022
4. Almeida, F, Buzady, Z, "Development of soft skills competencies through the use of FLIGBY", TECHNOLOGY PEDAGOGY AND EDUCATION, pp.1-14, 2022
5. Almeida, F, Buzady, Z, "Recognizing leadership styles through the use of a serious game", JOURNAL OF APPLIED RESEARCH IN HIGHER EDUCATION, 2022

6. Almeida, F, Devedzic, V, "The Relevance of Soft Skills for Entrepreneurs", JOURNAL OF EAST EUROPEAN MANAGEMENT STUDIES, vol.27, pp.157-172, 2022
7. Almeida, F, Espinheira, E, "Adoption of Large-Scale Scrum Practices through the Use of Management 3.0", INFORMATICS-BASEL, vol.9, pp.20, 2022
8. Almeida, F, Miguel Oliveira, J, "The Role of Intrapreneurship in Portuguese Startups", Periodica Polytechnica Social and Management Sciences, 2022
9. Almeida, F, Morais, J, Pereira, A, "Portuguese Volunteer Firefighters in the Context of the Challenges Posed by the COVID-19 Pandemic", SOCIAL SCIENCES-BASEL, vol.11, pp.285, 2022
10. Almeida, F, Morais, J, Santos, JD, "A Bibliometric Analysis of the Scientific Outcomes of European Projects on the Digital Transformation of SMEs", PUBLICATIONS, vol.10, pp.34, 2022
11. Almeida, FL, Simões, J, Lopes, S, "Exploring the Benefits of Combining DevOps and Agile", Future Internet, vol.14, pp.63, 2022
12. Daniel, AD, Junqueira, M, Rodrigues, JC, "The influence of a gamified application on soft mobility promotion: An intention perspective", JOURNAL OF CLEANER PRODUCTION, vol.351, pp.131551, 2022
13. Leite, L, dos Santos, DR, Almeida, F, "The impact of general data protection regulation on software engineering practices", INFORMATION AND COMPUTER SECURITY, 2022
14. Rodrigues, JC, "Business models for the digital transformation of audiovisual archives", INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH, 2022
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1. Faria, BS, Simoes, AC, Rodrigues, JC, "Impact of Governmental Support for the Implementation of Industry 4.0 in Portugal", INNOVATIONS IN INDUSTRIAL ENGINEERING, pp.108-120, 2022
2. Gomes, N, Rego, N, Claro, J, "Supply Chains' Digitalization: Boosters and Barriers", INNOVATIONS IN INDUSTRIAL ENGINEERING, pp.197-208, 2022
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10.10 HUMANISE – ACTIVITY RESULTS IN 2022

10.10.1 Activity indicators

The following tables present HUMANISE research team composition and evolution and the main indicators of its activity carried out in 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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 - HumanISE - Research team composition

Type of Human Resources			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	14	11	14	3
		Academic Staff	27	27	33	6
		Grant Holders and Trainees	42	43	45	2
		Total Core Researchers	**83**	**81**	**92**	**11**
		Total Core PhD	**32**	**31**	**38**	**7**
	Affiliated Researchers		17	16	18	2
	Administrative and Technical Employees		1	1	1	
		Total Integrated HR	**101**	**98**	**111**	**13**
		Total Integrated PhD	**49**	**47**	**47**	

Table 10.10.2 - HumanISE – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes - FCT	294	221	109	-112
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	45	98	226	128
PUE-FP	EU Framework Programmes	443	786	943	157
PUE-DIV	EU Cooperation Programmes - Other	34	45	76	30
SERV-NAC	R&D Services and Consulting - National	293	354	450	96
SERV-INT	R&D Services and Consulting - International	31	26	12	-13
OP	Other Funding Programmes	55	6	1	-6
	Total Funding	**1 194**	**1 535**	**1816**	**281**

Table 10.10.3 - HumanISE - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	56	49	55
Indexed Conferences	82	88	84
Books		1	
Book Chapters	3	5	4
Concluded PhD Theses - Members	8	2	7
Concluded PhD Theses - Supervised	20	18	11

Table 10.10.4 - HumanISE - Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre-Disclosures (PDF)		1	5
Technology Disclosures (TDF)		1	1
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			

Table 10.10.5 - HumanISE - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	1
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	12
International events in which INESC TEC members participate in the program committees	32
Participation in events such as fairs, exhibitions or similar	3
Conferences, workshops and scientific sessions organised by the Centre	4
Participants in the conferences, workshops and scientific sessions organised by the Centre	140
Advanced training courses organised by the Centre	

Table 10.10.6 – HumanISE - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	PAINTER	Rui Pedro Rodrigues	01/07/2018	31/03/2022
PN-FCT	SCReLProg	Leonel Morgado	01/10/2018	30/09/2022
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-FCT	DBoidS	João Barroso	01/01/2022	31/12/2024
PN-FCT	EESDataLab	Alexandre Carvalho	22/03/2022	21/06/2023
PN-COOP	FDControlo-1	Lino Oliveira	02/01/2018	31/12/2022
PN-COOP	INFRAVINI	Lino Oliveira	01/07/2019	31/12/2021
PN-COOP	Replant-3	Lino Oliveira	01/07/2020	30/06/2023
PN-COOP	REV@CONSTRUCTION-2	Lino Oliveira	01/07/2020	30/06/2023
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	01/04/2021	31/03/2023
PN-COOP	VitalPROVID-1	Artur Rocha	31/08/2020	31/12/2021
PN-COOP	SMARTCUT-1	Miguel Correia Melo	01/12/2020	30/06/2023
PN-COOP	InOlive	Lino Oliveira	01/09/2021	30/06/2023
PN-COOP	Continental FoF-3	Miguel Correia Melo	01/07/2020	30/06/2023
PN-COOP	FLORESTa	José Correia	03/04/2021	30/06/2023
PUE-DIV	MarRisk	Artur Rocha	01/07/2017	30/06/2021
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-DIV	TRIO	Leonel Morgado	28/02/2022	27/05/2024
PUE-DIV	WavyNOS	Artur Rocha	06/06/2022	30/04/2024
PUE-FP	RECAP	Artur Rocha	01/01/2017	30/09/2021
PUE-FP	MELOA	Artur Rocha	01/12/2017	28/02/2022
PUE-FP	FEEdBACk-1	António Coelho	01/11/2017	30/04/2021
PUE-FP	iReceptor+	Artur Rocha	01/01/2019	31/12/2022
PUE-FP	EUCAN_CONNECT	Gonçalo Campos Gonçalves	01/01/2019	31/12/2023
PUE-FP	TIPES	Susana Alexandra Barbosa	01/09/2019	29/02/2024
PUE-FP	INCLUDING	Miguel Correia Melo	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	31/12/2022
PUE-FP	PAFSE	Paulo Martins	01/09/2021	31/08/2024
PUE-FP	VR2Care	Hugo Paredes	01/01/2022	31/12/2023
PUE-FP	ILIAD	Artur Rocha	01/02/2022	01/02/2025
PUE-FP	EPOSSP	Artur Rocha	10/02/2020	10/02/2023
SERV-NAC	SIGMAIA2	Ricardo Henriques	30/07/2019	28/04/2022
SERV-NAC	CholdaDigital	Lino Oliveira	17/06/2021	11/04/2022
SERV-NAC	Data4CiMob	José Correia	15/06/2021	31/03/2022
SERV-NAC	ARQNET3	José Correia	10/07/2021	10/01/2023
SERV-NAC	CoolBizDOC	José Correia	01/10/2021	13/05/2022

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	BPrepared	Fernando Cassola Marques	08/11/2021	08/11/2022
SERV-NAC	COLOGISTICS	Lino Oliveira	01/12/2021	30/11/2022
SERV-NAC	SEPIA	Gonçalo Campos Gonçalves	01/02/2021	01/02/2024
SERV-NAC	Data4Bus	José Correia	17/12/2021	31/12/2024
SERV-NAC	CHUSJ_Genetica	Marco Amaro Oliveira	25/05/2022	31/12/2022
SERV-NAC	PFAI4_3ed-7	António Coelho	04/05/2022	04/07/2022
SERV-NAC	MAP3	José Correia	15/09/2022	14/01/2024
SERV-NAC	SIGMAIA3	Ricardo Henriques	01/09/2022	30/11/2024
SERV-INT	Boozebuster	Gonçalo Campos Gonçalves	01/05/2021	30/09/2022
SERV-INT	PORT XXI-1	Lino Oliveira	15/11/2020	31/05/2022

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

10.10.2 List of publications

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1. Dias, J., “Increasing the Dependability of Internet-of-Things Systems in the context of End-User Development Environments”
2. Fernandes, L., “Cultural Gestures and Virtual and Augmented Reality to enable Non-Experts to Explore Systemic Concepts and Complexity”
3. Martins, M., “Metodologias e técnicas de avaliação das normas europeias de acessibilidade em procedimentos de compras públicas de produtod e serviços de TIC”
4. Marto, A., “Um Modelo de adaptação de health games comunitários em ambiente de rede social”
5. Narciso, D., “Simulador da realidade virtual multissensorial realista para treino de bombeiros: comparando a resposta fisiológica de formadores em ambientes reais e virtuais”
6. Oliveira e Sousa, M., “Jogar o Museu: Uma framework para o design de jogos baseados em localização com realidade aumentada para espaços museológicos”
7. Raimundo, J., “Jogos para Literacia Criativa: Uma framework para cultivar a literacia criativa através de jogos”

10.11 LIAAD – ACTIVITY RESULTS IN 2022

10.11.1 Activity indicators

The following tables present LIAAD research team composition and evolution and the main indicators of its activity carried out in 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	8	8	7	-1
		Academic Staff	24	22	23	1
		Grant Holders and Trainees	25	26	27	1
		Total Core Researchers	**57**	**56**	**57**	**1**
		Total Core PhD	**33**	**29**	**28**	**-1**
	Affiliated Researchers		7	8	7	-1
	Administrative and Technical Employees			1	1	
	Total Integrated HR		**64**	**65**	**65**	
	Total Integrated PhD		**40**	**37**	**37**	

Table 10.11.2 – LIAAD - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	190	196	122	-74
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	38	132	173	41
PUE-FP	EU Framework Programmes	51	83	69	-13
PUE-DIV	EU Cooperation Programmes – Other	1	15	61	46
SERV-NAC	R&D Services and Consulting – National	239	283	73	-210
SERV-INT	R&D Services and Consulting – International	1	8		-8
OP	Other Funding Programmes	7	22		-22
Total Funding		**528**	**739**	**498**	**-241**

Table 10.11.3 – LIAAD - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	50	44	45
Indexed Conferences	37	45	37
Books			2
Book Chapters	6	4	9
Concluded PhD Theses - Members	4	2	2
Concluded PhD Theses - Supervised	6	4	2

Table 10.11.4 – LIAAD - Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		1	1
Technology Disclosures (TDF)			1
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			

Table 10.11.5 – LIAAD - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	48
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	34
Participation in events such as fairs, exhibitions or similar	3
Conferences, workshops and scientific sessions organised by the Centre	12
Participants in the conferences, workshops and scientific sessions organised by the Centre	300
Advanced training courses organised by the Centre	0

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	MaLPIS	Paula Brito	01/10/2018	30/09/2022
PN-FCT	Text2Story	Alípio Jorge	14/11/2019	30/06/2023
PN-FCT	DAnon	João Vinagre	01/02/2022	31/01/2023
PN-COOP	PROMESSA	João Mendes Moreira	01/08/2019	30/06/2023
PN-COOP	TRF4p0-2	Ricardo Teixeira Sousa	01/07/2020	01/07/2023
PN-COOP	AIDA-1	João Vinagre	12/05/2020	30/06/2023
PN-COOP	SIGIPRO-1	João Vinagre	01/04/2021	31/03/2023
PN-COOP	City Analyser	João Gama	31/12/2021	30/06/2023
PN-COOP	AgWearCare-1	João Vinagre	01/08/2021	30/06/2023
PN-COOP	SADCoPQ-1	Ricardo Teixeira Sousa	22/05/2021	30/06/2023
PN-COOP	OnlineAIOps-1	João Mendes Moreira	18/01/2021	30/06/2023
PN-COOP	Continental FoF-1	Alípio Jorge	01/07/2020	30/06/2023
PUE-DIV	XPM	João Gama	01/03/2021	29/02/2024
PUE-FP	RECAP-1	Rui Camacho	01/01/2017	30/09/2021
PUE-FP	HumanE-AI-Net	João Gama	01/09/2020	31/08/2024
PUE-FP	EMERITUS	João Gama	01/09/2022	31/08/2025
SERV-NAC	PAFML	Alípio Jorge	01/03/2020	01/03/2023
SERV-NAC	SIS-1	João Vinagre	12/02/2021	31/03/2023
SERV-NAC	SSPM-1	João Mendes Moreira	04/02/2021	30/09/2022
SERV-NAC	THEIA-3	Alípio Jorge	03/01/2022	31/12/2023
SERV-NAC	PAPVI	Ricardo Teixeira Sousa	15/10/2022	15/01/2023

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

10.11.2 List of publications

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2. Accinelli, E, Martins, F, Pinto, AA, Afsar, A, Oliveira, BMPM, "The power of voting and corruption cycles", JOURNAL OF MATHEMATICAL SOCIOLOGY, pp.1-24, 2022
3. Alves, H, Brito, P, Campos, P, "Centrality Measures in Interval-Weighted Networks", JOURNAL OF COMPLEX NETWORKS, vol.abs/2106.10016, 2022

4. Brazdil, P, Muhammad, SH, Oliveira, F, Cordeiro, J, Silva, F, Silvano, P, Leal, A, "Semi-Automatic Approaches for Exploiting Shifter Patterns in Domain-Specific Sentiment Analysis", MATHEMATICS, vol.10, pp.3232, 2022

5. Cabral, M, Fonseca, TF, Cerveira, A, "Optimization of Forest Management in Large Areas Arising from Grouping of Several Management Bodies: An Application in Northern Portugal", FORESTS, vol.13, pp.471, 2022

6. Cerqueira, V, Torgo, L, Soares, C, "Machine Learning vs Statistical Methods for Time Series Forecasting: Size Matters", JOURNAL OF INTELLIGENT INFORMATION SYSTEMS, vol.abs/1909.13316, 2022

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12. Gama, J, Ribeiro, RP, Veloso, B, "Data-Driven Predictive Maintenance", IEEE INTELLIGENT SYSTEMS, vol.37, pp.27-29, 2022

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10.12 CRACS – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	1	1	1	
		Academic Staff	17	16	16	
		Grant Holders and Trainees	16	19	14	-5
		Total Core Researchers	**34**	**36**	**31**	**-5**
		Total Core PhD	**19**	**17**	**16**	**-1**
	Affiliated Researchers		1	1	2	1
	Administrative and Technical Employees		1			
		Total Integrated HR	**36**	**37**	**33**	**-4**
		Total Integrated PhD	**19**	**18**	**18**	

Table 10.12.2 - CRACS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	16	2		-2
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	1			
PUE-DIV	EU Cooperation Programmes – Other	50	60	96	35
SERV-NAC	R&D Services and Consulting – National	94	35	85	50
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	11	8	5	-3
	Total Funding	**173**	**106**	**186**	**81**

Table 10.12.3 - CRACS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	15	38	17
Indexed Conferences	36	30	27
Books			
Book Chapters			3
Concluded PhD Theses - Members	1	5	2
Concluded PhD Theses – Supervised	1	6	2

Table 10.12.4 – CRACS - Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre-Disclosures (PDF)			
Technology Disclosures (TDF)			
First Priority Patent Applications (New inventions)			
First Patents Internationalisation	2		
First Patents Granted		1	
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			

Table 10.12.5 – CRACS - Summary of dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	11
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	11
International events in which INESC TEC members participate in the program committees	42
Participation in events such as fairs, exhibitions or similar	
Conferences, workshops and scientific sessions organised by the Centre	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	25
Advanced training courses organised by the Centre	

Table 10.12.6 – CRACS - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PUE-DIV	PANDORA	António Pinto	01/12/2020	30/11/2022
PUE-DIV	FGPEPlus	Ricardo Queirós	01/06/2021	31/05/2023
PUE-DIV	JuezLTI	Ricardo Queirós	01/05/2021	30/04/2023
SERV-NAC	AI4DM	Vítor Santos Costa	01/09/2021	30/12/2022
SERV-NAC	THEIA-1	Rolando Martins	03/01/2022	31/12/2023
OP	HLPP2022	Miguel Gonçalves Areias	07/07/2022	31/03/2023

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

10.12.2 List of publications

International Journals with Scientific Referees

1. Alves, F, Martins, FMS, Areias, M, Munoz Merida, A, "Automating microsatellite screening and primer design from multi-individual libraries using Micro-Primers", SCIENTIFIC REPORTS, vol.12, 2022
2. Alves, S, Kiefer, S, Sokolova, A, "Report on women in logic 2020 & 2021", ACM SIGLOG News, vol.9, pp.31-33, 2022
3. Antunes, M, Maximiano, M, Gomes, R, "A Client-Centered Information Security and Cybersecurity Auditing Framework", APPLIED SCIENCES-BASEL, vol.12, pp.4102, MAY, 2022
4. Antunes, M, Oliveira, L, Seguro, A, Verissimo, J, Salgado, R, Murteira, T, "Benchmarking Deep Learning Methods for Behaviour-Based Network Intrusion Detection", INFORMATICS-BASEL, vol.9, pp.29, 2022
5. Areias, M, Rocha, R, "On the correctness of a lock-free compression-based elastic mechanism for a hash trie design", COMPUTING, 2022
6. Cirne, A, Sousa, PR, Resende, JS, Antunes, L, "IoT Security Certifications: Challenges and Potential Approaches", COMPUTERS & SECURITY, pp.102669, 2022
7. Dovier, A, Formisano, A, Gupta, G, Hermenegildo, MV, Pontelli, E, Rocha, R, "Parallel Logic Programming: A Sequel", THEORY AND PRACTICE OF LOGIC PROGRAMMING, vol.abs/2111.11218, 2022
8. Ferreira, D, Oliveira, JL, Santos, C, Filho, T, Ribeiro, M, Freitas, LA, Moreira, W, Oliveira, A, “Planning and Optimization of Software-Defined and Virtualized IoT Gateway Deployment for Smart Campuses”, SENSORS, vol.2, 2022
9. Ferreira, S, Antunes, M, Correia, ME, "Digital Forensics for the Detection of Deepfake Image Manipulations", ERCIM NEWS, vol.2022, pp.0, 2022
10. Figueira, A, Vaz, B, "Survey on Synthetic Data Generation, Evaluation Methods and GANs", MATHEMATICS, vol.10, pp.2733, 2022
11. Korner, P, Leuschel, M, Barbosa, J, Costa, VS, Dahl, V, Hermenegildo, MV, Morales, JF, Wielemaker, J, Diaz, D, Abreu, S, Ciatto, G, "Fifty Years of Prolog and Beyond", THEORY AND PRACTICE OF LOGIC PROGRAMMING, 2022

12. Paiva, JC, Leal, JP, Figueira, A, "Automated Assessment in Computer Science Education: A State-of-the-Art Review", ACM TRANSACTIONS ON COMPUTING EDUCATION, 2022
13. Paiva, JC, Queiros, R, Leal, JP, Swacha, J, Miernik, F, "Managing Gamified Programming Courses with the FGPE Platform", INFORMATION, vol.13, pp.45, 2022
14. Queiroz, S, Vilela, JP, Monteiro, E, "Is FFT Fast Enough for Beyond 5G Communications? A Throughput-Complexity Analysis for OFDM Signals", IEEE ACCESS, vol.10, pp.104436-104448, 2022
15. Silva, VF, Silva, ME, Ribeiro, P, Silva, F, "Novel Features for Time Series Analysis: A Complex Networks Approach", DATA MINING AND KNOWLEDGE DISCOVERY, vol.abs/2110.09888, 2022
16. Sousa, PR, Resende, JS, Martins, R, Antunes, L, "The case for blockchain in IoT identity management", JOURNAL OF ENTERPRISE INFORMATION MANAGEMENT, vol.ahead-of-print, 2022
17. Tavares, O, Sin, C, Sa, C, Bugla, S, Amaral, A, "Inbreeding and research collaborations in Portuguese higher education", HIGHER EDUCATION QUARTERLY, 2022

International Conference Proceedings with Scientific Referees

1. Alves, J, Pinto, A, "Blockchain Assisted Voting in Academic Councils", Blockchain and Applications, 4th International Congress, BLOCKCHAIN 2022, L'Aquila, Italy, 13-15 July 2022., vol.595, pp.173-182, 2022
2. Alves, S, Florido, M, "Structural Rules and Algebraic Properties of Intersection Types", Theoretical Aspects of Computing - ICTAC 2022 - 19th International Colloquium, Tbilisi, Georgia, September 27-29, 2022, Proceedings, vol.13572, pp.60-77, 2022
3. Alves, S, Ventura, D, "Quantitative Weak Linearisation", Theoretical Aspects of Computing - ICTAC 2022 - 19th International Colloquium, Tbilisi, Georgia, September 27-29, 2022, Proceedings, pp.78-95, 2022
4. Barbosa, J, Florido, M, Costa, VS, "Data Type Inference for Logic Programming", LOGIC-BASED PROGRAM SYNTHESIS AND TRANSFORMATION (LOPSTR 2021), vol.13290, pp.16-37, 2022
5. Barbosa, J, Florido, M, Costa, VS, "Typed SLD-Resolution: Dynamic Typing for Logic Programming", LOGIC-BASED PROGRAM SYNTHESIS AND TRANSFORMATION (LOPSTR 2022), vol.13474, pp.123-141, 2022
6. Brandão, A, Mendes, R, Vilela, JP, "Prediction of Mobile App Privacy Preferences with User Profiles via Federated Learning", CODASPY 2022 - Proceedings of the 12th ACM Conference on Data and Application Security and Privacy, 2022
7. Buhrman, H, Loff, B, Patro, S, Speelman, F, "Limits of Quantum Speed-Ups for Computational Geometry and Other Problems: Fine-Grained Complexity via Quantum Walks", 13th Innovations in Theoretical Computer Science Conference, ITCS 2022, January 31 - February 3, 2022, Berkeley, CA, USA., vol.215, pp.31:1-31:12, 2022
8. Buhrman, H, Loff, B, Patro, S, Speelman, F, "Memory Compression with Quantum Random-Access Gates", 17th Conference on the Theory of Quantum Computation, Communication and Cryptography, TQC 2022, July 11-15, 2022, Urbana Champaign, Illinois, USA., vol.232, pp.10:1-10:19, 2022
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10. da Costa, ARSL, Santos, A, Leal, JP, "Large Semantic Graph Summarization Using Namespaces", 11th Symposium on Languages, Applications and Technologies, SLATE 2022, July 14-15, 2022, Universidade da Beira Interior, Covilhã, Portugal., vol.104, pp.12:1-12:9, 2022
11. Figueira, A, Nascimento, LV, "Do Top Higher Education Institutions' Social Media Communication Differ Depending on Their Rank?", International Conference on Web Information Systems and Technologies, WEBIST - Proceedings, 2022

12. Goncalves, R, Ferreira, I, Godina, R, Pinto, P, Pinto, A, "A Smart Contract Architecture to Enhance the Industrial Symbiosis Process Between the Pulp and Paper Companies - A Case Study", BLOCKCHAIN AND APPLICATIONS, vol.320 LNNS, pp.252-260, 2022
13. Guimaraes, V, Costa, VS, "Online Learning of Logic Based Neural Network Structures", INDUCTIVE LOGIC PROGRAMMING (ILP 2021), pp.140-155, 2022
14. Leal, JP, Primo, M, "A Matching Algorithm to Assess Web Interfaces", ADVANCED RESEARCH IN TECHNOLOGIES, INFORMATION, INNOVATION AND SUSTAINABILITY, ARTIIS 2022, PT I, pp.115-126, 2022
15. Leal, JP, Queirós, R, Ferreirinha, P, Swacha, J, "A Roadmap to Convert Educational Web Applications into LTI Tools", Third International Computer Programming Education Conference, ICPEC 2022, June 2-3, 2022, Polytechnic Institute of Cávado and Ave (IPCA), Barcelos, Portugal., vol.102, pp.12:1-12:12, 2022
16. Leal, JP, Queirós, R, Primo, M, "Generation of Document Type Exercises for Automated Assessment", 11th Symposium on Languages, Applications and Technologies, SLATE 2022, July 14-15, 2022, Universidade da Beira Interior, Covilhã, Portugal., vol.104, pp.4:1-4:6, 2022
17. Machado, D, Costa, VS, Brandão, P, "Impact of the glycaemic sampling method in diabetes data mining", IEEE Symposium on Computers and Communications, ISCC 2022, Rhodes, Greece, June 30 - July 3, 2022, vol.2022-June, pp.1-6, 2022
18. Mendes, R, Brandao, A, Vilela, JP, Beresford, AR, "Effect of User Expectation on Mobile App Privacy: A Field Study", 2022 IEEE INTERNATIONAL CONFERENCE ON PERVASIVE COMPUTING AND COMMUNICATIONS (PERCOM), 2022
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21. Queirós, RAPD, "Integration of a Learning Playground into a LMS", Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE, vol.2, 2022
22. Shehu, AS, Pinto, A, Correia, ME, "A Decentralised Real Estate Transfer Verification Based on Self-Sovereign Identity and Smart Contracts", SECRYPT : PROCEEDINGS OF THE 19TH INTERNATIONAL CONFERENCE ON SECURITY AND CRYPTOGRAPHY, vol.abs/2207.04459, 2022
23. Silva, B, Ribeiro, M, Henriques, TS, “Compression of Different Time Series Representations in Asphyxia Detection”, 10th E-HEALTH AND BIOENGINEERING CONFERENCE, 2022
24. Sousa, H, Ribeiro, M, Henriques, TS, “Entropy Analysis of Total Respiratory Time Series for Sepsis Detection”, 10th E-HEALTH AND BIOENGINEERING CONFERENCE, 2022
25. Ribeiro, M, Castro, L, Carrault, G, Pladys, P, Costa Santos, C, Henriques, T, “Evolution of Heart Rate Complexity Indices in the Early Detection of Neonatal Sepsis”, 44th ANNUAL INTERNATIONAL CONFERENCE OF THE IEEE ENGINEERING IN MEDICINE & BIOLOGY SOCIETY (EMBC), 2022
26. Vaz, B, Barros, MD, Lavoura, MJ, Figueira, A, "What Makes a Movie Get Success? A Visual Analytics Approach", MARKETING AND SMART TECHNOLOGIES, VOL 1, pp.79-91, 2022
27. Vaz, B, Bernardes, V, Figueira, A, "On Creation of Synthetic Samples from GANs for Fake News Identification Algorithms", Information Systems and Technologies, Worldcist 2022, VOL 3, pp.316-326, 2022

Books

Blank

Chapter/Paper in Books

1. Coelho, LP, Freitas, I, Kaminska, DU, Queirós, R, Laska-Lesniewicz, A, Zwolinski, G, Raposo, R, Vairinhos, M, Pereira, ET, Haamer, E, Anbarjafari, G, "Virtual and Augmented Reality Awareness Tools for Universal Design", Emerging Advancements for Virtual and Augmented Reality in Healthcare - Advances in Medical Technologies and Clinical Practice, pp.11-24, 2022
2. Mendes, R, Vilela, JP, "Geo-Indistinguishability", Encyclopedia of Cryptography, Security and Privacy, pp.1-2, 2022
3. Queiros, RAPd, Pinto, M, Simões, A, Portela, CF, "A Primer on Gamification Standardization", Advances in Human and Social Aspects of Technology - Next-Generation Applications and Implementations of Gamification Systems, pp.1-13, 2022

Publications (Editor)

1. Prieto, J, Partida, A, Leitão, P, Pinto, A, "Blockchain and Applications - 3rd International Congress, BLOCKCHAIN 2021, Salamanca, Spain, 6-8 October, 2021", BLOCKCHAIN, vol.320, 2022
2. Ribeiro, P, Silva, F, Ferreira Mendes, JF, Laureano, RD, "Network Science - 7th International Winter Conference, NetSci-X 2022, Porto, Portugal, February 8-11, 2022, Proceedings", NetSci-X, vol.13197, 2022

Dissertations (PhD)

1. Guimarães, N., “Towards realistic scenarios concerning the identification of unreliable information in social networks”
2. Guimarães, V., “NeuralLog: A Neural Logic System for Parameter and Structure Learning”

10.13 HASLAB – ACTIVITY RESULTS IN 2022

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 2022 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2022 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			2020	2021	2022	Δ 2021-22
Integrated HR	Core Research Team	Employees	9	8	7	-1
		Academic Staff	19	21	23	2
		Grant Holders and Trainees	28	32	42	10
		Total Core Researchers	**56**	**61**	**72**	**11**
		Total Core PhD	**26**	**26**	**28**	**2**
	Affiliated Researchers		6	6	7	1
	Administrative and Technical Employees		2	2	3	1
		Total Integrated HR	**64**	**69**	**82**	**13**
		Total Integrated PhD	**32**	**32**	**32**	

Table 10.13.2 - HASLab - Project funding Table

Funding Source		Total Income (k€)			Δ (k€)
		2020	2021	2022	2021-22
PN-FCT	National R&D Programmes – FCT	206	252	84	-168
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	122	217	234	17
PUE-FP	EU Framework Programmes	148	130	195	65
PUE-DIV	EU Cooperation Programmes – Other				
SERV-NAC	R&D Services and Consulting – National	353	459	431	-29
SERV-INT	R&D Services and Consulting - International	30	85	15	-70
OP	Other Funding Programmes	137	29	25	-4
	Total Funding	**997**	**1 173**	**984**	**-189**

10.13.3 - HASLab - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2020	2021	2022
Indexed Journals	14	14	12
Indexed Conferences	41	42	32
Books			
Book Chapters		2	
Concluded PhD Theses - Members	2	2	3
Concluded PhD Theses – Supervised	3	2	3

Table 10.13.4 - HASLab - Summary of IP protection, exploitation and technology transfer

Type of Result	2020	2021	2022
Pre Disclosures (PDF)		3	3
Technology Disclosures (TDF)			2
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted	1		
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			

Table 10.13.5 - HASLab - Summary of participation in dissemination activities

Type of Activity	2022
Participation as principal editor, editor or associated editor in journals	5
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	12
International events in which INESC TEC members participate in the program committees	19
Participation in events such as fairs, exhibitions or similar	4
Conferences, workshops and scientific sessions organised by the Centre	6
Participants in the conferences, workshops and scientific sessions organised by the Centre	140
Advanced training courses organised by the Centre	

Table 10.13.6 - HASLab - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DaVinci	Guillermina Cledou	26/07/2018	31/03/2022
PN-FCT	PassCert	José Bacelar Almeida	01/02/2021	30/06/2022
PN-FCT	IBEX	Renato Jorge Neves	01/01/2022	31/12/2024
PN-FCT	SpecRep	Nuno Moreira Macedo	01/01/2022	30/06/2023
PN-FCT	FLEXCOMM	João Marco	01/01/2022	01/07/2023
PN-COOP	BigHPC	João Tiago Paulo	31/03/2020	31/03/2023
PN-COOP	AIDA	Ricardo Pereira Vilaça	12/05/2020	30/06/2023
PUE-FP	InterConnect-2	Fábio André Coelho	01/10/2019	31/03/2024
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
PUE-FP	ENERSHARE-1	Fábio André Coelho	01/07/2022	30/06/2025
PUE-FP	BeFlex-1	Fábio André Coelho	01/09/2022	31/08/2026
SERV-NAC	MobileID	Vítor Francisco Fonte	01/10/2019	30/06/2022
SERV-NAC	IoT4Distribuicao-1	Fábio André Coelho	04/01/2021	28/02/2023
SERV-NAC	ENSCOMP	José Nuno Oliveira	01/09/2020	20/01/2022
SERV-NAC	DigiLightRail	Alcino Cunha	26/10/2020	31/03/2023
SERV-NAC	SIS	Ana Nunes Alonso	12/02/2021	31/03/2023
SERV-NAC	IDINA	João Marco	20/10/2021	01/09/2024
SERV-NAC	STDCNCS	João Marco	10/12/2021	28/02/2023
SERV-NAC	THEIA-2	Manuel Barbosa	03/01/2022	31/12/2023
SERV-NAC	fMP	João Carlos Barbosa	11/10/2022	30/11/2022
SERV-NAC	AURORA-1	António Luís Sousa	01/10/2022	30/11/2024
SERV-NAC	Formacao_ABD_MP	Ricardo Pereira Vilaça	28/11/2022	31/12/2022
SERV-INT	VIATEXT-1	Fábio André Coelho	01/11/2021	23/03/2022
SERV-INT	LazyFS	João Tiago Paulo	01/04/2022	11/07/2022
OP	Sustainable HPC-1	António Luís Sousa	01/07/2021	30/06/2023

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

10.13.2 List of publications

International Journals with Scientific Referees

1. Almeida, JCB, Barbosa, M, Barthe, G, Pacheco, H, Pereira, V, Portela, B, "A formal treatment of the role of verified compilers in secure computation", JOURNAL OF LOGICAL AND ALGEBRAIC METHODS IN PROGRAMMING, vol.125, pp.100736, 2022
2. Barbosa, LS, "Coalgebra for the working software engineer", FLAP, vol.9, pp.41-92, 2022
3. Bashford Rogers, T, Santos, LP, Marnerides, D, Debattista, K, "Ensemble Metropolis Light Transport", ACM TRANSACTIONS ON GRAPHICS, vol.41, 2022
4. Cledou, G, Edixhoven, L, Jongmans, SS, Proença, J, "API Generation for Multiparty Session Types, Revisited and Revised Using Scala 3 (Artifact)", Dagstuhl Artifacts Ser., vol.8, pp.19:1-19:4, 2022

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9. Macedo, N, Brunel, J, Chemouil, D, Cunha, A, "Pardinus: A Temporal Relational Model Finder", JOURNAL OF AUTOMATED REASONING, 2022
10. Moreno, M, Vilaca, R, Ferreira, PG, "Scalable transcriptomics analysis with Dask: applications in data science and machine learning", BMC BIOINFORMATICS, vol.23, 2022
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2. Caffiau, S, Campos, JC, Martinie, C, Nigay, L, Palanque, P, Spano, LD, "Teaching HCI Engineering: Four Case Studies", SENSE, FEEL, DESIGN, INTERACT 2021, vol.13198, pp.195-210, 2022
3. Campos, JC, Ribeiro, AN, "Addressing Interactive Computing Systems' Concerns in Software Engineering Degrees", SENSE, FEEL, DESIGN, INTERACT 2021, vol.13198, pp.248-256, 2022
4. Cerqueira, J, Cunha, A, Macedo, N, "Timely Specification Repair for Alloy 6", SOFTWARE ENGINEERING AND FORMAL METHODS, SEFM 2022, vol.13550, pp.288-303, 2022
5. Cledou, G, Edixhoven, L, Jongmans, SS, Proença, J, "API Generation for Multiparty Session Types, Revisited and Revised Using Scala 3", 36th European Conference on Object-Oriented Programming, ECOOP 2022, June 6-10, 2022, Berlin, Germany., vol.222, pp.27:1-27:28, 2022
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8. Cruz, A, Madeira, A, Barbosa, LS, "A Logic for Paraconsistent Transition Systems", Proceedings of the 10th International Conference on Non-Classical Logics. Theory and Applications, NCL 2022, Lódz, Poland, 14-18 March 2022., vol.358, pp.270-284, 2022
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