

INESCTEC

ACTIVITY REPORT

2023



Editorial Notes

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GLOBAL ACTIVITY REPORT 2023

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EXECUTIVE SUMMARY

The year 2023 unfolded against a backdrop of notable geopolitical shifts and emerging mega-trends, profoundly influencing INESC TEC's operations and strategic trajectory. Geopolitically, 2023 witnessed ongoing global power dynamics reconfiguration, characterised by the rise of multipolarity alongside persistent conflicts such as the situation in Ukraine and recent outbreaks of violence in the Middle East.

A prominent trend of 2023 was the rapid acceleration of digital transformation across various industries, propelled by advancements in technologies like artificial intelligence, cybersecurity, and quantum computing. Embracing this trend, our institution intensified research efforts in these domains and fostered collaborations to harness innovation for economic competitiveness and societal advancement.

Sustainability was once again confirmed as a pivotal theme, with an increasing urgency to address issues such as climate change, resource scarcity, and environmental degradation. Aligning with these priorities, our institution directed much of its research agenda towards eco-friendly technologies and advocated for responsible innovation practices.

In terms of achievements and performance indicators, 2023 was yet another year of growth for the INESC TEC community, reflected in expanded economic activity and enhanced capabilities in conducting and disseminating top-tier research. This was clearly evidenced by increased scientific output, consistent performance in technology valorisation and transfer, and effective scientific outreach to society.

In addition to the achievements in the areas of energy, manufacturing and sea, INESC TEC demonstrated a proactive commitment to fostering international collaborations and assuming leadership roles in high-performance computing (HPC) and quantum computing initiatives. Additionally, the institute pioneered innovative approaches in training and educational programs while implementing enduring, comprehensive reforms and transformative measures. These included the formulation of a Strategic Plan extending to 2030, progressive refinement of its human resources management model, and restructuring of its scientific organisational framework.

Overall, INESC TEC successfully executed its main initiatives planned for 2023, with varying degrees of adaptation depending on each initiative's nature, alongside significant new additions, resulting in a substantial 25% increase in activity size.

At the end of 2023, INESC TEC hosted more than 890 integrated researchers, more than 380 with a PhD. The most noticeable evolution in Human Resources was the increase in R&D employees (26%), and an increase in 13% in the number of grant holders.

In scientific terms, it kept the progressive redefinition of its model as a means to strengthen the institution's scientific strategy and prepare it for the FCT R&D Unit Evaluation process, to be held in 2024. The fifth call for Internal Seed Projects, aiming at supporting internal exploratory R&D activity led to the support of seven new projects, three inter-centre research projects, one junior researcher development project, and three commercialisation proof-of-concept projects. The scientific areas covered Spectral Imaging; Reagent-less point-of-care; Object individuation; Acoustic communication; Synthetic data generation; Compensatory patterns; and Infrastructure Automation.

INESC TEC reached 29 M€ of activity (a 25% increase when compared to the previous year), extending a period of more than a decade of continuous and sustainable growth. The most noticeable increase in project activity was in the National Cooperation Programmes with Industry (102%), mainly related with the approval of projects in Innovation Agendas and Green Agendas supported by the Portuguese Recovery and Resilience Plan (PRR), with a total funding of 5.7M€. These Agendas are unanimously considered strategic instruments fostering the economic development and social progress in Portugal towards 2030. Despite all this, in 2023, 43% of the total project funding (115 projects) came from European programmes.

Another significant highlight was the launch of the second call of the INESC TEC International Visiting Researcher Programme, with 5 additional positions when compared to the previous edition and providing the opportunity to 15 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 institutions from Japan and Taiwan.

In 2023, INESC TEC saw improvements in its scholarly output, particularly focusing on publications in indexed journals, with a total of 489 articles—a key priority for the institute. Notably, 86% of these articles were published in first and second quartile journals. Throughout the year, INESC TEC researchers supervised more than 300 ongoing PhD theses, in addition to 38 that were completed, as part of the institute's commitment to supporting academic growth and development. Globally, INESC TEC members contributed to over 100 editorial roles in journals and organised more than 70 conferences, serving on organising committees or chairing technical committees. Additionally, the R&D Centres organised over 60 conferences, workshops, and scientific sessions, attracting over 3300 participants. Furthermore, 11 advanced training courses were held and a partnership with Porto Business School, to launch the inaugural edition of the Executive Master in Cybersecurity in 2024, was established.

In our pursuit to amplify our contribution to regional, national, and European research and innovation-driven sustainable growth, we were actively involved in a range of initiatives at different levels. We focused on crafting policy and intelligence briefs that reflected INESC TEC's research priorities, advocating for policies aligned with our research and innovation objectives.

Furthermore, in terms of Technology Transfer, a comprehensive improvement across all Key Performance Indicators (KPIs) compared to 2022 was observed. Notably, 8 new patent applications were submitted, marking the second-highest number since 2018. Moreover, the year saw a notable increase in patent internationalisations, with 5 recorded compared to 2 in 2022, and 7 patent families received their first grants, affirming the quality of past submissions. By the end of 2023, INESC TEC had 36 active patent families, the highest count on record, spanning various technological domains. Additionally, valorisation performance showed improvement, with the signing of 3 new licensing contracts and several promising leads poised for transition into 2024, signalling sustained output in this area. The growth in valorisation through spin-offs was also notable, with both newly established spin-offs and those in development experiencing an upswing, the latter strengthened by INESC TEC's seed projects in the commercialisation proof-of-concept category.

Despite the intensity of its research and innovation endeavours, INESC TEC's efforts to engage with society and promote science remained unwavering. Its Annual Autumn Forum centred on the theme "Innovation Ecosystems: The Role of Interface Entities." Additionally, the sixth issue of the magazine "INESC TEC Science & Society," targeting individuals interested in general knowledge about research, was published, focusing on "Empowering the Blue Economy through Innovation and Technology." Following this line of engagement, the first season of the INESC TEC podcast and videocast series "Science and Society," with a focus on Artificial Intelligence and Health, was launched. Furthermore, the podcast "INESC TEC's Science Bits" was nominated in the "Science, Technology, and Education" category of the 2023 PODES awards, recognising podcasts at a national level across various domains.

In 2023, INESC TEC was awarded the "Mar Sustentável" Award in the "Science and Technology" category, in recognition of its efforts to advance and enhance various sectors related to the ocean. Moreover, 13 researchers from INESC TEC were ranked among the top 2% globally in their respective scientific fields by Stanford University, highlighting the institution's excellence in areas such as Artificial Intelligence, Energy, Optoelectronics, and Computer Hardware. Additionally, INESC TEC's innovative "MyNPK" technology, which optimises fertiliser use through smart photonics and Artificial Intelligence, secured the institution third place in the esteemed EARTO Innovation Prize, further solidifying its position as a leader in research and technology on both national and international fronts.

In 2023, INESC TEC maintained its position in the national Top 10 of the European Patent Office's "Patent Index", underscoring its consistent commitment to responsible and sustainable innovation, with a focus on societal benefit. This enduring achievement reflects INESC TEC's notable performance and reinforces its standing as a respected national entity in the field.

At the end of its 2021-2023 mandate, as the Board of Directors reflects on the institute's recent past and looks towards its future, we extend our heartfelt gratitude to the INESC TEC community, researchers, and staff for their unwavering dedication and energy in advancing our shared mission.

Despite the challenges and uncertainty that we are confronted with, INESC TEC remains optimistic about the future, driven by adaptability, innovation, and collaboration. By remaining agile and responsive, we aim to catalyse positive change and contribute to a sustainable and fulfilling future.

1 INTRODUCTION

This document presents the scientific and technological activities, as well as the results of INESC TEC during 2023.

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 2023, namely those regarding Human Resources, Activity in Projects, and Publications, as well as a short summary of the Board's 2021-2023 term, which is now coming to a close.

Research at INESC TEC is developed by thirteen Research Centres covering eight core scientific domains: Artificial Intelligence (AI), Bioengineering (BIO), Communications (COM), Computer Science and Engineering (CSE), Power and Energy Systems (PES), Photonics (PHT), Robotics (ROB) and Systems Engineering and Management (SEM). Section 4 presents these eight Domains and their scientific outcomes in 2023.

Section 5 focuses on the TEC4 initiatives, platforms that articulate the activity towards economic and societal impacts, presenting their main achievements in 2023 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 Purpose, Vision, Mission and Values

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 Porto, Braga and Vila Real. At the end of 2023, INESC TEC hosted 891 integrated researchers (381 PhDs), including academic staff, R&D employees, grant holders and affiliated researchers. INESC TEC's team also includes technical and administrative support staff and trainees.

INESC TEC's purpose is to create a fulfilling and sustainable future through impactful science, technology, and innovation.

Its history and purpose are deeply intertwined with those of its academic associates. As set out in its bylaws INESC TEC was founded to carry out excellent research and enhance their involvement and intervention of its academic associates in the development of the economic and social fabric, thus contributing to improve the performance and competitiveness of companies and institutions.

INESC TEC aims to be an inspiring and empowering force, driving the science and technology of digitally-enabled systems into overcoming society's challenges.

Pursuing this vision, the institution aspires to continually innovate across all the mission areas of academia, emphasising research and innovation but also contributing distinctively to education and furthering a flourishing collaborative environment, bridging it to the economy and society. The institute endeavours to be an international reference in its fields of activity, underpinned by the excellence of its research and innovation.

As a free-thinking and diverse community, INESC TEC's mission is to take on bold science, technology, and innovation challenges, empowering talent, collaborative ecosystems, and public policies that make a difference in our economy and society.

INESC TEC is a people-centred organisation that cultivates an inspiring discovery and learning environment where a diverse, critical- and free-thinking, venturesome, and creative talent community thrives. It values excellence and openness in science and technology. As such, the institute seeks purpose and sensemaking in its research as it reaches from its scientific domains to societal challenges and problems. It collaborates with academia and other stakeholders to develop talent and build science, technology, and innovation awareness and capability, transforming its ecosystems at all levels and supporting policy- and decision-makers in implementing and formulating public policies.

The **merit of INESC TEC in accomplishing its mission** has been formally acknowledged by the Foundation for Science and Technology, with the institute's recognition as an **Associate Laboratory**, and by the Portuguese Ministry of Economy, with its recognition as a **Technology and Innovation Centre (CTI)**.

INESC TEC's **six guiding principles adopted as the shared core values** of its community are: 1) **Rigour and excellence** – Thoroughly embed rigour in all work, from ideation to realisation to evaluation; 2) **Freedom to create and think** - Autonomy in pursuing intellectual agendas, free of unreasonable interference; 3) **Integrity** – Remain true to the institution's principles and act with transparency and compliance with ethical standards; 4) **Collaboration** – Share, with each other and with partners, all successes and challenges, as a cohesive community; 5) **Creativity** - Explore new areas to advance science and innovation, with bold curiosity and accepting the risk of failing as intrinsic to creating new things; and 6) **People-centredness** - Place people at the centre of everything the institution does, as a community in which everyone is welcome and fully supported in their development.

2.2 High-level view of science and innovation

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 2.1).

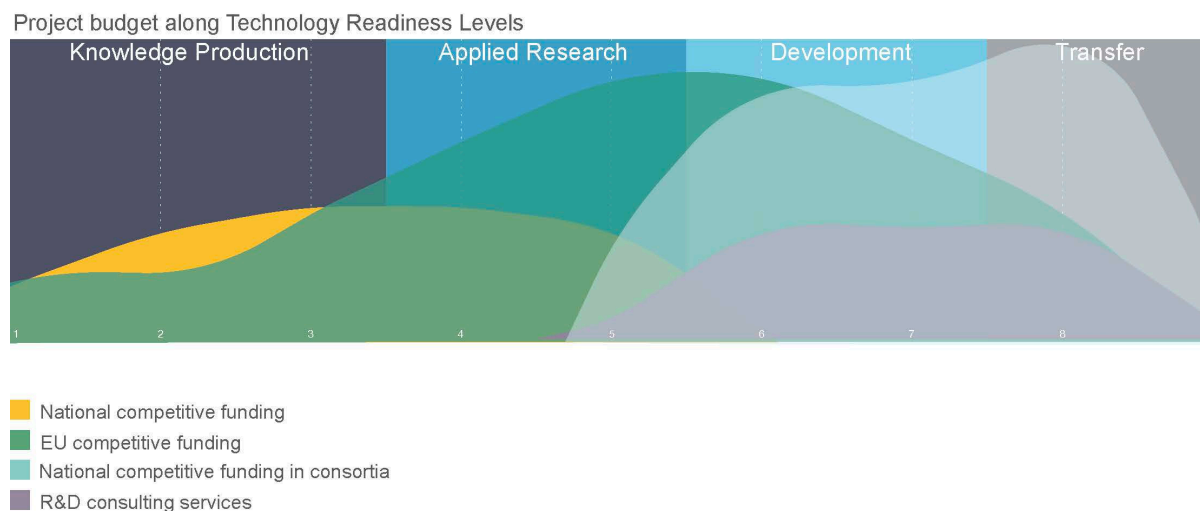


Figure 2.1 -End-to-end knowledge value chain: an integrated two-way pipeline

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. Activities and outcomes of projects active in 2023 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.

Centres, Scientific Domains and TEC4s

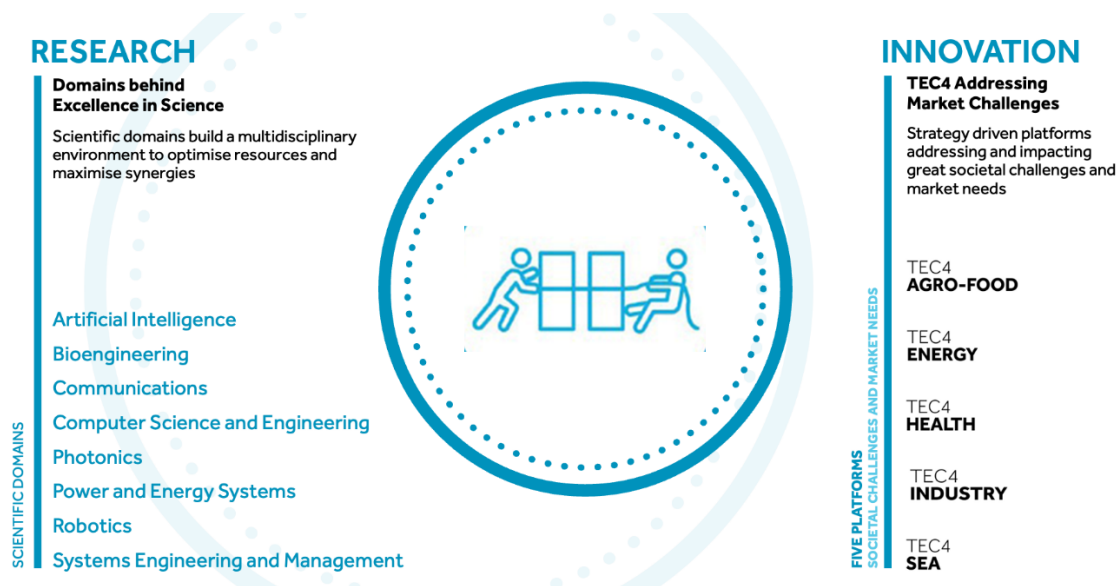


Figure 2.2 - High-level view of science and innovation at INESC TEC

Research and innovation at INESC TEC are undertaken in its 13 Research Centres.

Research is structured in eight broad Scientific Domains: Artificial Intelligence, Bioengineering, Communications, Computer Science and Engineering, Photonics, Power and Energy Systems, Robotics, and Systems Engineering and Management. Innovation is focused on main technology market drivers expressed internally through the TEC4 initiatives, currently TEC4AGRO-FOOD, TEC4ENERGY, TEC4HEALTH, TEC4INDUSTRY and TEC4SEA.

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

The institution's organisational structure (Figure 2.3) comprehends a Board of Directors composed of nine members and an Executive Board comprising five of those nine members, responsible for the high-level management of INESC TEC. The Boards act in close coordination with the Council of R&D Centres, meeting with the Centre Coordinators and the Managers of the different Support Services every other week. This ensures institution-wide coherence in vision, policy and operations, and joint responsibility and commitment in strategic and operational management decisions.

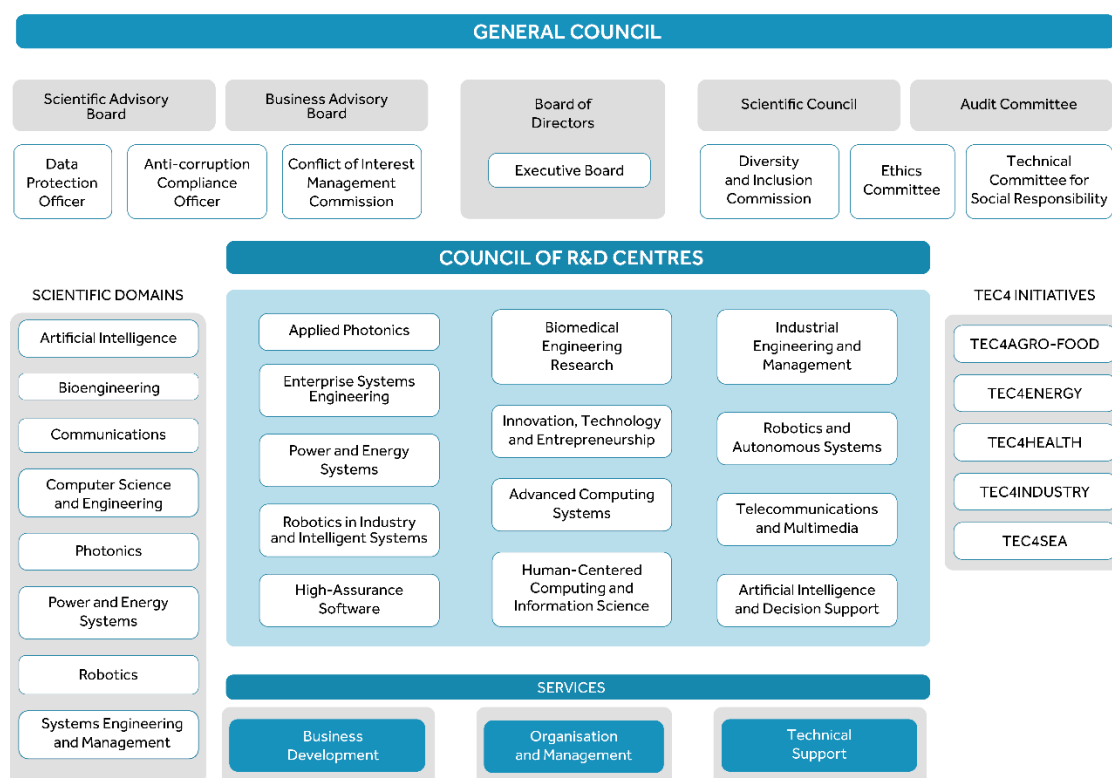


Figure 2.3 - Organisational Structure

The Scientific Advisory Board comprises twelve internationally recognised scientists who support the institution's search for continuous improvement and excellence, building a vision for future research through a valuable benchmark at the 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 relevant 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 Certified Public Accountant and oversees and validates the financial behaviour of the Institute.

Six non-statutory bodies oversee aspects that INESC TEC particularly values. The Ethics Committee ensures the observance and promotion of integrity, honesty, and responsibility standards in research activities carried out by INESC TEC's members by implementing the institution's Code of Ethics. The Conflict of Interest Management Commission (CGCI) and the Data Protection Officer are responsible for implementing the institute's Policy on Conflicts of Interest Management and the General Data Protection Regulation, respectively. The Anti-Corruption Compliance Officer is responsible for implementing 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 encourages the organisation to implement practices that promote diversity and inclusion and develops long-term work in this field by proposing and implementing a D&I Program for INESC TEC, including gender balance as a major priority. A new office has been set up to promote and articulate the institution's contributions to public policies.

INESC TEC's activities are supported by a streamlined and dynamic team of highly qualified technical and administrative personnel, organised across the following areas: Business Development, Organisation and Management, and Technical Support.

Table 2.1 - Support Services

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

2.4 Areas of Intervention and Responsibility of the Board of Directors

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

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

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

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

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

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

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

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

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

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

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

2.5 From policy priorities to strategic commitments

In its nearly four decades of existence, INESC TEC has engaged in and evolved a strategic reflection on crucial institutional pillars, namely relations with higher education institutions, organisation of science, innovation activities, international networking or the nurturing of start-ups.

As a result of the preceding strategic reflection, in recent years, INESC TEC has pursued its mission and guided its activities based on six 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.

In 2022 and 2023, the Board of INESC TEC led the preparation of INESC TEC's Strategic Plan 2023-2030, a comprehensive strategic plan, with the appropriate balance of breadth and depth.

This endeavour drew upon the strong motivation and diverse experience of the INESC TEC community, incorporating the analysis of inspiring international benchmarks and involving internal and external stakeholders through cross-cutting consultation.

The pillars and long-term foundations of its strategy, articulated as its purpose, mission, vision and values, were redefined, as detailed in Section 2.1 of this report. Furthermore, within INESC TEC's new strategy framework, the policy priorities have now evolved into five core strategic commitments, adopted by our community for the ensuing years, guiding our priorities and actions in our science and innovation endeavours.

2.6 Strategic commitments

To accomplish its vision, INESC TEC has defined the following five core strategic commitments:

- C1. Excel and innovate across the missions of academia, harnessing the collective strength of our community.
- C2. Make an impact on the toughest challenges of our time in science, technology, and society, through bold creativity and transformative action.
- C3. Increase our relevance by closely integrating across science and innovation, disciplines, and ecosystems.
- C4. Cultivate an attractive, people-centred and talented community.
- C5. Strive for a sound, sustainable and effective operational model.

Excel and innovate across the missions of academia, harnessing the collective strength of our community

INESC TEC aims to excel and innovate across all its work, from research and innovation to its distinctive contribution to education and the collaboration between academia, the economy and society – to be a community that inspires and empowers. Its international standing will be underpinned by the individual and collective merit of its talented and diverse community, to which it will provide the fullest support in their personal and professional growth, while cultivating a freethinking and inclusive environment.

Strategic objectives to address this commitment span from raising the contribution and visibility of research, namely by increasing the involvement in the leadership of scientific initiatives, to improving the base conditions for technology commercialisation and developing closer and deeper relationships with innovation partners and the broader community. Other objectives, such as providing innovative learning experiences, increasing international embedment, reinforcing strategic alignment, and ever-closer collaborations with Higher Education Institutions (HEI), are also key priorities.

Make an impact on the toughest challenges of our time in science, technology, and society, through bold creativity and transformative action

INESC TEC will take on the toughest challenges through transformative science and technology. It will work hard, acting in the public interest, contributing to implementing current policy priorities and shaping future policies tackling critical societal challenges. It will be boldly creative, blending novelty, freedom, and action through endeavour and a relentless focus on excellence.

To that end, the institution's strategic objectives focus on increasing its contribution to regional and national R&I-based sustainable growth, better aligning the delivery of R&I with the industry's needs and the SDGs. Furthermore, it will contribute to the digitalisation of public administration and raise its involvement in informing debates on issues that matter to society. Finally, it will endeavour to engage in direct dialogue with the public and to communicate scientific and technological achievements and their impact.

Increase our relevance by closely integrating across science and innovation, disciplines, and ecosystems

The institution will act in an integrated manner across the knowledge value chain, researching and developing technology-based systems and fostering sustainable innovation. Its paths to solutions will build on an integrated multidisciplinary approach. Striving for impactful innovation, jointly with its stakeholders, it will strengthen the technology and innovation capabilities of the ecosystems it is a part of.

To fulfil this commitment, INESC TEC's primary goals are to build more vital knowledge-based and multidisciplinary R&I ecosystems and to develop better linkages between knowledge production, development, and market uptake. Moreover, initiatives will be undertaken to increase strategic integration in national and international tech-intensive value chains and promote proactive participation in R&I agenda-setting at regional, national and EU levels. It will aim to expand its international networking, leadership, and competitiveness.

Cultivate an attractive, people-centred and talented community

INESC TEC will attract and retain world-class talent, motivating, recognising, and fully supporting individuals in their personal and professional growth. It will expand the diversity of its talent, with priority for gender diversity, and be a welcoming home for international researchers, cultivating an inclusive and freethinking environment. It will promote a good working environment, fostering team spirit, engagement, and social responsibility. It will value and endeavour to act with openness, transparency, independence, and compliance with ethical principles in research.

The strategic objectives for this commitment encompass attracting and retaining world-class talent and ensuring opportunities and recognition for career achievements. In addition, it also entails expanding the diversity of INESC TEC's community, providing a more dynamic and fulfilling working environment, and, finally, strengthening the institution's commitment to independence and compliance of research with ethical principles.

Strive for a sound, sustainable and effective operational model

The institute will strive for sustainability and resilience in its economic model, providing its community with the best conditions to create new knowledge and impact society. It will promote and contribute to environmental sustainability, provide excellent facilities, and cultivate a discovery and learning environment, enabling its critical talent community to thrive.

This commitment's strategic objectives include strengthening the sustainability and resilience of INESC TEC's economic model, the improvement, management, and usage of its infrastructures and, to a more significant degree, cementing the distinctive aspects of its institutional model.

2.7 Research

Research at INESC TEC is centred around eight broad Scientific Domains. Researchers across INESC TEC come together in each domain to establish a critical mass of scientific competences and enhance scientific cohesion, strategy, impact and communication. These forums enable discussing and planning INESC TEC's longer-term research trajectory, becoming platforms for strategising, with medium to long-term goals leading to measurable results.

The institution's scientific strategy in each domain is fully articulated with the strategies of the R&D Centres, the organisational units that effectively plan, manage, and carry out the research activities at INESC TEC. INESC TEC's R&D Centres-based model is at the root of its sustainable growth and distinctive multidisciplinary.

Today's Grand Challenges, such as resilient responses to climate change, the decarbonisation of the economy, or the design of sustainable circular solutions, business models and value chains, present demanding multidisciplinary research challenges. INESC TEC draws on the expertise of its scientists in different fields to assemble multidisciplinary teams to tackle large-scale, time-sensitive projects addressing such critical social and economic challenges quickly and successfully with lasting impacts.

This INESC TEC hallmark stems from its diversity, critical mass, and intrinsic purpose to cover the entire knowledge value chain. The joining of internal efforts is a crucial enabler for the higher impact of research achievements.

2.8 Innovation

Contemporary societies face multiple major social, economic, political, and cultural issues – societal challenges shaped by contemporary megatrends, such as climate change, increasing demographic imbalances, shifting health challenges, or accelerating technological change and hyperconnectivity.

The sciences and technologies of digitally-enabled systems have a vital role in addressing these challenges, and INESC TEC has been fully committed to that endeavour, defining five main areas of intervention in the innovation arena:

- Market-pull innovation in which it aligns its strategy with relevant challenges of the main economic sectors;
- Large-scale innovation strategies to increase the level of intervention and impact, from sectors to societal challenges;
- Knowledge management and valorisation paving the way to take full advantage of the cross-sectorial nature of its research results;
- Entrepreneurship support to boost scientific knowledge valorisation and upgrade Portugal's economic fabric;
- Advanced training and capacitation to develop the conditions for adequate knowledge transfer, absorption, and transformation into impactful innovations.

Addressing the first area of intervention, INESC TEC created the TEC4 ("TEChnologies FOR ...") internal initiatives as an organisational approach aiming at structuring and promoting the market-pull innovation process, targeting specific economic sectors. Each TEC4 addresses the market's regional, national, international, or global/societal challenges by mapping and linking its short, medium, and long-term needs (strategic agenda and roadmap) with INESC TEC's scientific and technological competences and experience.

In line with the above innovation strategy, as a Technology and Innovation Centre recognised by the Portuguese Ministry of Economy, its pluriannual action plan to promote science-based innovation with economic and social impact spans across eight axes: Networking and promoting new projects in companies; Promoting technology transfer and cross-fertilization; Internationalisation; Strengthening and boosting technological infrastructures; Attracting and developing talent; Digitising processes and continuous improvement; Sustainability and budget predictability; Developing relevant knowledge and technology in the circular economy and decarbonisation, artificial intelligence and cybersecurity.

3 RESULTS ACHIEVED IN 2023

This section presents a short summary of the results INESC TEC achieved during 2023, including highlights of the activity and the main indicators for human resources, activity in projects, scientific publications, knowledge transfer and dissemination. The section finalises with a short summary of the Board's 2021-2023 term, which is now coming to a close. 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 2023 in review

Reflecting on the year 2023 reveals a landscape shaped by significant geopolitical shifts and emerging megatrends with significant impacts on our activities and strategic direction.

Geopolitically, 2023 was marked by a continued reconfiguration of global power dynamics, with the rise of multipolarity but also by the ongoing conflict in Ukraine and a new outbreak of violence in the Middle East. European and national initiatives influenced by these developments, such as the Chips Act or the European Defence Fund, are emerging as public policy priorities of relevance for INESC TEC.

A notable trend in 2023 was the rapid acceleration of digital transformation across industries, driven by advancements in areas such as artificial intelligence, cybersecurity and quantum computing. Our institution embraced this trend, intensifying research efforts in these areas and fostering collaborations to leverage innovation for economic competitiveness and societal progress.

Sustainability was further reinforced as a defining theme, with a growing imperative to address climate change, resource scarcity, and environmental degradation. Our institution kept aligning its research agenda with these priorities, focusing on eco-friendly technologies and advocating for responsible innovation practices.

In terms of achievements and indicators, 2023 was, yet again, a year in which the INESC TEC community grew, and so did its overall activity and its capability to conduct and disseminate excellent research, with an increase of its scientific production, and further consolidating its track-records in technology valorisation and transfer, and scientific dissemination towards society.

In addition to these major achievements, INESC TEC has demonstrated a proactive commitment to fostering international collaborations and exchanges, and assuming leadership roles in high-performance computing (HPC) and quantum computing initiatives. Furthermore, the institute has pioneered innovative approaches in training and educational activities. Alongside, it implemented enduring, comprehensive reforms and transformative measures, including the conclusion of the preparation of a strategic plan extending to 2030, the progressive refinement of its human resources management model, and the restructuring of its scientific organisational architecture.

Looking ahead, there is no question these were and still are challenging times, but INESC TEC remains optimistic about the future. Adaptability, innovation, and collaboration remain central to its success as it navigates a rapidly changing world. By staying agile and responsive, we aim to continue to drive positive change and, at our core, contribute to a sustainable, fulfilling future.

3.2 Highlights in 2023

Once again, 2023 marked a year of growth, yielding significant results and institutional achievements for INESC TEC. Overall, the organisation successfully carried out the steps outlined for its primary initiatives planned for the year, with a few naturally requiring some adjustment, depending on their nature.

Notably, INESC TEC experienced a 25% increase in its activity level, underscoring its commitment to strengthening its foundational elements and enhancing its capacity to engage with national and international Science and Technology systems, all while fulfilling its societal mission.

Outlined below are the key accomplishments and highlights of 2023, presented within the context of the new framework of the five core strategic commitments, demonstrating the ongoing implementation of its Strategic Plan. However, these activities do not exhaust institutional action in achieving INESC TEC's goals and

commitments. There are other cross-cutting efforts, to which the several centres, services, and commissions make additional vital contributions and are introduced in other Sections of this report.

C1. Excel and innovate across the missions of academia, harnessing the collective strength of our community.

- **C1.1. Raise the contribution and visibility of our research**
 - Increase in both journal and conference publications, with the latter experiencing a particularly significant rise, and an uptick in the number of journal articles published in first and second quartile journals, as well as an increase in the number of conference publications presented at conferences rated as Core A* and Core;
 - INESC TEC's involvement in PhD and Masters Programmes, essential to its ability to attract and involve young talent in conducting and disseminating excellent research while leveraging the intervention of Higher Education Institutions (typically assisting more than 20 PhD programmes, and involving over 300 PhD students and 600 master's students);
 - Attraction of new PhD students by leveraging new R&D projects and funding for PhDs in both academic environment;
 - Reinforcement of INESC TEC's research team with the recruitment of researchers for key strategic areas (26% overall increase in R&D Employees), in line with the institute scientific strategy and the government policy for scientific employment;
 - Announcement of the results of the fifth call for Internal Seed Projects, aiming at supporting internal exploratory R&D activity – the Evaluation Committee (composed by Aníbal Matos (chair), Bernardo Silva, Luís Lopes, Maria Antónia Carravilla, Rita Lopes, and Susana Barbosa) selected three inter-centre research projects, one junior researcher development project, and three commercialisation proof-of-concept projects, covering the following scientific areas: Spectral Imaging; Reagent-less point-of-care; Object individuation; Acoustic communication; Synthetic data generation; Compensatory patterns; and Infrastructure Automation;
 - Preparation of the coming FCT R&D Unit Evaluation process, namely through groundwork with the Scientific Domains' Steering Committees, and taking into account the review and discussion of the institute's scientific strategy and goals undertaken by the Scientific Advisory Board;
 - Initial steps under the "Agreement on Reforming Research Assessment" subscribed by several entities at the European level, of which INESC TEC is also a signatory, towards committing the institution to a set of principles, initiatives and time horizons to implement changes in the way it conducts the assessment of research activities;
 - Reinforcement of the international recognition of researchers, through the encouragement of high-quality publication profiles, and actions to support applications to international awards, and ACM and IEEE Fellowships;
 - Awarding of two postdoctoral grants in the areas of Informatics, Computer Sciences and Applied Mathematics, aimed at foreign researchers with a PhD framed in the international programme Alain Bensoussan – promoted by the European Research Consortium for Informatics and Mathematics (ERCIM), of which INESC is a founding member.
- **C1.2. Increase our involvement in the leadership of scientific initiatives**
 - Continued involvement in the leadership of national initiatives and European collaboration on HPC and Quantum Computing;
 - Installation of the Deucalion supercomputer, situated at the University of Minho on the Azurém Campus in Guimarães, now standing as the leading supercomputer in Portugal;
 - Active participation in international scientific initiatives including: Centra, EFFRA, and Manufuture.
- **C1.3. Improve the base conditions for technology commercialisation**

- Increase in the number of new patent applications, active patent families, granted patents, and licensing contracts;
- Focus on unlocking the potential of the institute's portfolio in all dimensions, including its economic impact, intensifying the contacts with relevant agents more broadly across value chains;
- Active participation in international tech fairs and contribution to leading organisations in the areas of knowledge valorisation and transfer, such as the TTO Circle and EARTO.
- **C1.4. Develop closer and deeper relationships with our innovation partners and the broader community**
 - Organisation of workshops and establishment of regular contacts with technology-based companies. In 2023, the fourth edition of the “Advanced Programme in Industry 4.0”, promoted by INESC TEC and INEGI, provided training to Portuguese companies that are part of the national industrial fabric, while providing support to address the challenges of digital transformation.
- **C1.5. Provide innovative learning experiences**
 - Organisation of 11 advanced training courses, alongside the establishment of a collaboration with Porto Business School to launch the first edition of the Executive Master in Cybersecurity in 2024;
 - Establishment of a student-centred initiative aimed at analysing and enhancing the appeal and retention of students engaged as young researchers. Drawing upon responses from over 250 participants to a survey conducted in May to gather insights and concerns from hosted students, an analytical report has been formulated and is currently being scrutinised to enhance the research experience, as well as to attract and retain highly qualified talent.
- **C1.6. Increase the international embedment of our community**
 - Increased participation in international mobility programmes, namely with Taiwan (NARLabs – National Applied Research Laboratories) and Japan (NII – National Institute of Informatics);
 - Launch of the second edition of the INESC TEC International Visiting Researcher Programme, which provides researchers from institutions abroad the opportunity to conduct research activities at INESC TEC for up to three months while maintaining their affiliation with their home institutions;
 - Renewal of the INESC TEC - NII (Japan) MoU with the establishment of a collaborative framework to support joint exploratory research projects in areas of mutual interest.
- **C1.7. Reinforce strategic alignment and close collaboration with HEI**
 - Continued work on the protocols with INESC TEC's Associate HEIs, framing the assignment and sharing of human and material resources;
 - Continued collaboration in the Advanced Studies Programmes running in several Associate HEIs, to offer post-graduate training within the scope of R&D projects, both through hands-on learning of transferable skills (innovation, entrepreneurship, leadership, and time management, among others) and through the specialisation in technological areas;
 - Further collaboration and sharing of good practices between INESC TEC and ISPUP – Institute of Public Health of the University of Porto in the area of data protection;
 - Initial steps of a formal strategic cooperation initiative between INESC TEC and i3S – Institute for Research and Innovation in Health;
 - New facilities of iiLab – Industry and Innovation Lab, a cross-Centre infrastructure covering areas such as Cyber Physical Systems (CPS) and Internet of Things (IoT), Business Intelligence and Decision Support Systems, Advanced Automation and Industrial Robotics, Mobile Robotics

and Internal Logistics, Industrial Vision Systems for Inspection and Quality Control, located in a P.Porto building.

C2. Make an impact on the toughest challenges of our time in science, technology, and society, through bold creativity and transformative action.

- **C2.1. Develop impactful research and innovation aligned with the SDG**
 - INESC TEC's 380 R&D active projects in 2023 addressed the wide range of the United Nation's 17 Sustainable Development Goals (SDGs), through innovative research and collaborations, with special emphasis on affordable and clean energy, industry, innovation and infrastructure, good health and well-being, and life below water as on land.
- **C2.2. Increase our contribution to regional and national R&I-based sustainable growth**
 - Participation in the Advisory Committee for a study promoted by CCDR-N on best practices in regional innovation systems and governance models for smart specialisation strategies, involving representatives of relevant entities in the regional innovation system in the North of Portugal;
 - Participation in the Focus Group within the scope of the Interim Evaluation of the Northern Regional Operational Programme whose main objectives are to evaluate the implementation, results and impacts of the projects supported by Norte 2020;
 - Support of the development and operation of innovation eco-systems, including eleven Clusters and twelve CoLABs (Collaborative Laboratories), with academic and business partners, in order to exploit knowledge created in research institutions and address major societal challenges.
- **C2.3. Better align and deliver R&I with industry's needs**
 - Securing of R&D contracts with new clients, both nationally and internationally;
 - New composition of the Business Advisory Board for the five-year period 2023/2027 and convening of its first working meeting.
- **C2.4. Contribute to the digitalisation of public administration**
 - More than ten projects with relevant partners aiming at improving and transforming public administration in the areas of hospital management, education, ITS solutions for urban road policing, consulting and studies to public utilities providers (electricity and water) or national observatories;
 - Hosting of the training workshop "Science and Public Policy: How to build bridges between researchers and policymakers?" organised by PlanApp for INESC TEC Researchers. This initiative sought to bring science and public policy closer together in the construction of evidence-informed policies, sensitising and empowering the scientific community to this need.
- **C2.5. Raise our contribution to inform debates on issues that matter to society**
 - First full year of operation of the Public Policy Office, the new organisational structure to advance the involvement of the institute's community with public policies, promoting the effective use of scientific evidence resulting from INESC TEC research by public bodies and policy makers, as detailed in Section 3.5.1;
 - Active participation in the Associated Laboratories Council and contribution to draft legislation and funding programmes in preparation;
 - Organisation of the annual Autumn Forum, with the motto "Innovation ecosystems: the role of interface entities". 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;

- Development of policy and intelligence briefs by INESC Brussels HUB, reflecting INESC TEC's research focus, advocating for EU policies that support its research and innovation objectives.
- **C2.6. Engage in direct dialogue with the public**
 - Active involvement in events promoting science and innovation, such as Ciência 2023 - the annual meeting of science, technology and innovation in Portugal, Mostra UPorto 2023, and acting as a host institution for internship programmes;
 - Participation in an educational initiative in 23 schools about increasing energy efficiency and reducing energy poverty, with the support of the local electricity distribution company;
 - Promotion of webinars, as part of an educational component of the CAMões project and in close collaboration with Ciência Viva, targeting schools in mainland Portugal, Madeira, the Azores, the United States of America, Puerto Rico, Indonesia, and South Africa – granting students the opportunity to closely follow the mission and ask questions to the team. The CAMões project was the first analogue mission carried out in Portugal, where a team of seven people from various nationalities was isolated in Gruta do Natal, Terceira Island (Azores), replicating the lunar environment.
- **C2.7. Communicate scientific and technological achievements and their impact**
 - Launch of the 6th issue 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. This edition's special topic was focused on "Empowering the blue economy through innovation and technology". 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;
 - Launch of the first season of INESC TEC podcast and videocast "Science and Society" focused on Artificial Intelligence and Health. Furthermore, the podcast "INESC TEC's Science Bits" was among the five nominees in the "Science, Technology, and Education" category of the 2023 edition of the PODES awards, which aim to recognise podcasts at a national level in various areas;
 - Organisation and co-organisation of several international conferences, namely as host and organiser of the 7th IEEE Portuguese Meeting in Bioengineering 2023 (ENBENG 23), held at the Serralves Foundation, Porto, on June 22 and 23, 2023 or by being responsible for the organisation of the industry panel in IEEE GLOBECOM 2023, a flagship conference from IEEE ComSoc;
 - Promotion of summer schools, workshops, talks and open days, organised by several INESC TEC R&D 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;
 - Presence in renowned international expositions and fairs to showcase the institution's cutting-edge research, innovations, and technological advancements to a global audience and technology companies.

C3. Increase our relevance by closely integrating across science and innovation, disciplines, and ecosystems.

- **C3.1. Build stronger knowledge-based and multidisciplinary R&I ecosystems**
 - 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;
 - Significant engagement in projects and activities of the European Knowledge and Innovation Communities (KICs) EIT Raw Materials and EIT Manufacturing;

- Active participation in several research associations, at national and international levels, with entry into three new associations: ADRA, CCILF and CRESYM.
- **C3.2. Develop better linkages between knowledge production, development, and market uptake**
 - Initial steps towards an Internal Entrepreneurship Program aimed to support the entrepreneurial initiatives and spin-offs of INESC TEC researchers;
 - Support to the creation and development of new spin-offs (one new spin-off created and five new ones in development);
 - Through LET-In, INESC TEC coordinated two international accelerator programs – EIT Jumpstarter 2023 and EIT Ukraine, where it provided expert training and mentorship to 20 early-stage entrepreneurial projects.
- **C3.3. Increase strategic integration in national and international tech-intensive value-chains**
 - Kick-off of the ATTRACT DIH (Digital Innovation Hub for Artificial Intelligence and High-Performance Computing, coordinated by INESC TEC), a European project that aims to help companies embrace digital transformation at lower costs, with an emphasis on AI and HPC solutions. Active participation in the DigitalBuilt and PRODUTECH DIHs.
- **C3.4. Promote our pro-active participation in R&I agenda-setting at regional, national and EU level**
 - INESC TEC's research priorities in manufacturing, communications, sea, agro-food, energy, bioengineering were prominently represented in high-level and expert groups, through INESC Brussels HUB. This strategic positioning allowed INESC TEC to directly influence EU agenda-setting in these critical areas and position itself in key projects and initiatives;
 - A working group was convened to develop a comprehensive strategy for participation in the Chips Act dynamics. Throughout the year, contacts with both national and international partners were organised by the group, promoting collaborations and aligning objectives. Additionally, a contribution to the National Semiconductor Strategy was prepared, seeking to ensure that insights and proposals from the institute were integrated into broader efforts.
- **C3.5. Increase our international networking, leadership and competitiveness**
 - 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 activity of the Hub is detailed in Section 3.5.2;
 - 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;
 - Consolidation of INESC P&D Brasil's operation, with a consistent trajectory of growth and overcoming challenges since its inception in 2012 (the institution had 27 R&D projects in progress in 2023);
 - Active participation in projects and activities of the European Knowledge and Innovation Communities (KICs) EIT Raw Materials and EIT Manufacturing;
 - Participation of INESC TEC researchers in international exchange mobility programs, namely with Taiwan (NARLabs – National Applied Research Laboratories) and Japan (NII – National Institute of Informatics);
 - Strengthening of the participation as a member in international organisations (15+), in broadened geographies, and the collaboration with international partners (Memoranda of Understanding, R&D contracts, researchers exchange programmes, etc);
 - Establishment of close collaboration mechanisms and protocols with international leading organisations, such as Sintef Norway and GCE Ocean;

- Monitoring of INESC TEC's strategy for successful participation in the European calls, especially in the scope of the Horizon Europe programme;
- INESC TEC researchers benefited from specialised training sessions held by INESC Brussels Hub aimed at building skills for successful EU project applications, further boosting the institute's funding acquisition capabilities.

C4. Cultivate an attractive, people-centred and talented community.

- **C4.1. Improve attraction and retention of world-class talent**
 - The implementation of a new model for Human Resources management continued in 2023. For that purpose, the work on job descriptions and competences, performance appraisal, training, career development, recruitment, onboarding, and employee life cycle went on, as detailed in Section 9.4;
 - Maintenance of a hybrid work model where co-workers can alternate between remote work and in person work.
- **C4.2. Ensure opportunities and recognition for career achievements**
 - Reinforcement of the implementation of research careers namely through the progressive consolidation of the document "Guidelines for INESC TEC's new Career Policy".
- **C4.3. Expand the diversity of our community**
 - Support of the initiatives of the Diversity and Inclusion Commission focused on gender equality, interculturality, accessibility and age diversity as described in greater detail in Section 3.4.2;
 - Second edition of the INESC TEC International Visiting Researcher Programme, providing the opportunity to 15 researchers from institutions abroad to conduct research activities at INESC TEC for up to three months while maintaining their affiliation with their home institutions.
- **C4.4. Provide a more dynamic and fulfilling working environment**
 - Promotion of several initiatives by INESC TEC's Committees to foster a sense of cohesion and community, such as INESC TEC on foot, INESC TEC on the move, INESC TEC having (fun)mily, Strategic Meeting, Roasted Chestnuts Party, and INESC TEC Season Party;
 - Improvement of the working conditions in several labs and premises of INESC TEC buildings;
 - Implementation of the 4-day week pilot, from June to November 2023, within the context of the national initiative launched by the Portuguese government, with INESC TEC being the sole R&D institution participating;
 - Definition and presentation of the new INESC TEC training policy;
- **C4.5. Strengthen our commitment to independence and compliance of research with ethical principles**
 - Continuous support and empowerment of the internal Commissions and Committees dedicated to ethics, conflict of interest management, social responsibility, data protection and anti-corruption compliance. Their activities in 2023 are detailed in Sections 3.3, 3.4 and 3.5.

C5. Strive for a sound, sustainable and effective operational model.

- **C5.1. Strengthen the sustainability and resilience of our economic model**
 - Intensive participation in the calls of the Horizon Europe programme, with 93 proposals submitted; 2 EUROHPC proposals submitted in the Digital Europe Programme and 4 proposals presented in the European Defence Fund;
 - Kick-off of 29 PRR projects: 22 mobilising agendas, 3 bioeconomy agendas, 3 agriculture agendas and 1 infrastructure;

- INESC TEC's recognition as a Technology and Innovation Centre, including a multi-annual base funding for three years, focused on capacity-building and promotion of activities closer to the market;
- Diligence and coordination with other INESC entities aiming for the replacement of the current Accounting and Financial information system.
- **C5.2. Promote and contribute to environmental sustainability**
 - Allocation of funding and training, aimed at enhancing competencies in sustainability certification, with the objective of establishing and developing a sustainability area at INESC TEC.
- **C5.3. Improve quality, management and usage of our infrastructures**
 - Continuous investment and support to develop our research infrastructures and laboratories. Some featured examples are detailed in Section 7 of this report;
 - New facilities for iiLab – Industry and Innovation Lab at PORTIC, a P.Porto building;
 - Launch of the public tender (4.9M€) for the construction of the Leixões Blue Hub (HAL), a scientific, technological and innovation infrastructure, funded under the PRR, and aimed at the sustainable development of the Blue Economy. Its implementation is being ensured by a consortium, led by INESC TEC, and that brings together the Municipality of Matosinhos, CIIMAR, INEGI, Fórum Oceano and APDL. The Leixões Blue Hub – I is one of the eight hubs that are part of the Blue Hub Portugal Network.
 - Participation and support to 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);
 - Full upgrade of INESC TEC's Wi-Fi infrastructure to an IEEE 802.11ax ("Wi-Fi 6") capable solution, expansion of INESC TEC's headquarters' main datacentre, improvements on the headquarters' secondary datacentre and leveraging of the off-site disaster recovery infrastructure located at U. Minho.
- **C5.4. Strengthen the distinctive aspects of our institutional model**
 - Conclusion of the preparation of INESC TEC's Strategic Plan for 2023-2030, that allowed for the integration, alignment and planning of different components of the institution's strategy, instrumental to address INESC TEC's increasing dimension and complexity, as a result of the strong growth experienced in recent years, as well as the intensification of external interventions in response to stakeholders' requests and expectations;
 - Conclusion of the review of INESC TEC's managed science model, by proceeding with the implementation of the new organisation of Research Domains and by fostering their closer strategic integration with the two key internal R&D organisational units – Centres and TEC4s;
 - New composition of the Business Advisory Board for the five-year period 2023/2027 and convening of its first working meeting;
 - Expansion of the use of the recently implemented Customer Relationship Management system.

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

- Between 2017 and 2023, INESC TEC has had a presence in the Top 10 of the European Patent Office's national "Patent Index ". INESC TEC is one of the few national entities to appear in the ranking year after year, as the result of a sustainable IP portfolio management strategy. It is within the institution's strategy to continue aiming for this top 10, in line with a commitment to the quality of its patent applications and, above all, their orientation towards benefiting society.

- “*Mar Sustentável*” Award in the “Science and Technology” category promoted by Jornal de Negócios and Fórum Oceano, with the sponsorship of the Municipality of Oeiras and the institutional support by the Office of the Secretary of State for Maritime Affairs, an initiative that aims to advance, encourage, and improve the development of the different Ocean sectors.
- Thirteen INESC TEC researchers were among the world’s best in four scientific areas in the ranking, published by Stanford University, and that includes the top 2% of scientists worldwide. The researchers represented four scientific areas at INESC TEC: Artificial Intelligence and Image Processing (two), Energy (five), Optoelectronics and Photonics (five) and Computer Hardware and Architecture (one).
- INESC TEC won third place in the Innovation Prize of EARTO (European Association of Research and Technology Organisations), with MyNPK, a smart photonics solution that combines spectroscopy and Artificial Intelligence to quantify nitrogen, phosphorus, and potassium (NPK) in liquid fertilisers – in situ and in real time. The technology allows to manage and optimise the use of fertilisers according to the plants’ nutritional needs. INESC TEC was the only Portuguese entity among the winners of the 2023 edition of the EARTO Innovation Awards.

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 Anti-corruption Compliance Officer

Officer: Ana Maria Mendonça

Presentation

The Regulatory Compliance Programme for the Prevention of Corruption, whose implementation is mandatory by law, includes the appointment of an anti-corruption compliance officer, who ensures and controls the application of said Programme and performs her duties independently, permanently and with decision-making autonomy.

At INESC TEC, the anti-corruption compliance officer also takes on the duties of implementation, control and review of the Risk Prevention Plan (PPR), which is an integral part of the above-referred Programme.

Highlights in 2023

During 2023, the first version of the Compliance Programme for the Prevention of Corruption, that was approved in 7 June, 2022, was reviewed and consolidated, mainly with regard to the identification of preventive and corrective measures. To this end, meetings were held with the INESC TEC's services' managers involved in the identified processes, who validated the risks previously acknowledged and added new situations of potential risk, as well as the corresponding preventive measures.

The Training Plan, that is part of the Compliance Programme, started with, an awareness raising training action on the subject of "General Regime for the Prevention of Corruption and the Whistleblower Protection Regime". This training was aimed at all members of INESC TEC's management, including members of the Board of Directors, research centres' coordinators and services' managers. This training action was organised in two editions, in July and in September.

An improved version of the reporting channel on corruption and breaches of EU law was also developed during the second semester.

In December, the final versions of the Compliance Programme for the Prevention of Corruption and of the Reporting channel were presented in a Centres' Council meeting, preceding the general presentation that will occur in 2024.

3.3.2 Data Protection Officer

Data Protection Officer: Vasco Rosa Dias

Presentation

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

Highlights in 2023

- Monitoring of the implementation, updates and awareness raising of the approved data protection internal procedures.
- Following up of the implementation of the new tool for the assessment and monitoring of Data Protection Agreements and updated inventory of DPAs in force.
- A large number of data processing and joint controllership agreements was negotiated and implemented.
- Design of model master data processing agreements that are also being negotiated with health and academic institutions.
- 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. Occasional participation in Privacy related activities of EU projects.
- Monitoring of data protection related aspects of Data Management Plans in several H2020 projects, in articulation with AG.
- Strengthening of the training plan for staff members and researchers, including the launch of a second version and an English version of the online course on Moodle and several contents covering important data protection aspects of INESC TEC's activity.
- Continuity of the awareness-raising initiatives, including the participation in an externally financed project (CAPIES/ SAMA project) comprising the supply to U.Porto of specialised consultancy services in training and mentoring in the area of data protection and an adapted version of INESC TEC online course on data protection.
- Issuing and dissemination of guidelines and policies, e.g. on processing personal data collected through forms and interviews.
- Issuing of DPO's opinions and recommendations in English version for wider dissemination at INESC TEC community.
- 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 (e.g. INESC TEC's website). Planning of complementary auditing activities. Creation of support materials and procedures for these internal audits.
- 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 Committee for Conflicts of Interest Management has the responsibility to ensure compliance throughout the Institution, namely by:

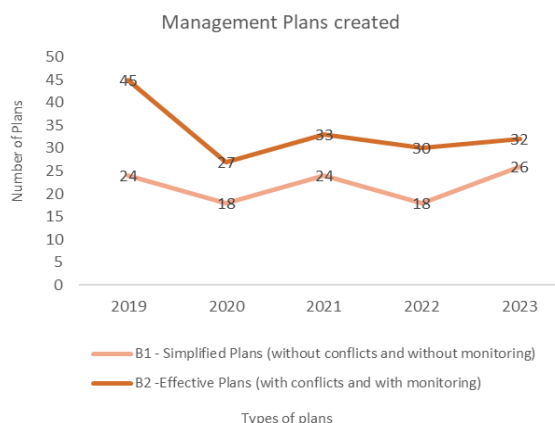
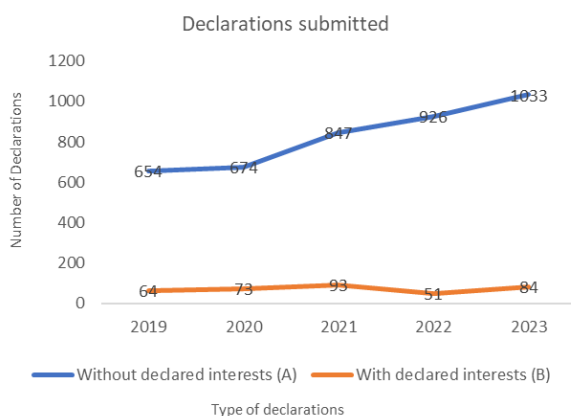
- Assessing the declarations of interests and identifying the conflicts of interest;
- Agreeing with the collaborator on the terms and proposing to the Board of Directors management plans for identified conflicts of interest, in order to reduce or eliminate those conflicts;
- Informing the collaborators 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 2023

During 2023, 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;
- Disseminating relevant guidelines regarding the Conflict of Interest Management Policy within the intranet area or by specific messages through the commission mailbox;
- Ensuring continuous improvement of the IT platform, enhancing the process of managing and controlling conflicts of interest, especially by conducting tests in the new feature to support monitoring report filling;
- Developing training documents for PGCI monitors, considering the training sessions scheduled for the first quarter of 2024;
- Receiving, assessing, and processing the Declarations of Interest submitted by employees and ensuring the processing and monitoring of Management Plans.

Main activity indicators are the following:



It should be noted that 26 declarations were initially classified by the collaborator as type B (with declared interests) due to incorrect declaration fulfilment on the platform. All were duly identified, resubmitted, and appropriately addressed as type A (without interests).

3.4.2 Diversity and Inclusion Commission

Chairperson: Ana Sequeira

Presentation

The INESC TEC Board of Directors established the Diversity and Inclusion (D&I) Commission in September 2021. This commission is currently chaired by Ana Filipa Sequeira, who replaced Beatriz Oliveira from November 2023. Throughout 2023, the D&I was composed of diverse INESC TEC collaborators: Ana Lopes, Tiago Silva, Tiago Gonçalves and Rita Costa. The commission's work is supported by the Internal Advisory Group - a representative set of collaborators contributing through brainstorming, discussion, and validation; and the External Advisory Group – a set of key players in the D&I field providing strategic counselling.

Highlights in 2023

In 2023, INESC TEC's Diversity and Inclusion Commission (D&I) focused on raising awareness, developing skills, monitoring the D&I landscape, and promoting events in the three priority areas: 1) **Gender equality**; 2) **Interculturality** and 3) **Accessibility**.

Report, presentation and discussion of the 2nd D&I Survey results: On November 10th, the most relevant results of the 2nd edition of the survey developed by D&I for the entire INESC TEC community were presented. Additionally, comparative data between the 1st and 2nd edition were presented, highlighting the indicators that showed positive development and the indicators that showed fewer positive results compared to the 1st edition.

D&I Internal Advisory Group: D&I challenged the INESC TEC community to express interest in joining D&I's internal advisory group. Due to the constant entry and exit of researchers and staff not dedicated to research at INESC TEC, this flow equally affects both the composition of the internal advisory group and the composition of the D&I itself. Given the departure of several members of D&I's internal advisory group, there was a call within the INESC TEC community to express the interest in belonging to this group. In result, new elements were integrated into the internal advisory group.

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

- **Training:** i) *Portuguese Sign Language Workshop (two editions: 24th of January and 2nd of November):* In this event, open to the entire community and held in Portuguese, participants were challenged to enter the world of Portuguese Sign Language (PSL) and learn the most common gestures in PSL. ii) *1st Workshop of Self-defense for ALL (July 25th):* At this event, the entire INESC TEC community was challenged to learn self-defence techniques. Due to the high number of registrants, D&I had to organised two shifts and the initiative was a success.
- **Events:** i) *World Braille Day (5th January):* A technician from ACAPO presented and demonstrated the use of Braille. Participants were challenged to write their name on a Braille machine and took home a personalised bookmark as a souvenir. This initiative aimed to present Braille as an alternative language that blind people can use to read and write. ii) *Eid al-Fitr (5th of May):* The entire community was invited to participate in this celebration, which marks the end of the Ramadan period. This initiative had a strong multicultural support, was marked by a rich exchange of cultural gestures, the opportunity to enjoy some Middle Eastern cuisine and to socialise with people from more than 10 different nationalities. iii) *Mobility for Blind People (June 27):* In this event, the participants were invited to know more and experience what mobility means for blind people, using white canes.
- **Communications:** *International Mother Language Day (February 15); PWIT Women's Mentorship Program #4 (February 23); D&I Summer Reading List (June 21); White Cane Safety Day (October 15); D&I highlights at the INESC TEC Season Party 2023 (December 13).*
- **Awards:** the D&I applied for the award "Selo da Diversidade", promoted by Associação Portuguesa para a Diversidade e Inclusão (APPDI), under the scope of "Promoting interculturality", with the initiative "Sharing Celebrations for Building Community". This initiative consisted of the systematic sharing of important national/religious celebrations of diverse communities inside our institution, through an informative email with several testimonials.

3.4.3 Technical Committee for Social Responsibility

Chairperson: Joana Coelho

Presentation

Social Responsibility is “a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis”, as defined by the European Commission in 2011. The Technical Committee for Social Responsibility was created with the goal of working on INESC TEC's philanthropic dimension from an internal point of view, i.e., issues related to the institution itself and its employees; and from an external point of view, i.e., how INESC TEC can support the local community.

Highlights in 2023

In 2023, the main highlights of the commission were:

External dimension:

- Establishment of a protocol with the European Recycling Platform for the collection of electronic waste;
- Enrolment in the “Healthy Workplaces Campaign 2023-2025 - Safe and healthy work” campaign promoted by the European Agency for Safety & Health at Work in the digital age; and participation in the national Kick off meeting in Braga;
- Participation in Wellbeing Games Edition of 2023;
- Celebration of the “World Health and Safety at Work Day” with a thematic video presentation and organisation of a training session – “Técnicas Básicas de Utilização dos Meios de Primeira Intervenção – Extintores” with the Aguda Volunteer Fire Brigade;
- Preparation of the initiative “Levar a Ciência ao IPO do Porto”, that started in 2024, which aims to share the research carried out at INESC TEC with children undergoing in hospital treatment;
- Promotion of volunteerism “Dia do Voluntariado” to encourage the participation in community service or charitable activities;
- Promotion of a series of campaigns, namely:
 - Blood donation campaign, in line with the growing need in Hospitals;
 - Celebration of the “World Children's Day” with a specific initiative to collect goods.
 - Christmas donation campaign.

Internal dimension:

- Organisation of a series of workshops to target some of the dimensions identified as a priority in what concerns the employees, namely:
 - Laboral gymnastics Workshop;
 - Organisation of a talk session “How to embrace wellbeing & performance” targeted to INESC TEC managers;
- Participation in the appreciation of the internal code of conduct, following the premises of SC linked with the organisational principles;
- Internal 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, following the environmental principles.

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 news pieces throughout the social responsibility section on BIP INESC TEC Magazine, that were also shared on the social media channels of INESC TEC.

3.4.4 Ethics Committee

Chairperson: Pedro Guedes de Oliveira

Presentation

The Ethics Committee (EC) was appointed by the Board of INESC TEC in 2022, after consulting with the Scientific Board, and 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. It also integrates Susana Magalhães, who holds a 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 2023

In 2023 the IT supporting tools for project leaders to submit their ethics questionnaires, online —whenever their projects deal with human beings or personal data but also if they involved artificial intelligence or autonomous systems—, have come to a regular and intense use. This is the base for the EC to make its first appraisal of the projects and clear them if the answers are within the expectations and no special issues are identified.

The experience gained along the year with the use of these tools has led to several changes, to improve the system and make it more user friendly.

The members of the EC have met frequently, not only to discuss aspects that were raised by the projects but also to assess the methods and instruments in use. In various circumstances a dialog has been established with the principal investigators (PIs), in order to clarify possible doubts or to improve accompanying documents, as e.g. informed consent to be signed by the participants in the projects. No projects have been refused, on ethical grounds, so far.

To simplify the PI's task, a template for the informed consent was developed, as well as another template to request a formal opinion of the EC, being it to accompany a submission for approval or publication. Up to the end of 2023, six requests for an EC opinion had been submitted and answered.

The fact that the issues raised by data protection and ethics are often close, has led to a frequent contact between the two bodies, which was made easier by the fact that one of the members of the EC is also INESC TEC DPO.

Finally, the EC has kept track with the national and international practices concerning ethical issues in research, especially the particular attention raised by the use of AI. Any position papers or legislation deemed relevant, were made available on INESC TEC Ethics Committee site.

We have to express our thanks to INESC TEC researchers for their reasonable and attentive behaviour, which have made our task easy and rewarding.

3.5 Other institutional initiatives

3.5.1 Public Policy Office

Team: José Manuel Mendonça, João Claro, Carolina Pedrosa, Sara Brandão

Presentation

The Public Policy Office's mission is to advance INESC TEC's policy engagement, collaborating with our community to develop and implement bespoke engagement strategies with impact, at individual, group, and institutional levels. We offer support, services, and programs to enhance our community's policy impact.

To accomplish this mission, the office's activities are organised according to the following action lines:

- Identify and disseminate recent and current contributions.
- Connect and raise the impact on public policy dynamics.
- Support the design and enactment of strategies for policy development and engagement.
- Experiment and innovate with approaches to policy engagement.

Highlights in 2023

The Public Policy Office had two main objectives for its activities in 2023: (1) set up operations to disseminate policy contributions; and (2) undertake a policy contribution dissemination proof of concept.

Contributing to the former, the office: (1.1) developed a Science4Policy repository that will be fully available and operational in early 2024; (1.2) actively worked on the institutional embedment of a policy impact framework and culture through multiple meetings with internal and external stakeholders and the organisation of a training event with PlanAPP for 17 members of INESC TEC; (1.3) and developed the concept for a website section and a newsletter, to be implemented jointly with INESC TEC's new website.

Towards the latter, the office: (2.1) worked on two policy briefs, one with contributions of a scientific nature and the other focused on institutional contributions, to be published and disseminated in early 2024; (2.2) identified and defined a dissemination strategy regarding publications with potential policy impact to be included in the repository; (2.3) started the fieldwork to develop an impact case study related to the contribution of INESC TEC to the sustainability transition; and (2.4) was involved in multiple interactions for the development of engagement strategies.

As a result of this activity, the office also established its methodology for producing policy briefs and impact case studies, as well as a set of processes for impact communication and digital dissemination. With significant progress along all its main Action Lines, in 2023 the office contributed to a more vibrant Science-Policy interface at INESC TEC and to advancing the institute's mission with a focus on the empowerment of public policies that make a difference in our economy and society.

3.5.2 INESC Brussels Hub

Coordinator: Ricardo Miguéis

Presentation

INESC Brussels HUB represents a strategic initiative by the INESC institutes to strengthen their presence and impact within the European Union's research and innovation ecosystem. Established as the first Portuguese research and innovation (R&I) representation in Brussels, the HUB embodies a commitment to excellence, collaboration, and innovation. Its creation marks a significant step in aligning INESC's vast expertise across various domains with the priorities and funding mechanisms of the EU.

Highlights in 2023

EU Representation and Networking

- **Strategic Engagement:** INESC TEC benefited significantly from INESC Brussels HUB's involvement in EARTO, enhancing our networking capabilities with vital EU stakeholders and collaboration opportunities. The HUB's participation in key networks such as IGLO and the CRIQUE network has broadened INESC TEC's collaborative landscape across Europe.
- **Project Meetings Hosted:** The HUB's role in facilitating over 15 EU project meetings was pivotal for INESC TEC, offering platforms for direct engagement with project partners and showcasing INESC TEC's leadership in European research initiatives.

Research & Innovation Policy Influence

- **Policy Engagement and Influence:** INESC TEC's research priorities in manufacturing, communications, sea, agri-food, energy, bioengineering were prominently represented in high-level and expert groups, thanks to INESC Brussels HUB. This strategic positioning allowed INESC TEC to directly influence EU agenda-setting in these critical areas and position itself in key projects and initiatives.
- **Policy Advocacy:** INESC Brussels HUB developed policy and intelligence briefs that reflected INESC TEC's research focus, advocating for EU policies that support our research and innovation objectives.
- **R&I Trends Analysis:** INESC TEC leveraged the HUB's insights into the evolving EU R&I landscape, ensuring our strategic alignment with emerging opportunities and challenges in the European research ecosystem.

Capacity Building & Skills Development

- **SEPP Tool for INESC TEC:** The introduction of the SEPP tool marked a significant advancement for INESC TEC researchers, streamlining the process of identifying EU funding opportunities that align with their research interests and enhancing INESC TEC's success rate in securing EU projects.
- **Targeted Trainings:** INESC TEC researchers benefited from specialised training sessions aimed at building skills for successful EU project applications, further boosting our institute's funding acquisition capabilities.

Communication and Dissemination

- **Website and Morning Brief Revamp:** INESC TEC's achievements and updates were prominently featured in the continuous publication of the Morning Brief and through the revamped INESC Brussels HUB website, ensuring our research community stayed informed and engaged.
- **Thought Leadership through External Events:** Participation in external events, notably with our media partner, Science Business, positioned INESC TEC as a thought leader in our research domains. These engagements were instrumental in raising the visibility of INESC TEC's contributions to EU-funded projects and research innovation.

3.6 Human Resources

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 2021. The number of researchers with PhDs is also shown (381 at the end of 2023).

It should be noted that, in terms of Full-Time Equivalent (FTE) measures, INESC TEC employees have typically a FTE corresponding to 100%, while academic staff usually have a 50% FTE and affiliated researchers 20% FTE. Grant holders FTE are variable, depending on the type of grant, ranging usually from 30% in master students up to 100% in post-docs.

Table 3.1 - Evolution of Human Resources

Type of Human Resources			2021	2022	2023	Δ 2022-23	
Integrated HR	Core Research Team	Employees	159	189	238	49	26%
		Academic Staff	174	185	187	2	1%
		Grant Holders and Trainees	324	354	400	46	13%
		Total Core Researchers	657	728	825	97	13%
		Total Core PhD	255	272	290	18	7%
	Affiliated Researchers		67	73	66	-7	-10%
	Administrative and Technical	Employees	102	115	126	11	10%
		Academic Staff	11	10	9	-1	-10%
		Grant Holders and Trainees	6	6	2	-4	-67%
		Total Mgmt, Admin and Tech	119	131	137	6	5%
	Total Integrated HR		843	932	1028	96	10%
	Total Integrated PhD		342	364	381	17	5%
Curricular Trainees		35	16	10	-6	-38%	
External Research Collaborators		247	241	249	8	3%	
External Administrative and Technical Staff		8	9	11	2	22%	
External Students		169	239	238	-1	0%	
Total		1302	1437	1536	99	7%	

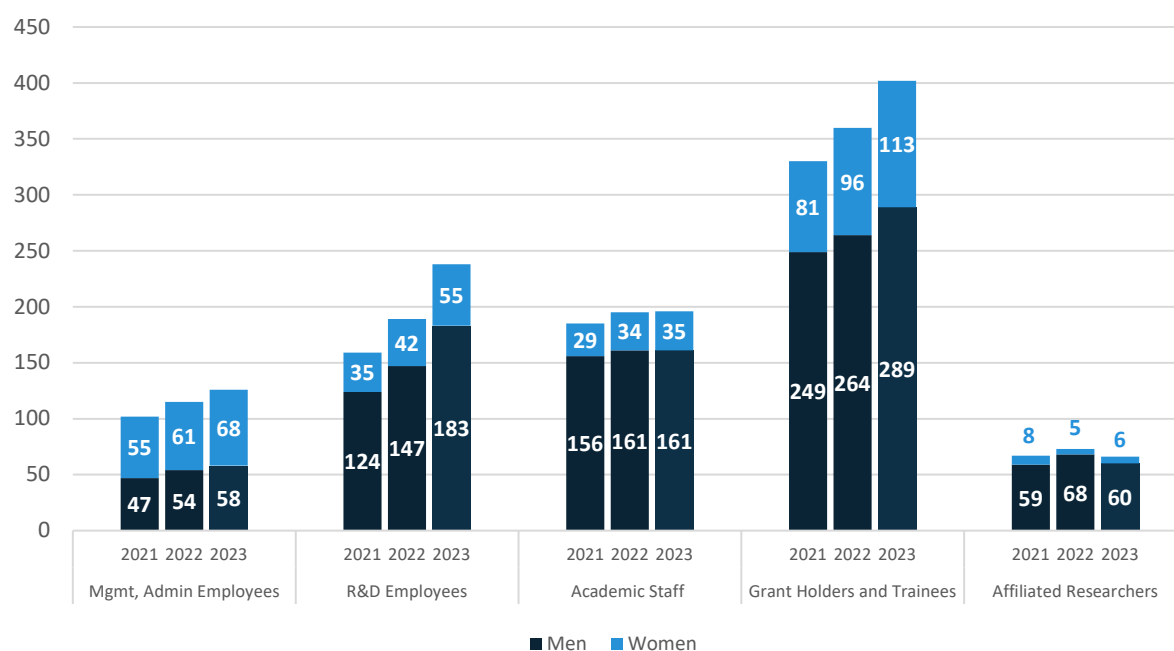


Figure 3.1 - Evolution of Human Resources

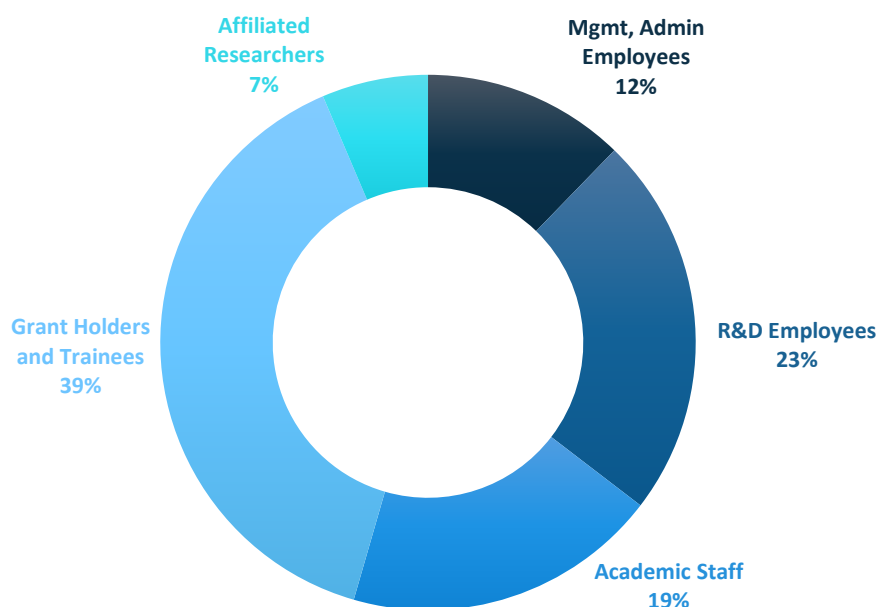


Figure 3.2 - Distribution of Human Resources



As seen in Figure 3.2, grant holders and trainees remain the largest human resources group (39%) at INESC TEC, showing a growth trend (Figure 3.1). However, the most significant surge was observed in the count of R&D employees (26% in 2023), notably comprising PhD researchers. This growth aligns with INESC TEC's strategy to recruit talent in pivotal areas and is in line with the Portuguese Government's policy on scientific employment.

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.

The team composition closely adhered to the profile outlined in the 2023 plan, with the number of grant holders exceeding the projected figure. This outcome was anticipated, as the projected number is typically conservative, reflecting only ongoing projects and those anticipated with a certain degree of certainty for 2023. However, the total count of R&D employees slightly fell short of 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 (27% for Integrated HR and 23% for Integrated Researchers). This and other dimensions have been analysed by the Diversity and Inclusion Commission and are being addressed in the Gender Equality Plan in implementation (please refer to Section 3.4.2 for further information).

R&D Centres Indicators

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

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

Type of Human Resources			Total R&D Centres	R&D Centres														Special Projects
				CTM	CAP	CRAS	CBER	CPES	CESE	CRIS	CEGI	CITE	HUMANISE	LJAAD	CRACS	HASLAB		
Integrated HR	Core Research Team	Employees	238	13	15	28	4	63	30	25	13	7	19	11	2	8		
		Academic Staff	187	15	7	11	6	9	6	13	18	2	36	23	16	25		
		Grant Holders and Trainees	400	65	16	40	25	47	16	41	29	3	35	23	14	46		
		Total Core Researchers	825	93	38	79	35	119	52	79	60	12	90	57	32	79		
		Total Core PhD	290	24	19	17	8	31	16	22	29	6	41	31	17	29		
	Affiliated Researchers		66	10	2		1	2	9	1	5	2	21	7		6		
	Administrative and Technical	Employees	25	1	1	5	1	2	2	3	1		1	1		5	2	
		Total Admin and Tech	25	1	1	5	1	2	2	3	1		1	1		5	2	
	Total Integrated HR		916	104	41	84	37	123	63	83	66	14	112	65	32	90	2	
	Total Integrated PhD		357	34	21	17	9	33	25	23	34	8	62	38	17	35	1	
Curricular Trainees			10	1		1			2	2	1	3						
External Researchers			225	29	5	5	14	23	14	17	20	11	27	34	6	17	3	
External Administrative and Technical Staff			6				1	1		1	2	1						
External Students			238	57	12	4	13	9	7	8	11	1	47	25	3	41		
Total			1 395	191	58	94	65	156	86	111	100	30	186	124	41	148	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 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

Support Services Indicators

The Human Resources figures by the end of 2023 for the Board of Directors, the TEC4 teams, and the Support Services are provided in Table 3.3.

Table 3.3 - Human Resources by type and Service

Type of Human Resources		Total	Board and Advisors	Business Development Services						Support Services					Technical Support Services			
				TEC4	SAL	SAAF	SRI	SCOM	DPO	AG	AJ	CF	CG	RH	SAS	SIG	SRC	SGI
Integrated HR	Employees	101	17	7	3	2	5	8	2	3	2	9	12	8	4	8	4	7
	Academic Staff	9	6	3														
	Grant Holders and Trainees	2		1											1			
	Affiliated Researchers																	
	Total Integrated HR	112	23	11	3	2	5	8	2	3	2	9	12	8	5	8	4	7
	Total Integrated PhD	24	12	6	3					1	1	1						

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

3.7 Activity in Projects

Global Indicators

Table 3.4 shows the breakdown of INESC TEC's funding sources and the evolution from 2019 to 2023.

Table 3.4 - Funding sources and evolution

Sources			Value (k€)					Δ (k€ %)	
			2019	2020	2021	2022	2023	2022-23	
Projects	PN-FCT	National R&D Programmes - FCT	3 677	3 524	2 295	1 522	1 428	-94	-6%
	PN-PICT	National R&D Programmes - S&T Integrated Projects	468	22	49	154	103	-51	-33%
	PN-COOP	National Cooperation Programmes with Industry	928	1 250	2 189	3 720	7 507	3 787	102%
	PUE-FP	EU Framework Programmes	3 910	4 903	5 529	7 642	9 273	1 631	21%
	PUE-DIV	EU Cooperation Programmes - Other	713	300	449	534	590	56	11%
	SERV-NAC	R&D Services and Consulting - National	2 527	2 899	3 519	3 527	2 726	-801	-23%
	SERV-INT	R&D Services and Consulting - International	410	547	678	326	579	253	78%
	OP	Other Funding Programmes	1 067	955	560	713	797	84	12%
	Closed Projects		185	0					
	Total Projects		13 884	14 399	15 270	18 137	23 003	4 865	27%
National Strategic Programme - Pluriannual			2 307	2 396	2 257	3 062	2 442	-620	-20%
National Strategic Programme - RHAQ			0	289	520	507	128	-379	-75%
National Strategic Programme - EEC			368	460	484	509	732	223	44%
National Strategic Programme - CIT			961	599	836	28	1 461	1 433	5204%
National Strategic Programmes - Other			73	10	241	350	584	234	67%
Other Revenues			375	102	520	443	469	26	6%
Total Revenues			17 966	18 255	20 127	23 036	28 819	5 783	25%

Figure 3.3 illustrates the distribution of funding for the projects carried out in 2023, and its evolution since 2019. 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.

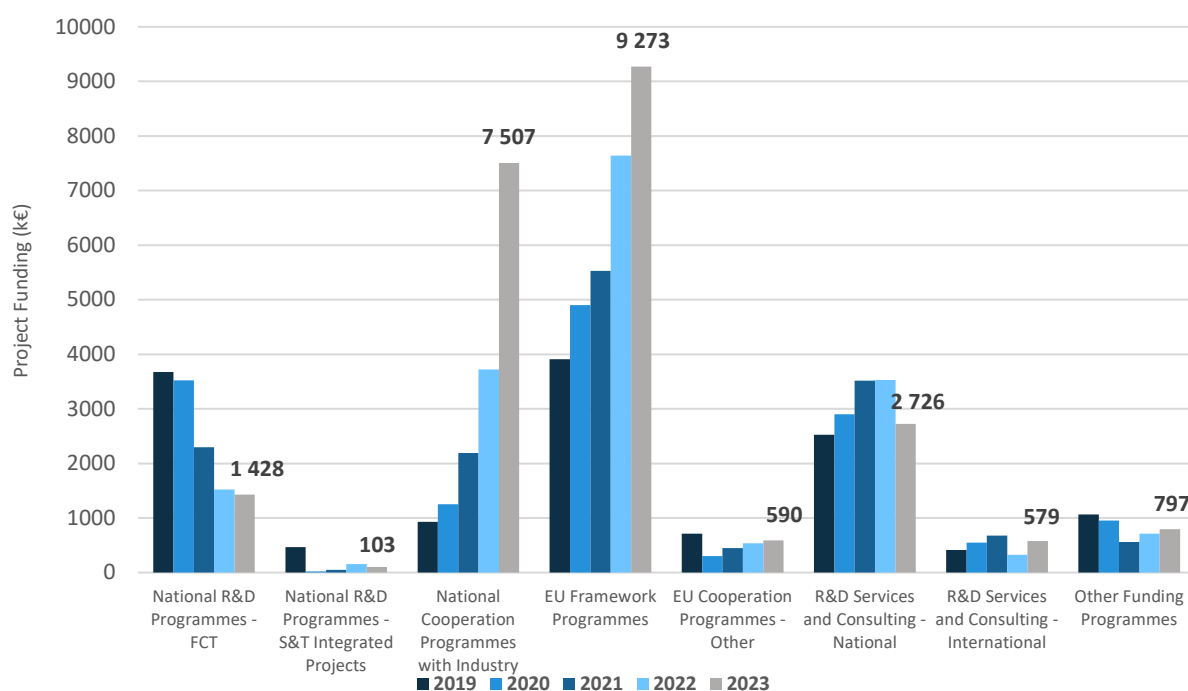


Figure 3.3 - Evolution of project funding by source (k€)

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

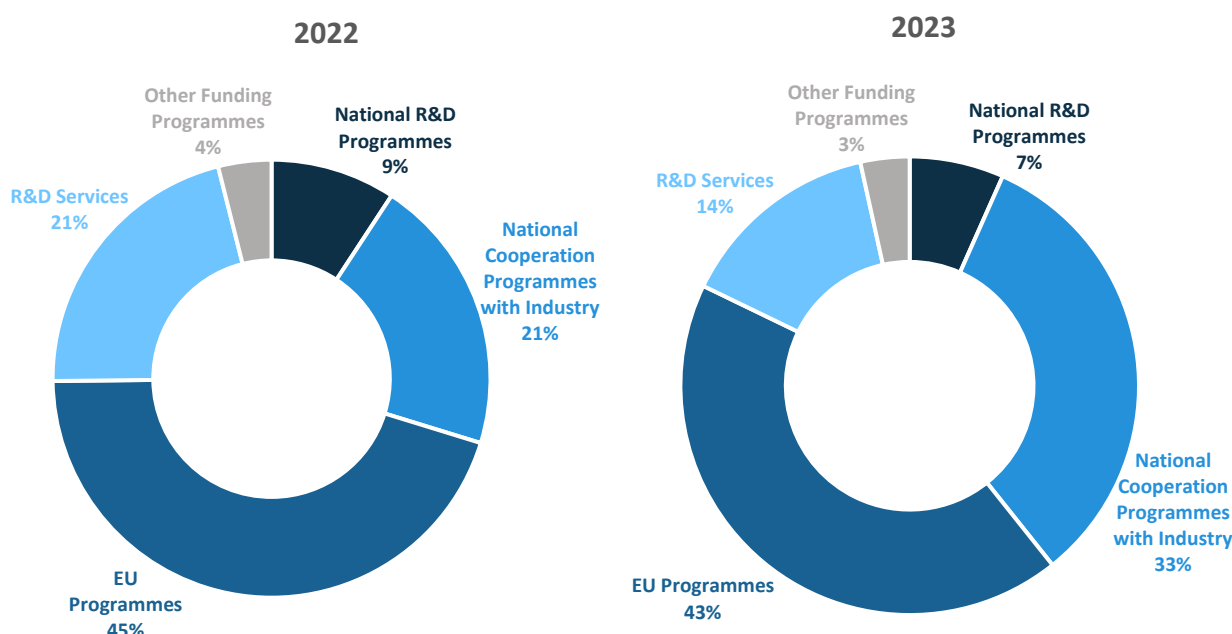


Figure 3.4 - Distribution of project funding by source – 2022 and 2023

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

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

Type of Project		Number of Active Projects					Δ (%)	Average Funding (k€)	
		2019	2020	2021	2022	2023		2022	2023
PN-FCT	National R&D Programmes - FCT	74	68	61	48	33	-15	32	43
PN-PICT	National R&D Programmes - S&T Integrated Projects	10	0	1	1	1	0	154	103
PN-COOP	National Cooperation Programmes with Industry	21	33	46	63	71	8	59	106
PUE-FP	EU Framework Programmes	48	72	67	76	96	20	101	97
PUE-DIV	EU Cooperation Programmes - Other	20	18	15	21	19	-2	25	31
SERV-NAC	R&D Services and Consulting - National	121	126	125	121	116	-5	29	24
SERV-INT	R&D Services and Consulting - International	13	20	20	16	25	9	20	23
OP	Other Funding Programmes	31	40	27	18	19	1	40	42
Total		338	377	362	364	380	16	50	61

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 29 M€, consolidating the continuous growth observed in previous years, with an increase in its level of activity of about 25%, and 380 active R&D projects during the year;

- It was possible to keep a certain balance between the different funding sources, with an increase in European funding Programmes, as well as in National R&D Programmes, that somehow compensated for the reduction in FCT projects, R&D Services and other funding programmes;
- The most noticeable increase was observed in the National Cooperation Programmes with Industry (102%), mainly related to the approval and start of the 22 mobilising agendas supported by the Portuguese Recovery and Resilience Plan (PRR), with a total funding of 5.7 M€;
- The decline in FCT project funding can be related to the conclusion of multiple projects and to the delay in the opening of new calls for funding. The reduction of activity in R&D Services is mainly related with the high involvement of companies in the PRR agendas and the delayed start of the P2030 programme, which has led companies to postpone new R&D contracts;
- The National Strategic Programme, known as the "Pluriannual," represents 8% of the overall funding sources. Despite its relatively small share of total funding, its significance lies in its flexibility and stability. The institution greatly leverages this program in its activities;
- The base funding for technology transfer activities, "CTI" (1.5 M€) started in 2023, being of significant importance since it is a multi-annual base funding for technology transfer capabilities and activities;
- The average funding per project of National Cooperation Programmes has now surpassed that of EU Framework Projects, since the PRR agendas are indeed projects with significant dimension. R&D and Consulting Services projects, typically shorter in duration, tend to feature below-average funding per project.

R&D Centres Indicators

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

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

Funding Source		Total (k€)	R&D Centres													
			CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	HUMANISE	LIAAD	CRACS	HASLAB	Special Projects
Projects	PN-FCT	1 428	103	113	566	99	84	21	19	165	0	59	96	0	106	0
	PN-PICT	103	32	0	0	0	70	0	0	0	0	0	0	0	0	0
	PN-COOP	7 507	671	287	843	83	1 083	1 367	1 416	239	126	701	314	19	357	0
	PUE-FP	9 273	983	169	1 769	98	2 831	550	875	512	212	623	106	84	370	93
	PUE-DIV	590	9	4	276	0	2	-1	-1	0	54	147	16	34	27	22
	SERV-NAC	2 726	235	5	68	10	1 044	225	177	35	2	470	63	93	269	32
	SERV-INT	579	0	14	124	163	168	64	9	0	28	0	0	0	5	5
	OP	797	5	89	0	7	11	2	6	-2	0	0	14	0	193	472
Total Funding		23 003	2 037	680	3 646	460	5 293	2 227	2 500	949	422	2 001	608	230	1 326	624

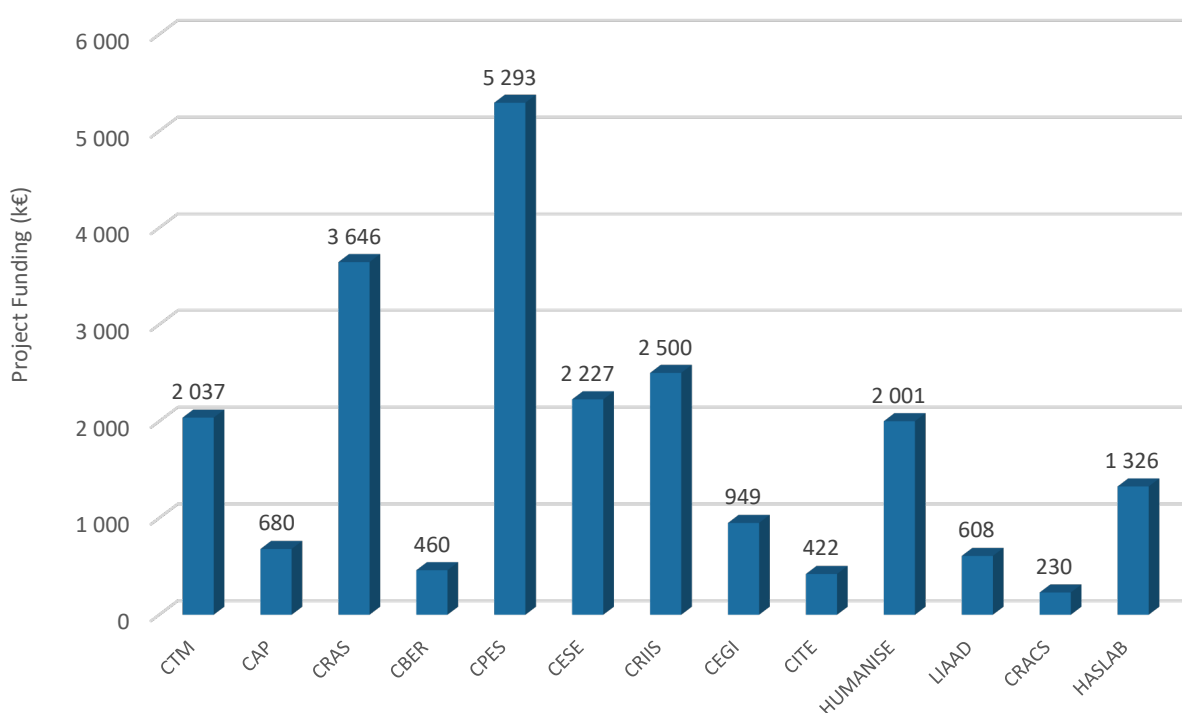


Figure 3.5 - Total Project Funding per R&D Centre (k€)

3.8 Publications

Global Indicators

Table 3.7 and Figure 3.6 show the number of INESC TEC publications and their evolution between 2019 and 2023.

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 called corrected.

To allow a more accurate analysis of the evolution of INESC TEC's publications data, two different views will be presented. Table 3.7 and Figure 3.6 present the consolidated data for 2023 compared with the corrected and closed data from previous years, in order to yield the best information available at the time of elaboration of this document. In turn, Table 3.8 and Figure 3.7 only compare consolidated data for the various years to allow a more realistic perception of INESC TEC's publication performance in 2023.

Table 3.7 - Evolution of Publications (2023 Consolidated vs Previous years' Corrected)

Publication Type	2019 (Corrected)	2020 (Corrected)	2021 (Corrected)	2022 (Corrected)	2023 (Consolidated)
Indexed Journals	381	444	451	539	489
Indexed Conferences	570	413	471	446	427
Books	6	2	4	4	3
Book Chapters	29	25	33	40	31
PhD Theses - Members	19	28	30	31	25
PhD Theses - Supervised	33	46	58	43	38

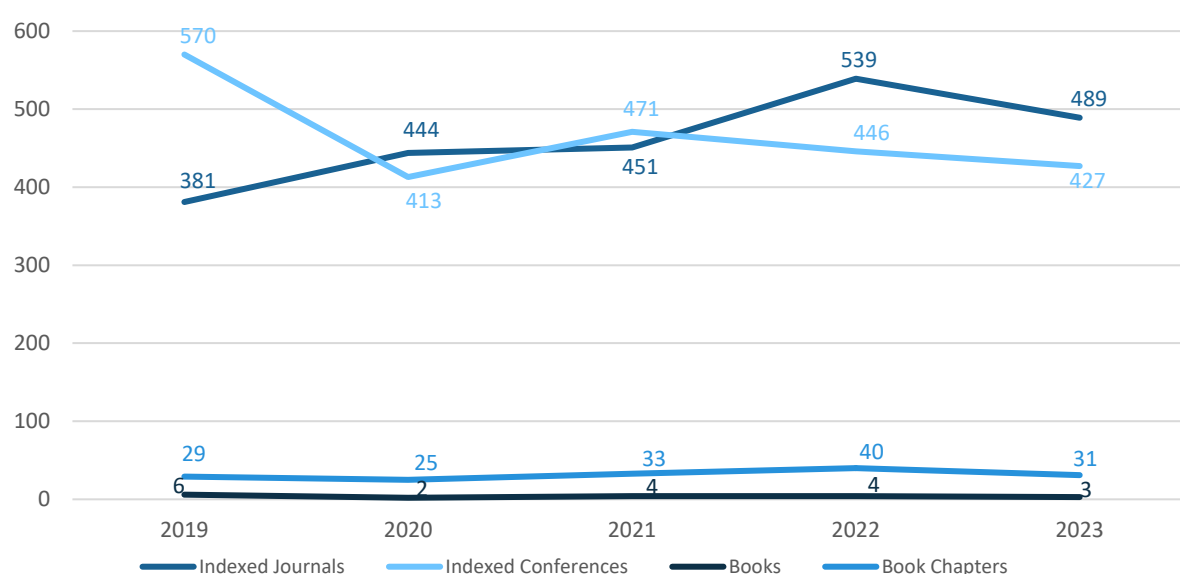


Figure 3.6 - Evolution of Publications (2023 Consolidated vs Previous years' Corrected)

Table 3.8 - Evolution of Publications (Consolidated)

Publication Type	2019 (Consolidated)	2020 (Consolidated)	2021 (Consolidated)	2022 (Consolidated)	2023 (Consolidated)
Indexed Journals	369	398	440	465	489
Indexed Conferences	410	317	362	349	427
Books	4	2	3	3	7
Book Chapters	29	25	34	45	31
PhD Theses - Members	19	28	30	31	25
PhD Theses - Supervised	33	46	58	43	38

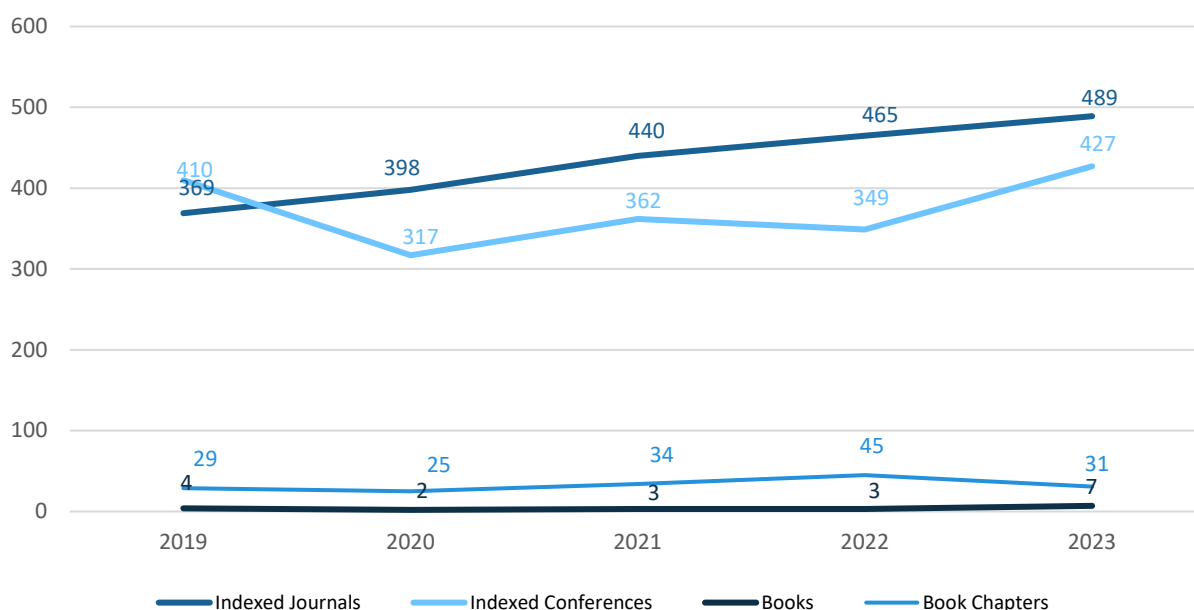


Figure 3.7 - Evolution of Publications (Consolidated)

Exceeding the projections outlined in the 2023 plan, which anticipated 314 journal papers, INESC TEC has consistently expanded its publication output in indexed journals, which are prioritised by the institute.

The number of publications in indexed conferences rebounded in 2023, reversing a decline that had been observed at the onset of the pandemic. Additionally, upon comparing Figure 3.6 and Figure 3.7, it becomes evident that this metric tends to undergo significant changes in the subsequent year as indexing sources continuously update their data. It is confidently anticipated that this trend will continue to improve until the calculation is finalised.

Analysing the evolution of publications per capita (as depicted in Figure 3.8) based on consolidated data, we note that the number of articles in indexed journals per Core PhD has remained steady compared to the previous year, while the conference-related indicator shows improvement.

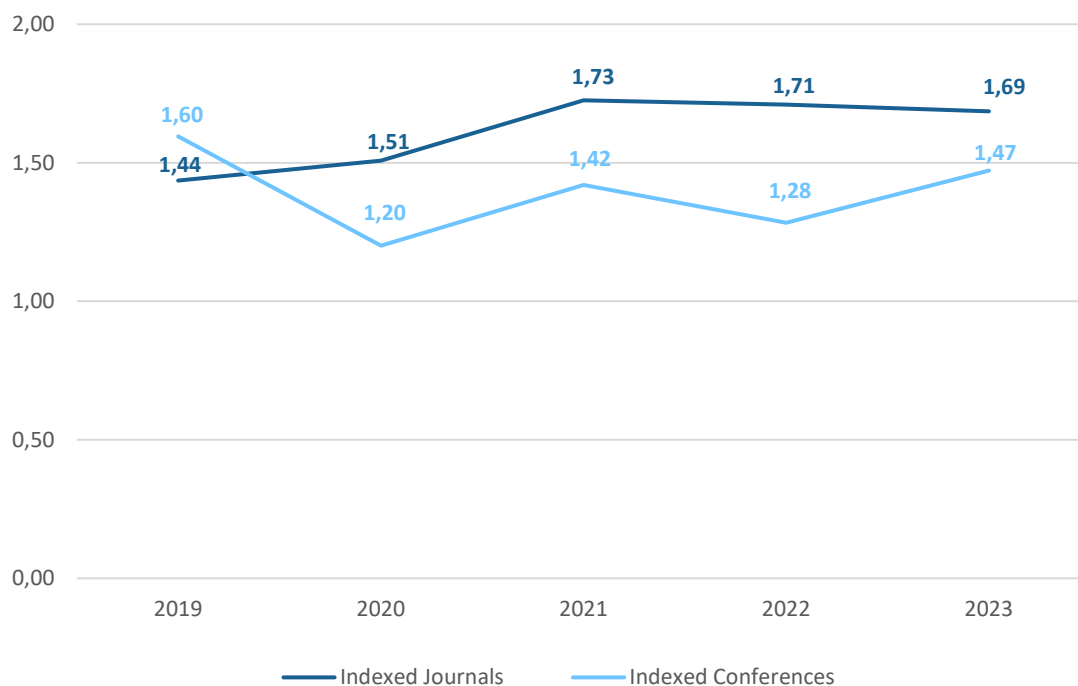


Figure 3.8 - Evolution of Publications per Core PhD (consolidated)

Regarding publications in journals indexed by Scopus, Figure 3.9 illustrates their distribution across impact factor quartiles. In the current reporting period, 422 articles were published in first and second quartile journals, accounting for 86% of the total articles in indexed journals, compared to 411 articles in 2022. A slight increase was also observed in publications in conferences rated as Core A* and Core A, totalling 29 publications, compared to 24 in the preceding year's report.

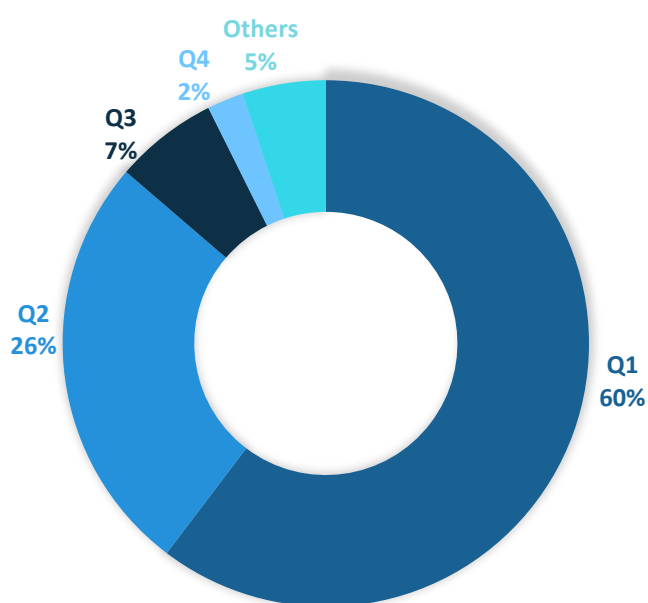


Figure 3.9 - Indexed Journal impact factor Quartile distribution (Scopus)

With regard to Open Access, based on 968 INESC TEC documents indexed in Scopus on 25 March 2024 (Article, Conference Paper and Book Chapter), 43% of INESC TEC publications are Open Access (419 documents), from which 21% are Gold Open Access (208 documents).

In terms of collaboration with researchers from international institutions, 33% of INESC TEC publications involved international co-authorship (319 of the 968 documents extracted from Scopus), 39% if only journal articles are considered (459 documents). These figures are relevant as a direct measure of collaboration in science and the networking between organisations across borders. As a reference, in 2021 the overall percentage of publications representing international collaboration stood at 25%, according to a study that evaluated more than 50 million publications, published in the Journal of Data and Information Science, in 2023 (doi: 10.2478/jdis-2023-0015).

R&D Centres Indicators

Figure 3.10 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.

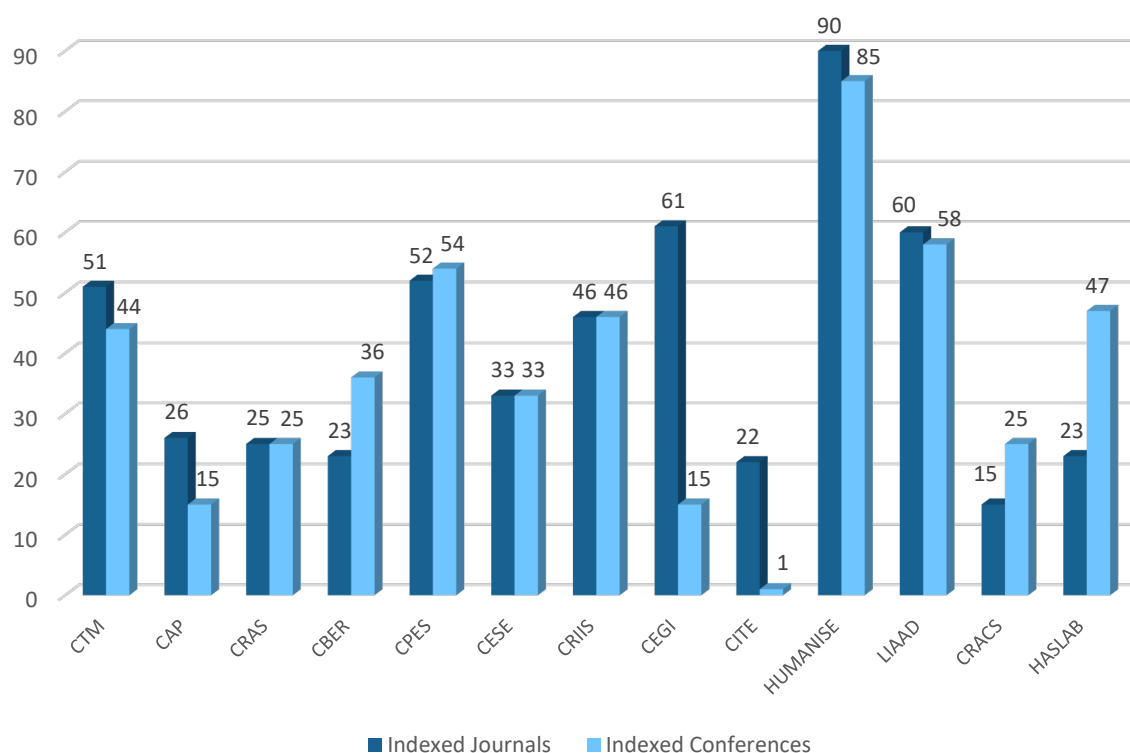


Figure 3.10 - Indexed Publications in Journals and Conferences by Centre

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

Research Data Publication

The publication of research data is essential to the reproducibility of research and is an explicit principle of the European Commission (Article 29.3 of the Model Grant Agreement - Open access to research data). INESC TEC is committed to this principle, aiming to facilitate the access, sharing and reuse of research data, in order to increase the visibility and impact of INESC TEC's research.

In line with European policies for open data, INESC TEC has an institutional data repository - RDM INESC TEC, since 2017. By the end of 2023, the RDM INESC TEC had a total of 133 open datasets (9 in private mode). In 2023, 20 open datasets were published in the RDM INESC TEC, which makes 2023 the year with the second highest publication rate, slightly above the average rate of 19 datasets published per year.

Table 3.9 outlines open datasets published in 2023 in the institutional data repository.

Table 3.9 - Open data published in the RDM INESC TEC repository

Dataset	Description
Ambient radioactivity data from S. Jorge island (Azores), since March 2022 Susana Barbosa et al., 2023 https://doi.org/10.25747/9SF6-K141	Includes measurements of soil radon gas concentration, gamma radiation, and environmental parameters at S. Jorge Island.
NEREON (uNderwater dataset for monocular dEpth estimation), João Dionísio et al., 2023 https://doi.org/10.25747/CR2F-NZ60	Provides information for training Deep Learning Networks which aimed at estimating depth from single images in underwater environments.
Indoor point cloud dataset for BIM related applications Data and Resources Nuno Abreu et al., 2023 https://doi.org/10.25747/6FAM-VY11	Annotated point cloud of the CRAS labs@FEUP in ASCII format.
Heart and Clavicle Segmentation References in Chest Radiography – Montgomery Dataset, Ricardo Brioso et al., 2023 https://doi.org/10.25747/td00-7k67	Manual annotation of segmentation masks for the heart and clavicles in the Montgomery dataset, a public repository of 138 chest radiographies.
Sagres ship corrected meteorological data 2020 Susana Barbosa, 2023 https://doi.org/10.25747/FYKZ-9H72	Meteorological data over the Atlantic Ocean collected onboard the NRP Sagres Ship.
Automated Image Label Extraction from Radiology Reports Sofia Cardoso Pereira et al., 2023 https://doi.org/10.25747/xhbn-b855	Raw data about co-authorship links among authors and the occurrences of named entities in the abstracts of the reviewed studies.
Pre-processed atmospheric data from the SAIL campaign onboard the Sagres Ship Susana Barbosa et al., 2023 https://doi.org/10.25747/58P6-6B76	Comprises the pre-processed atmospheric measurements from the SAIL campaign, by applying preliminary quality-control and pre-processing procedures.
Synthetic electricity distribution network from UK for flexibility analysis – ATTEST project Eduardo Martinez-cesena and Andry Churkin, 2023 https://doi.org/10.25747/RE7B-ES77	Information about a realistic 6.6 kV weakly meshed synthetic UK distribution network with 38 buses and 38 lines, and 124 buses and 124 lines.
Consensual ArchOnto representation of 13 Portuguese Historical Archival Records based on their Digital Representations Mariana Dias and Carla Teixeira Lopes, 2023 https://doi.org/10.25747/EADP-M943	Contains archival descriptions represented in the ArchOnto models of 13 records from the 20 th century with typewritten digital representations.
User evaluation of the DigitArq and DigitArq+ interfaces Margarida Gouveia Augusto, 2023 https://doi.org/10.25747/4rcb-8k59	Interviews and usability test data generated with common users and archivists, of both the DigitArq and DigitArq+ (developed by the EPISA project).
Analysis of the DigitArq archive record entities and their properties in Wikidata and in DBpedia Camilla Oliveira da Silveira, 2023 https://doi.org/10.25747/gv77-5k64	A sample of 25 records from the Portuguese National Archives, of different fonds and description levels, to identify entities and properties, and explore relationships with other non-archival resources.

Dataset	Description
Bibliography and analysis on studies of institutional DMP support services Yulia Karimova and Mafalda Lopes, 2023 https://doi.org/10.25747/YN8F-RA30	Bibliographic information selected to identify global studies on DMP support in different institutions and understand how institutions provide, implement, and support researchers.
Assessment of metrics for the development of an institutional DMP support system Yulia Karimova, 2023 https://doi.org/10.25747/YCC7-HH27	Combines the information related to the systematization of the DMP-building method and the development of the DMP support systems.
ArchOnto ontology representation of Portuguese archival description units (baptism records and passports) Catarina Pires et al., 2023 https://doi.org/10.25747/x78e-1a27	Excerpt of the ArchOnto ontology representation of the DigitArq baptisms records from Bragança District Archive and passports, obtained through an automatic transformation from CIDOC-CRM.
Text2Story Lusa Sérgio Nunes et al., 2023 https://doi.org/10.25747/et95-bx90	Contains 363 news articles, in JSON format published in European Portuguese by the Lusa news agency, including publication time, headline and content.
Text2Story Lusa Annotated Purificação Silvano et al., 2023 https://doi.org/10.25747/esfs-1p16	Contains multi-layered manual annotations for 119 articles from the Text2Story Lusa dataset. (https://doi.org/10.25747/et95-bx90).
Representation of 25 records from the Portuguese National Archives in Archonto Inês Koch et al., 2023 https://doi.org/10.25747/7k9z-8m60	Representation of 25 archival records from the Portuguese National Archive in ArchOnto, based on the archive descriptions made available on DigitArq, considering the ISAD(G) standard.
Research image management practices reported by scientific literature: Studies that explore the use and production of images in research Joana Rodrigues and Carla Teixeira Lopes, 2023 https://doi.org/10.25747/k9f6-kt23	A set of 109 articles that include relevant information about image management in the context of research, grouped according to Web of Science research domains.
Automatic Quality Assessment of Wikipedia Articles - A Systematic Literature Review Dataset Pedro Miguel Moás and Carla Teixeira Lopes, 2023 https://doi.org/10.25747/s5fa-d428	Includes metadata related to 149 papers about automatic quality assessment of Wikipedia articles, and the data from the analysis in both raw and structured formats.
Analysis of the interviews with DGLAB archivists and DGLAB satisfaction results Luana Ponte et al., 2023 https://doi.org/10.25747/p54w-e587	Script used to interview archivist at the DGLAB and the analysis of the satisfaction survey translated to English.

3.9 Technology Transfer

Overall, the results related with technology transfer (Table 3.10) were above or in line with the estimates included in the 2023 plan. This was the result of the strategic commitment of INESC TEC's R&D Centres in addition to the scouting activities of INESC TEC's Technology Licensing Office (SAL).

Table 3.10 - Results related with IP Protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre-Disclosures (PDF)	30	24	31
Technology Disclosures (TDF)	8	21	23
First Priority Patent Applications (New inventions)	5	5	8
First Patents Internationalisation	3	2	5
First Patents Granted	6	2	7
Commercial Contracts (Licences, Options, Assignments)	3	1	3
Spin-offs	1	0	1*
Spin-offs in development	2	2	5*

**Proprietary information; further details will be disclosed in an upcoming report*

In 2023, there was a notable uptick in the intensity of Knowledge Transfer activities at INESC TEC, resulting in an across-the-board increase in all Key Performance Indicators (KPIs) compared to 2022.

Despite a near-complete overhaul of the SAL team in 2023, more results were documented and formalised, surpassing the 50-mark threshold for the first time in a single year. This achievement stemmed from the strategic monitoring and knowledge management initiative, with particular emphasis on P2020 in 2023.

Eight new patent applications were submitted, marking the second-highest number since nine were submitted in 2018. These patents aim to safeguard technologies that will pave the way for new business partnerships and spin-offs over a span of 3 to 10 years, facilitating a return on investment. Additionally, five internationalisations were recorded in the year under review, compared to two in 2022, and seven patent families received their first grants, affirming the quality of applications submitted in prior years.

By the close of 2023, INESC TEC had 36 active patent families, the highest figure ever recorded and spanning a diverse array of technological domains. Furthermore, there was a noticeable improvement in valorisation performance, with the signing of 3 new licensing contracts and several leads poised for transition into 2024, indicating sustained emphasis on this front.

Valorisation through spin-offs also experienced growth, both in terms of newly established spin-offs and those in development, with the latter strengthened by INESC TEC's seed projects in the Commercialisation Proof of Concept category.

Technological entrepreneurship

INESC TEC facilitates the establishment of technology-based spin-offs, specifically created to advance and leverage intellectual property (IP) generated by the institute. The table below outlines the latest spin-offs initiated by INESC TEC, both those already established and those in various stages of development since 2015, along with their key progress updates in 2023.

Due to the sensitive nature of certain spin-offs still in development and a recently established spin-off, detailed information necessitates discretion in its disclosure. Therefore, additional specifics will be made available in upcoming reports.

Table 3.11 - Overview on INESC TEC's most recent established spin-offs

Name and description	Main developments in 2023
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	Study the application of Keyruptive's PI in a different context/sector, in order to either license the PI or develop a new product.
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	In 2023, Insignals successfully completed the development of its iOS App, allowing greater versatility of use for its users. It also marked the start of data collection in a clinical environment in collaboration with Hospital São João, with a focus on supporting the monitoring of Parkinson's patients. Collaboration with Maastricht University also progressed, with the start of data collection using its device in a hospital environment. In terms of business development, it submitted an application to the EIC Accelerator, and it is now preparing to apply for the second phase. After participating in the RESOLVE-Health programme, it was awarded the Startup Accelerator Prize by i3s, worth €1,500. inSignals was present at internationally renowned events such as WebSummit in Lisbon and MEDICA in Dusseldorf.
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	<p>The installation of the Ubirider Platform was done in just 5 weeks, including contactless payments, at the private operator that holds the public transport concession for the city of Faro, Próximo.</p> <p>Ubirider and Payshop began integrating their platforms to offer the biggest network of point-of-sales for transport and mobility services, aggregating physical (Payshop's 5000 agents) and digital (Ubirider applications) point-of-sales.</p> <p>The company signed two contracts with public entities in Cascais: with Cascais Próxima, for the continued use of the Ubirider platform for Mobicascais services; and with Cascais Ambiente, to incorporate carbon footprint measurement into the Mobicascais application.</p> <p>Ubirider was present at the Smart City Expo World Congress 2023 event, in Barcelona, to present and publicise common developments with two strategic partners: Deloitte and Mastercard, who participated in this relevant event with stands.</p> <p>Ubirider concluded an investment round in November, which involved several national and foreign investors.</p>

Name and description	Main developments in 2023
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	<p>The UGR started the development of an underwater GPR (Ground Penetrator Radar) that would be able to detect the structural stability of underwater concrete walls, pillars and other structures. The expected end date of the development is the second half of 2024.</p> <p>At the end of 2023, the UGR purchased a BlueROV2 from the 4DCoders (previous UNEXMIN and UNEXUP partner) and started to rebuild the ROV with new navigational instruments and improve its pressure resistance. The expected end date of the development is the second half of 2024.</p>

Table 3.12 - Overview on INESC TEC's spin-offs in development

Spin-offs in Development	
Name and description	Main developments in 2023
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): 22	Expanded further clinical studies with 12 major hospitals and 2 pharmaceutical companies around Europe

3.10 Dissemination activities

Table 3.12 illustrates the evolution of INESC TEC members and R&D Centres' participation in a variety of categories of dissemination activities.

Table 3.13 - Results related with dissemination activity

Type of Activity	2021	2022	2023
Participation as principal editor, editor or associated editor in journals	118	151	105
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	77	63	72
International events in which INESC TEC members participate in the program committees	259	228	258
Participation in events such as fairs, exhibitions or similar	82	43	92
Conferences, workshops and scientific sessions organised by the R&D Centres	75	76	66
Participants in the conferences, workshops and scientific sessions organised by the R&D Centres	7 239	3 549	3 347
Advanced training courses organised by the R&D Centres	15	10	11

Despite experiencing significant growth in their involvement in scientific and innovative projects, INESC TEC researchers have managed to maintain a dynamic level of activity in scientific dissemination events and other formats.

The majority of results related to dissemination activities have exceeded the estimates outlined in the 2023 plan. This includes dimensions such as participation in editorial roles, involvement in program committees of international events, and the number of attendees at conferences organised by INESC TEC's R&D Centres.

In addition to the INESC TEC Autumn Forum, not accounted for in the aforementioned figures, which are limited to R&D Centre activities, several other events were organised. Notable among these are various summer schools and advanced training courses. Special mention should be made of "SOE'23 | Space, Ocean, and Earth Insights," a unique event held during the GLEX summit to push the boundaries of science and technology in space and ocean-related research. Another noteworthy event is "WAVES 2023," a Workshop on Advanced Vehicles for Exploration of the Seas, marking the inaugural edition of a workshop focused on discussing how robotic solutions can address specific challenges in the Azores.

Moreover, INESC TEC researchers played key roles in organising committees and served as general chairs for prominent conferences and workshops, including the IEEE EMBS Portugal Chapter bi-annual conference held in Porto in June 22-23, 2023. They also actively participated in organising and serving on program committees for renowned conferences and workshops such as SIGIR, ECIR, TPD, CHIIR, AEIC, ETFA, WFCS, ISORC, EuroPLoP 2023, ASAP 2023, and DeCPS 2023.

The virtual alternatives provided in many of these events, including hybrid formats or full remote participation, have had the positive effect of reaching participants worldwide who otherwise might not have been able to attend.

3.11 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. Other than the participation in the General Assemblies where network and benchmark are added values, INESC TEC actively participates in several Boards, Committees, and Working Groups, thus gathering and sharing knowledge with top-of-the art experts in its field of activity.

In 2023, INESC TEC joined 3 new associations: ADRA, CCILF and CRESYM.

Table 3.14 - 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), EASTRO (Space), STICHTING SPRINT ROBOTICS COLLABORATIVE (Robotics).
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	ADRA, AIOTI, ASTP Proton, ATE, CCILF, CERVIM, CIGRÉ, CENTRA, CRESYM, DERLab, EBRAINS, EARTO, EERA, EFFRA, EPIC, ERCIM, EES-UETP, ETSI, EuRobotics, EtherCAT Technology Group, IEA Wind, IDSA, INESC P&D Brasil, ROS-INDUSTRIAL CONSORTIUM EUROPE, WA4ES.
COMPANIES	
CEO - Companhia da Energia Oceânica	<p>Since 2022, INESC TEC is 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.</p> <p>In addition to its strategic importance in the fields of Sea and Energy, it strengthens synergies with ongoing initiatives related to infrastructure, projects in progress, and research and development lines across various Centres.</p>

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 2023

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 2023, 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 2023 and the main developments in these fruitful relationships.

Table 3.15 - CoLAB AQUAVALOR

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	26/1
HR hired	16
Base funding planned	
Competitive funding – submitted and approved proposals	371 693€ (projects PROMOVE e SUDOE)
Main activities and achievements in 2023	<p>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.</p> <p>Preparation of proposals for several competitive funding calls (FCT/BPI La Caixa Promove 2023, PRIMA, SUDOE).</p> <p>Provisioning of services related to the digital transition of the Agrifood sector.</p> <p>Development of new and innovative food products based on the endogenous resources of the Alto Tamega region (ex: natural mineral water);</p> <p>The organisation of international scientific and technical events (ex: AQUAFORUM'23).</p>
Activities to foster Associates' involvement	<p>Proposals to competitive funding calls (ex: FCT/BPI La Caixa Promove 2023, PRIMA, SUDOE);</p> <p>The organisation of international scientific and technical events (ex: AquaForum'23).</p>
Fulfilment of INESC TEC's strategic objectives related to this participation	<p>INESC TEC main objectives with this participation are:</p> <ol style="list-style-type: none"> 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. <p>To date, the CoLAB's development is in line with these objectives as it has recruited several highly qualified human resources for the organisation. INESC TEC is engaged in some of its activities, such as projects and events, through the participation of its researchers.</p> <p>With the organisation's maturity level increasing and the commencement of PT2030 execution, it is anticipated that both activity levels and INESC TEC's involvement will rise.</p>

Table 3.16 - 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	15/0
HR hired	6 renewed 3 new
Base funding planned	458 410,82 €
Competitive funding – submitted and approved proposals	Submitted: 8 Approved: 3
Main activities and achievements in 2023	<p>Successful renewal of 60% of base team plus recruitment of 3 new HR for the ongoing projects.</p> <p>Conclusion of two funded projects, execution of 1 green agenda and 1 mobilizing agenda of the recovery and resilience plan. Competitive funding approval rate of 38%.</p> <p>Member of the monitoring committee for the future International Centre for Blue Biotechnology</p> <p>Provided Services to e.g., support the development of new products, Studies, Commercial Representation and Communication.</p> <p>Signed MoUs with international stakeholders.</p> <p>Active presence in media, social networks and engagement in Ocean Literacy actions.</p> <p>Development and participation in events e.g., B2E's events with local authorities with the presence of important stakeholders in the sector.</p> <p>Presence in relevant fair and expositions (Aquaculture Europe 2023)</p>
Activities to foster Associates' involvement	<p>Development of R&I projects with associates. Support the implementation of associates R&I priorities, providing new national and international funding opportunities and technology surveillance mechanisms.</p> <p>Networking events with international actors; internationalisation activities and presentation of INESC TEC projects and services in byproducts developments presented in One Ocean Week Norway to Norwegian blue economy and policy stakeholders.</p>
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 and sharing funding opportunities.

Table 3.17 - 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	7 HR were hired by the CoLAB in 2023
Base funding planned	1 085 555,53€
Competitive funding – submitted and approved proposals	8 Horizon Europe proposals were submitted. 2 European Urban Initiative – Innovative Actions. Participation in several others (decarbonisation and software development namely) via future subcontracting of the submitting companies/entities. Approved: A mobilising agenda, a “Fundo ambiental” Project, and two “Roteiro para a Descarbonização” projects (subcontracting).
Main activities and achievements in 2023	The year was a recovery year after some instability caused by internal and external factors and was characterised by a re-organisation of the internal processes, procedures and organisation. This has improved the efficiency and the quality of service. It was also a year marked by the beginning of new projects (investment and co-funded), an exponential growth in services provisions, international customers and licence agreements. It was also the year to close and start capitalising significant projects such as REV@Construction and FOC (Future of Construction).
Activities to foster Associates’ involvement	Meetings with the associates to present the skills, needs and promote co-creation/collaboration; Development of common competitive funding opportunities; Invitation to events, communication initiatives or business opportunities; Involvement of some partners in DIGITALbuilt (an EDIH); Establishment of partnerships to licence and scale technology; 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	Opens 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 proposals and projects.

Table 3.18 - 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	19/1
HR hired	7 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	1.1M€ from October 2023 to March 2026; CCDR Alentejo base funding terminated in October 2023.
Competitive funding – submitted and approved proposals	In 2023: 5 competitive proposals submitted (~1M€ applied budget), 3 approved (1 HEurope to start in January 2024, 2 PRR approved submitted in 2022. Total approved budget for the CoLAB of 300k);
Main activities and achievements in 2023	<p>Main activities:</p> <ul style="list-style-type: none"> - Throughout 2023, FeedInov continued to consolidate its activity and to establish itself as the reference interface structure in the livestock sector both national and internationally; - Publication of a second MSc thesis on Foresight scenario planning; - Publication of one BSc thesis with INESC TEC collaboration; - Writing of 1 scientific paper with INESC TEC collaboration (to be submitted in 2024); - Higher investment looking for private funding to pursue the private 1/3 <p>Main achievements in 2023:</p> <ul style="list-style-type: none"> - Initialisation of the HEurope thematic network EUNetHorse, of Mobilising agenda InsectEra, PRR FeedValue and PRR UsamSuLei, complying with the competitive 1/3 pursuit; - End of the first base funding and start of the Interface mission, second base funding round starting when the CoLAB reaches 3 years of activity. - Negotiations for providing product environmental footprint as a service contract to start in 2024.
Activities to foster Associates' involvement	<p>All associates have a place on the General Assembly. 2nd Collaborative meeting for associates held presential in FMV, Lisbon, for brainstorm and engagement. Regular B2B meetings with Associates.</p> <p>BSc, MSc theses in collaboration with Associates.</p>
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 and the situation is changing and results of the collaboration are appearing.

Table 3.19 - 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	16/1
HR hired	40 HR hired by the CoLAB by the end of 2023
Base funding planned	1 315 M€
Competitive funding – submitted and approved proposals	Involved in the submission of 17 proposals, raising 10 new contract R&D and consulting projects, along with participating in 7 national and 4 international R&D&I collaborative projects. This allowed the CoLAB to raise a total of 2 687 550€. Consultancy and services contributed to the financial sustainability of the institution, adding up to over 340 000€. The CoLAB's strong evolution and impact is demonstrated also by its capacity to mobilise the main players in the sector – 93 national and 8 international entities collaborate directly in projects or services developed by CoLAB ForestWISE.
Main activities and achievements in 2023	<p>2023 represented a period of consolidation of ForestWISE operations, with strong increase in its activity: participation in seven projects with national funding and four projects with international funding and intensification of consultancy activities and R&D services.</p> <p>The transition to a new base funding program prompted a review of the strategic vision and the resulting organisational realignment, with impacts on the management model and internal organisation.</p> <p>An important milestone in the CoLAB's journey was the registration of the CoLAB ForestWISE® trademark, which reinforces its strategic positioning. Also worthy of notice is the creation of the Scientific and Business Advisory Board, composed of national and international personalities of recognised merit in the CoLAB's areas of knowledge and activity.</p>
Activities to foster Associates' involvement	<p>The event organised to celebrate CoLAB's fifth anniversary - alongside with the inauguration of the new headquarters - was a fundamental opportunity to strengthen the Associates' engagement and enhance the communication with members of the Government and other official entities.</p> <p>During 2023, ForestWISE took part in 84 promotion and dissemination events, allowing the various players involved in integrated forest and fire management to share their knowledge and activities. The newsletter continues to be a key vehicle for the dissemination of information and communication with Associates, relevant stakeholders and the community, counting more than 2500 subscribers.</p>
Fulfilment of INESC TEC's strategic objectives related to this participation	<p>ForestWISE became a major strategic partner for INESC TEC essentially in close collaboration through the TEC4Agro projects and activities.</p> <p>INESC TEC participation in the Mobilising Project RePLANT and in the Transform Green Mobilising Agenda, as well in several European projects and industry contracts have been promoted by ForestWISE, leveraging INESC TEC's role as a developer of cutting edge technology for application in forestry and forest industry.</p>

Table 3.20 - CoLAB HYLAB

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	2
Base funding planned	In 2023, the execution of the base funding started.
Competitive funding – submitted and approved proposals	<p>By the end of 2023, it had the following situation regarding projects:</p> <p><u>New project approved:</u> H2tALENT - Alentejo Green Hydrogen Valley delivering integrated full-chain sustainable hydrogen ecosystem with technical, economic, social, and environmental benefits and superior upscaling/replicability – funded by Horizon Europe – Clean Hydrogen Partnership.</p> <p><u>On-going projects:</u> H2Enable, H2GreenValley, Moving2Neutrality, SinesH2GreenValley and H2Driven from Recovery and Resilience Plan.</p>
Main activities and achievements in 2023	<p>2023 was devoted to operational preparation and start-up by acquiring the supporting services namely accounting, legal, and human resources selection, together with the hiring of the first employees.</p> <p>The Executive Director started in September. The lead researchers and the first researchers started in January of 2024.</p>
Activities to foster Associates' involvement	At the management level, several meetings with the associates took place to prepare common projects and identify human resources needed by HyLab.
Fulfilment of INESC TEC's strategic objectives related to this participation	<p>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.</p> <p>HyLab provides the network of competences and synergies to further develop this strategic vision.</p>

Table 3.21 - RAIL CoLAB

CoLAB SEL	
Name	RAIL COLAB - COLLABORATIVE LABORATORY FOR THE FUTURE RAILWAY SYSTEM
Description	Aims to promote and carry out of R&D initiatives and activities aimed at improving the railway system, through scientific support and technological innovation in the intervention of relevant players in the business, academic and economic fabric
Areas of expertise	Railway
Year of establishment	2022
N.º of Associates / Accession of new Associates in 2022	17
HR hired	0
Base funding planned	0
Competitive funding – submitted and approved proposals	0
Main activities and achievements in 2023	<p>A General Assembly was convened on March 10th, 2023, to elect the Board, Audit Council and General Assembly Presidency and Secretariat.</p> <p>Meetings were held with all associates, including INESC TEC, the Portuguese Government, CP and IP. These last two entities are potential members, whose application is still pending due to budgetary problems.</p> <p>The Activity Plan and Internal Regulations were also prepared in 2023.</p> <p>This CoLAB was created in the last Call when base funding was not guaranteed. This situation continued in 2023 and therefore it was not possible to hire staff and develop activities.</p> <p>At the beginning of 2024, a meeting was held with FCT, ANI, and the other 5 CoLABs that don't have base funding approved. FCT and ANI reported that they tried to obtain funding from PRR reprogramming and Interface Mission, but they were not successful. Therefore, unless this CoLAB obtains some competitive funding, it will not be able to start its activities.</p> <p>At the beginning of 2024, this CoLAB submitted a proposal to EUROPE's RAIL, together with IST.</p>
Activities to foster Associates' involvement	Meetings with all associates.
Fulfilment of INESC TEC's strategic objectives related to this participation	Not applicable, due to a lack of activity in 2023.

Table 3.22 - 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	7/7
HR hired	Two (2) new HR have been hired in 2023 adding to existing 33 in 2022, with a total of 35 people on 31st December 2023.
Base funding planned	Subsidies (state and other public entities): 2 708 993€ Donations: 536 175€
Competitive funding – submitted and approved proposals	Horizon Europe: Submitted proposal: 1 (with a total budget: 332 k€). PRR Agendas Mobilizadoras Fase 3: Approved proposals: 1 (with a total budget: 11,7 M€).
Main activities and achievements in 2023	SEL continued developing its activity divided in 3 streams with a total of 21 projects along the year: Feature Acceleration; R&D Funded Projects; IP/Product projects, with the main focus on the IP/Products stream to generate market revenues from products and services created by the CoLAB. In 2023, SEL highlights the first European patent submission, the first international fair with a SEL own stand in Paris, the first sale of an IP/Products and a new PRR Agendas Mobilizadoras consortium granted, Aliança para a Transição Energética (ATE).
Activities to foster Associates' involvement	Monthly board meetings with associates with representation from Industry and Academia. Update on Scientific Council representants from academia associates, to be more in line with the activities of the CoLAB and areas of expertise. Annual meeting with Scientific Council to define priorities and present possible working areas. Proactive contact for outsourcing activities for CoLAB projects to academic partners.
Fulfilment of INESC TEC's strategic objectives related to this participation	PRR Agendas Mobilizadoras projects (Consortium ATE) and Horizon Europe Projects (Enershare) between INESC TEC and SEL are the main active working streams where there were tangible activities working together. Higher intensity in PRR Consortium ATE is foreseen and already ongoing on projects for E-mobility, Flexibility and Energy Management Systems.

Table 3.23 - 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 <i>Missão Interface</i>)
Competitive funding – submitted and approved proposals	12 proposals submitted and 4 approved: 2 national proposals and 2 international proposals (0.52M€ raise funding)
Main activities and achievements in 2023	<p>12 projects submitted, (10 international and 2 national) and of that 4 were approved (success rate greater than 33%); Ongoing projects: 5 (CENTRO, Smart Farm4.0, HIBA, DigiFarm2all, SFT-EDIH and Missão Interface); 9 collaboration protocol signed + manifest of the soil mission;</p> <p>15 technical papers published in journals with relevance for the agro-sector; more than 44 oral communications; 15 capacity building actions/ workshops with a participation of 900 people;</p> <p>2 awards, namely the i) innovation/ research award of the year by Revista de Vinhos and ii) innovation award by AIHO; internship and thesis program: 3 internships, 1 MSc student and 4 PhDs students;</p> <p>Social media: LinkedIn (3082), Twitter (168), Facebook (871), Instagram (1013).</p>
Activities to foster Associates' involvement	<p>The activities to foster Associates' involvement has been particularly performed through projects, services, and events.</p> <p>Projects: i) DigiFarm2all (Adega Cooperativa SMV, Quinta do Pinto, ImpactWave, INIAV); ii) Tec4Green (Tomix, ImpactWave, UNINOVA, COTHN-CC); iii) SustainGrowth (INIAV, COTHN-CC); iv) HIBA+ (INIAV); v) TID4Agro (INIAV); v) Naturagro (INIAV, Quinta do Pinto); Services: Challenge by STAGRIC - Intermediation between SFCOLAB and INESC TEC and Impactwave to present a proposal technique/budget; SOFIS - proximal sensing for educational purposes (AVA); SOFIS - to monitor the pruning effect on grape maturation (Adega Cooperativa SMV); Events: Reception of the EBAN - European Business Angels Network (CMTV, TOMIX and local agents); SFCOLAB vai à Escola - Educational service for science dissemination (CMTV, AVA, TOMIX); V Fórum Agricultura 4.0 - Evento Final Smart Farm 4.0 (72 participants); V Fórum 4.0: Ação de demonstração para a agricultura (44 participants); Espaços de Diálogo Session for viticulture sector (35 participants), Dia Aberto da Olivicultura/ alterações climáticas e olivicultura (ação em campo) - INIAV (65 participants), among others.</p>
Fulfilment of INESC TEC's strategic objectives related to this participation	Since the participation in the CoLAB did not generate relevant value for INESC TEC, besides existing a significant overlap in the activities of the two organisations, after a thorough reflection, the year 2023 will be the last year of INESC TEC's participation in SFCOLAB as an Associate.

Table 3.24 - 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 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 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 2023	10 / 0
HR hired	Coordination Team – 2 HRs / Innovation Team – 4 HRs / Lab & V&V – 3 HRs
Base funding planned	1 021 k€
Competitive funding – submitted and approved proposals	<p>At the European level, Vasco da Gama CoLAB focused on the Horizon Europe funding framework, coordinated by European Commission.</p> <p>Of the topics open in 2023, namely those defined by the BATT4EU Partnership, the only relevant topic was:</p> <ul style="list-style-type: none"> • HORIZON-CLS-2023-D2-01-04 - "Battery management system (BMS) and battery system design for stationary energy storage systems (ESS) to improve interoperability and facilitate the integration of second life batteries" as technical coordinator.
Main activities and achievements in 2023	<ul style="list-style-type: none"> • Beginning of Missão Interface/PRR (second base funding) • Beginning of IronFlow – FCT project focused on iron-based electrolytes for RFB • 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. • Execution and completion of service contract for Amnispura • Contractualisation of service contract with Net4CO2
Activities to foster Associates' involvement	<p>Periodic bilateral meetings with associates</p> <p>Regular scientific committees with associates</p> <p>Invitation for European projects</p> <p>Event of 3rd anniversary of Vasco da Gama CoLAB</p> <p>Execution of ongoing development projects (with INESC TEC: i-STENTORE and Agenda Mobilizadora "NGS-New Generation Storage")</p>
Fulfilment of INESC TEC's strategic objectives related to this participation	<p>Several opportunities are being discussed and joint participation in some European initiatives is under analysis.</p> <p>A list of points of interest from both organisations was discussed to define and align some of the common interest research topics.</p>

Table 3.25 - 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	197/14
HR hired	47 (33 from Associates + 14 from staff)
Base funding planned	388.263,55 €
Competitive funding – submitted and approved proposals	16 proposals submitted 4 proposals approved
Main activities and achievements in 2023	<p>Ongoing activities:</p> <ul style="list-style-type: none"> - R&D service contracted by a company of the sector for the development of an innovative food product from a viticultural by-product; - Establishment of WICA - Wine Innovation Collaboration Alliance, from the project EPAWI, as a 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). Release of the Innovation Catalogue, showcasing 85 remarkable solutions to face the main challenges of the Wine Sector, regarding viticulture, enology and management and marketing; - Collaboration in the 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) and in the development of new starter yeast cultures (Project Grapemicrobiota); - Allocation of funding to maintain the development of a network of low-cost sensors to spatially evaluate hydric stress; - The collection of viticultural, climatic and biological information, in order to support the development of models, has been supplemented by the real productivity of some reference plots, obtained from the producers to feed the yield prediction models of the wine4cast project.
Activities to foster Associates' involvement	Workshops, seminars and dissemination including technical bulletins. Technology/machinery demonstration sessions in the vineyard. Collaboration for partnerships in R&D projects and funding applications. SIFIDE applications. Assistance/supervision in the development of Sustainability plans.
Fulfilment of INESC TEC's strategic objectives related to this participation	ADVID is 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 3.26 - 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: 3 MSc: 17 BSc: 6 (Total 26 new hired in 2023) Overall hired: 49
Base funding planned	1 000 600k€
Competitive funding – submitted and approved proposals	2 proposals submitted (SUCCESS (KDT JU) e o ZeroGuard (Horizon Europe)) and 2 awarded Horizon Europe projects (ISEAMORE and BERTHA). Commercial: 20 leads that resulted in 6 contracts.
Main activities and achievements in 2022	<p>Acceleration Cycles: Vortex is committed to accelerate the launch of technology bricks through rapid and iterative acceleration cycles to drive rapid innovation and deliver tangible results within compressed timeframes. During 2023, Vortex has launched 2 new acceleration cycles.</p> <p>Establishing a Robust Foundation: Vortex prioritised the development of a strong foundation and management structure to facilitate team expansion. Additionally, resources were directed towards the successful setup of new equipment, enabling the organisation to enhance its research capabilities and operational efficiency.</p> <p>Achieving Financial Sustainability: Vortex placed a strong emphasis on attaining financial sustainability. We recruited a dedicated Business Development Manager for the commercial side and a dedicated Innovation Business Developer for the competitive funding. The aim is to transition towards a funding model where two-thirds of the total budget is derived from external sources by 2026.</p> <p>Cultivating Excellence in Knowledge: The organisation remained committed to nurturing a culture of innovation and continuous learning to fuel the growth of its R&I agenda. For this we have recruited a Solutions Architect and an Agile Coach.</p>
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	<p>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.</p> <p>Capgemini's activity in the automotive market holds a potential for technology transfer in High-Assurance Software.</p> <p>Although efforts have been made by all VORTEX partners, this potential has not yet been materialised in new projects with INESC TEC.</p>

3.12 Activities within the scope of INESC TEC's recognition as a Technology and Innovation Centre (CTI)

Presentation

INESC TEC recognition as a Technology and Innovation Centre (CTI) by the Portuguese Government was renewed in 2023. CTIs are entities dedicated to the production, dissemination and transmission of knowledge, oriented towards companies and the creation of economic value, contributing to the pursuit of public policy objectives. The CTIs provide technical and technological support to companies, promoting the use of technology and innovation as tools for improving business competitiveness, increasing added value and qualifying supply, particularly for small and medium-sized enterprises (SMEs).

The organisations recognised as CTIs are expected to reach the following specific objectives:

- Promote the development of R&D and Innovation activities, involving the business community, increasingly fostering the circulation of knowledge between the national innovation system and the generation of more value in the business community;
- Acquiring and developing resources, skills and tools that keep up with the state of the art in international reference knowledge;
- Strengthening the role of people in organisations, encouraging the hiring of highly qualified human resources and the training and qualification of existing profiles;
- Keeping up with the thematic priorities defined for Portugal in the European context, namely maintaining focus on decarbonisation, the circular economy and on digital technologies, in terms of the dual transition;
- Integrating the major international forums for discussion and development of knowledge on an increasingly regular basis, in order to expand the network of strategic partnerships for CTI and the potential for interaction and export of Portuguese companies with other international agents and markets and positioning in international value chains.

Highlights in 2023

During 2023 the following were the main outcomes of the work done in the scope of the recognition as a Technology and Innovation Centre (CTI):

- The support for companies was reinforced in three areas that are particularly critical nowadays: circular economy and decarbonisation, Artificial Intelligence, and cybersecurity. In particular, INESC TEC's methodology for supporting companies in the digital transition was extended to support also the transition to the circular economy and sustainability, allowing an increased operational efficiency and an enduring commitment to environmental and social responsibility. In the area of decarbonisation, significant investment was made in the industrialisation of an energy community management platform. A catalogue of services for companies in the field of Artificial Intelligence was developed and made available.
- Over the year, work meetings with more than 300 new companies took place to analyse and evaluate opportunities for new R&D and innovation projects. The participation and organisation of more than 50 industry related events aimed to transfer knowledge to companies and promote new innovation projects.
- Training in IP protection and analysis of the opportunities for protection and exploitation led to three new patent applications and the evaluation of 5 new spinoffs.
- INESC Brussels Hub promoted the participation in high level discussion forums and supported the launch of new international initiatives and projects. INESC TEC was active in 28 international networks and promoted the participation in European projects and initiatives.
- Research and innovation infrastructures were upgraded. Visits, meetings, and workshops with companies in these infrastructures were promoted.
- Specific training to researchers and support services was promoted. Internal processes were improved, and its digitalisation upgraded to better support companies and public organisations.

3.13 Environmental, Social and Governance

Inclusion of ESG Reporting: A Commitment to Transparent Sustainability

The commitment to sustainability is embedded in INESC TEC's values and translated in its mission and goals, so despite not being obliged to produce an ESG (Environmental, Social and Governance) report, ESG practices are in the core of INESC TEC's strategic commitment, being this section dedicated to a summary of the actions that were implemented during 2023.

ESG Initiatives: Shaping a Sustainable Future

At Environmental pillar:

INESC TEC contributes to the decarbonisation of its operation by implementing a set of measures and strategies that reduce its carbon footprint. Regarding 2023, the following measures are highlighted:

- Increase of electricity production from renewable sources, namely solar, and implementing a set of measures to increase energy efficiency and reduce waste; More than 30 led lights replaced old electromagnetic ballast, including PIR sensors, installation of 2 heat pumps with inertia reservoir to reduce the use of natural gas, by pre-heating the water circuit of the heating system;
- Foster electric mobility by providing information and means to employees, contributing to the reduction of greenhouse gas emissions by fostering vehicle charging in moments where the CO₂ level of the electricity produced is lower (including adequate communication with explanation on the composition of electricity production);
- Reformulation of HVAC control systems, to increase visibility on consumption and foster the adoption of corrective set points according to weather conditions;
- Maintenance plans considering waste management, by including sensors and timers to reduce water usage.

At Social pillar:

INESC TEC has a multicultural work environment with over 30 nationalities. This multicultural environment requires a set of concrete measures to foster everyone's inclusion. Some examples of actions in 2023 are:

- Creation of a meditation room introducing mindfulness at work and promoting mental health;
- Implementation of a "Gender equality plan" and promotion of initiatives as "Women and Girls in Science";
- 2 overall salary increases, favouring the lower salaries to support the economical difficulties felt by the families with the significant inflation felt in the country;
- In the performance appraisal exercise, the concern with gender unbalances was central in the process, guaranteeing gender pay equity;
- Supports of all actions of its Commissions for Social Responsibility and for Diversity and Inclusion (see Section 3.4.3 and 3.4.2) promoting diversity, inclusion, and community engagement;
- Hiring persons with disabilities, with concrete valorisation in the merit evaluation has been a growing practice that promotes an inclusive working environment;
- Specific training beyond the legal framework is promoted and supported;
- Implementation of flexible work arrangements, to allow better work-life balance between professional and personal life;
- Renegotiation of healthcare insurance benefits, with the inclusion in the new policy of the coverage for childbirth and increased outpatient cover;

- Employee health and safety activities have a specific program, having as example the “Wellbeing games 2023” in Lisbon, where INESC TEC opened to the community the opportunity of creating a team (with elements from the different poles in Porto, Braga and Vila Real) to compete in the event;
- Advanced leadership training, with one specific action in 2023 to immerse centre and services responsible on how to deal with the mental and physical wellbeing of their teams;
- Extended survey to all co-workers identifying their training needs, in order to create an advanced Training plan for 2024;
- Supplier Diversity and Labor Standards: Extending social responsibility practices to the supply chain by ensuring that suppliers adhere to fair labour practices, particularly in cleaning and security services, guaranteeing the accomplishment of human rights standards, and also promoting diversity and inclusion in the elements of the suppliers of INESC TEC.

At Governance pillar:

INESC TEC has been, over the years, reinforcing this pillar, including its leadership structure, transparency, accountability, and adherence to ethical standards. Here are some concrete examples of measures within the Governance pillar of an ESG policy that were implemented in 2023:

- Training on the General Regime for the Prevention of Corruption and the Whistleblower Protection Regime;
- Completion of the Code of Conduct for preventing and combating harassment;
- Compliance Programme for the Prevention of Corruption.

Future Outlook:

These sections are a compiled mode of what is being designed as a full ESG policy, able to face scrutiny on how sustainability practices are measured in impact performance metrics. Evolving to an ESG report will only bring to light the existing practices, reinforcing the need for “measure to manage”, and reassurance in a sense of contribution to a better, safer, and sustainable planet.

3.14 End-of-term reflection: a summary of the Board's intervention in 2021-2023

José Manuel Mendonça

The mandate now concluding successfully executed a carefully planned and timely approved transition in the institution's leadership, as endorsed by the associates. A pivotal element of this transition was the comprehensive sharing of responsibilities for high-level institutional representation between the Chairman and the Vice-Chairman and CEO. This collaborative approach to leadership extended to encompass all strategic matters, including the preparation of the Strategic Plan, the fostering of high-level relationships with associates, and the contributions to public policies in collaboration with various Government bodies. The Chairman's involvement in the leadership of both the UT Austin Portugal Program, shared with Rui Oliveira, and the National Council of Science, Technology and Innovation, as well as the presence in several other Councils, such as the Advisory Councils of ANI, COTEC, PRR and COMPETE, were also an important part of the work carried out throughout the mandate. Finally, high-level active involvement was crucial in several strategic initiatives, particularly in the maritime sector. This included participation in the National Task-force for the Sea, Leixões Blue HUB, Teaming in Ocean Engineering, and Innovation Valleys, among others. These efforts were closely coordinated with the Government, local authorities, the CCDR-N, and the European Commission.

João Claro

INESC TEC formulated its first comprehensive strategic plan in the mandate that now comes to a close. Seeking to balance ambition, practicality and adaptability, the plan was the result of extensive stakeholder engagement and integrated diverse experiences, with a pivotal involvement of our community, which was key to establishing firm foundations and the most favourable conditions for a successful implementation of the plan. The Board also committed considerable efforts to streamlining operational management and facilitating decision-making processes, to enhance operational efficiency, effectiveness, and strategic alignment. During the mandate, the Board of Directors was actively involved in fostering Institutional Relations, building and maintaining the valuable partnerships that support our mission, and bridging the institute's activity to Science, Technology and Innovation policies, across the regional, national and European levels, directly and through participation in multiple fora. The Board also led the establishment of a Public Policy Office, which had its first full year of operation in 2023, with the mission to advance INESC TEC's policy engagement, supporting our community in developing and implementing bespoke engagement strategies with impact.

Aníbal Matos

During the term, the activity was distributed as follows: a) management of the call process for internal seed projects, with the evolution of the proposal evaluation model and project execution; b) support in the evolution of the science management model, with the reorganisation into scientific domains, and in institutional science domains; c) initiatives with students, including the development of a pilot programme for extended summer internships across various INESC TEC centres, contribution to the creation of tools to streamline these initiatives, and systematisation of student support in the preparation of applications for FCT doctoral grants.

Gabriel David

The main results achieved during the 2021/2023 mandate were the following: In the information management area, the sustained support to the researchers in developing data management plans, the establishment of an archival policy to be followed by all the services, and the implementation of a dashboard with the main indicators used in the regular reports. In the data protection area, cruising speed has been reached with all the main dimensions foreseen in the GDPR already implemented and the capacity to lead the data protection work packages in several relevant European projects. In the management information systems area, a service specialisation module was developed and the use of the uOneConnect system was generalised to the European projects we lead. In the information technologies area, besides the consolidation of the data centre, a new self-service virtualisation system was launched, a centralized log management and alerts system started, and a disaster recovery infrastructure was established.

In the relationship with the Higher Education Institutions, the signature of a new comprehensive protocol with the University of Trás-os-Montes and Alto Douro is highlighted, as well as the establishment of a new INESC TEC pole in Madeira Island in cooperation with the University of Madeira and the Regional Agency for the Development of Research, Technology and Innovation (ARDITI). In the coordination of Computer Science research centres, the biggest imbalances were overcome and the development of research and innovation activities continued at a good pace.

Several other goals planned for this mandate are still work in progress that require more time to be concluded.

José Carlos Caldeira

This mandate was mainly dedicated to the consolidation of most of the projects and initiatives launched in the previous one. The INESC Brussels Hub project (in collaboration with the other INESC Institutes), now with 3 persons located in Brussels, saw a considerable increase of its activities and impact. In the scope of the Service SAL's new ambition, of a bigger and better valorisation of the knowledge generated by INESC TEC, a pilot project was launched to test and validate the defined methodological approach, that is now ready for its deployment. Regarding the articulation with the spin-offs, a joint intervention plan was developed, gathering the resources and competences of Service SAL and CITE Centre, and the processes to support the creation of new spin-offs and the follow-up of existing ones were revised, aiming at more efficiency and effectiveness. Considerable efforts were dedicated to the development of the TEC4 structure, both in what concerns its sectorial dimensions (with the development of specific strategies and action plans) and in more horizontal actions, such as a new TEC4 section in the INESC TEC website and also the development and implementation of a CRM application (now being deployed to INESC TEC organisation). Finally, it's relevant to highlight the development of a new model for the Business Advisory Board, with more members to ensure a better representation of our main sectors of intervention, the approval of the new board and its first meeting, in July 2023.

Luís Carneiro

During the mandate, instrumental efforts were made to advance INESC TEC's institutional applications and innovation initiatives. This included the successful recognition of INESC TEC as a Technology and Innovation Centre, alongside the securing of the associated base funding, and the first full year of implementation of the approved activity plan. Additionally, key steps were taken towards enhancing organisational efficiency, such as establishing a Project Management Office (PMO) and developing a comprehensive service catalogue for internal operations. Moreover, considerable progress was made in laying the groundwork for future technological advancements and operational enhancements through the definition of scope and detailed requirements analysis for a new Enterprise Resource Planning (ERP) system. These advancements have contributed to driving innovation, improving operational effectiveness, and fostering sustainability, growth and excellence within the institute.

Luís Seca

The beginning of the mandate still suffered from the impacts of COVID-19, that changed the way the organisation had to deal with work organisation, not only in the people domain but also with the necessary changes in infrastructure, to be able to deal with a new hybrid work regime that was put in place. To address the challenges, profound changes had to occur in the adaptation of infrastructures to allow the co-workers rotations, availability of necessary equipment and most of all, a complete change in the way our buildings and offices were explored, with several changes to increase the comfort and cosiness for co-workers. Significant effort was also made in the implementation of an ESG strategy, including several actions to increase sustainability from the technical perspective (heat pumps, efficient lighting, sensors, EV charging Wallboxes) but also in Social and Governance, with significant actions in favour of inclusion, social responsibility, and also transparency in the different models (Performance appraisal, careers and benefits) with workers Commission. In the Funding Domain, a significant effort was made in the creation of an internal micro-site, that more than opportunities calendar, makes available templates, rules, good examples of proposals and many other relevant documents to support researchers. The number of accesses and the feedback from researchers confirms that this initiative was right. As for Human resources, the actions were divided into two different areas; operational and strategic development; on

operational, several workflows were analysed and improved, namely the digitalisation of many of the processes and documents that were manuscripts. A strong bet was made with grant holders, with the formal and real implementation of the grant holders Nucleus. Decision like the payment of tuition fees, with all the requirements necessary for such a measure to work (dedicated platform, articulation with HEI) were on of the most relevant achievements in the area. In the recruitment area, a strong bet on LinkedIn, that has swooned to be a success, with a significant increase in the number of candidates to the different positions opened. At strategic level, the profound transformation of 5 different vectors (recruitment, onboarding and integration, performance appraisal, careers, and training) was developed, including the definition of functions and competences for the whole organisation. Some quick wins have already appeared, with a significant increase in training activities, recruitment, careers and internal mobility programme. Overall, in the HR level, a culture of proximity was put in place, with different events all over the year, to make co-workers feel that INESC TEC is now focused on people and not only on R&D achievements. In the different R&D centres under responsibility, specific mentorship actions for younger talent were developed, to improve not only the leadership capabilities but also an increase in the overall knowledge of the specificities of finance opportunities, people and resource management.

Maria da Graça Barbosa

In the domain of conflicts of interest management, coordination between the Conflicts of Interest Management Commission (CGCI) and the Board of Directors was facilitated, with a close follow-up of the commission's activities. INESC TEC's commitment to diversity and inclusion (D&I) led to the establishment of the Diversity and Inclusion Commission (D&IC) and its respective governance model. The rotation of commission members was well-supported throughout the mandate. The Gender Equality Plan and the D&I Programme were approved, and their implementation was started, with ongoing support and oversight from the Board. In the field of ethics, significant contributions were made through the creation of the Ethics Committee, which played a crucial role in implementing the newly adopted Code of Ethics. Additionally, key steps were taken in governance, risk management, and compliance with the drafting and approval of the Compliance Program for the Prevention of Corruption, the appointment of an anti-corruption compliance officer, and the implementation of reporting channels for ethics and compliance-related concerns. Oversight of the Legal Support Service and Secretarial Coordination was conducted with diligence and proficiency throughout the mandate. It is worthy of note that, in addition to the oversight of CGCI, the Legal Support Service, and Secretarial Coordination, responsibilities were concentrated on driving institutional change, tackling bold challenges, and adopting innovative solutions.

Rui Oliveira

The mandate's primary goal has been to improve INESC TEC's science management model, with the aim of better capturing the dynamics and multidisciplinary nature of the research centres and each researcher individually, as well as providing an overarching and easily understandable view of the institute's remarkable research strengths. The endeavour, undertaken with Aníbal Matos, yielded a notably inclusive and reflective process. The new model, based on *Scientific Domains* and *Research Challenges*, is already part of INESC TEC's 2023–2030 strategic plan and is central to the ongoing institutional application for the FCT R&D Units Evaluation. Furthermore, during the current term, two assessments by INESC TEC's Scientific Advisory Board were conducted to ensure alignment with the new model and to identify areas for improvement and growth. The feedback received from these assessments was used to further enhance the institute's research capabilities and strategic direction.

Internationalisation has always been a key enabler for the institution's long-term strategy. To that purpose, the consolidation of INESC TEC's International Relations Service (SRI) and the focus of its activity and contribution were important considerations throughout the now-ending term. Notable deliverables of this effort are a framework to map out the institute's international vision, a standard procedure and documents to support MoU negotiation and management with foreign partners, and the launch of the INESC TEC International Visiting Researcher Programme with three calls announced so far. Of noteworthy mention is the establishment of effective collaboration with prestigious Asian R&D&I institutions, which has significantly increased INESC TEC's global visibility and impact.

Additionally, the implementation of a comprehensive communication strategy has effectively promoted the institute's international activities and achievements to a wider audience. Communication of research and innovation activities, deliverables, and socio-economic impact has been the primary goal and priority of INESC

TEC's Communication Service (SCOM) leadership. This has been accomplished internally and externally through new initiatives such as INESC TEC's Spotlight, Science Bits, and Ciência e Sociedade. Of major relevance has been the thorough diagnosis followed by the structuring, modelling, and design of the new institutional website, whose implementation has already started.

Finally, leading the UTAustin Portugal Programme, which I shared with José Manuel Mendonça, the Minho Advanced Computing Centre, and serving on the EuroHPC JU Governing Board were all important and challenging responsibilities throughout the mandate.

4 INESC TEC SCIENTIFIC DOMAINS

As mentioned in Section 2, research at INESC TEC is centred around eight Scientific Domains – Artificial Intelligence (AI), Bioengineering (BIO), Communications (COM), Computer Science and Engineering (CSE), Power and Energy Systems (PES), Photonics (PHT), Robotics (ROB), Systems Engineering and Management (SEM). The next section presents those Scientific Domains and their objectives.

4.1 ARTIFICIAL INTELLIGENCE

Steering Committee: Andry Pinto, Alípio Jorge, Jaime Cardoso, João Gama, and Rita Ribeiro

Presentation of the Domain

Artificial Intelligence is a decades-old scientific domain which has recently boosted its importance and impact in science, the economy and society in general.

Stemming mostly from Computer Science, AI has strong influences from other scientific fields, namely mathematics, neuroscience, linguistics, psychology, philosophy, and physics. In the 21st century, AI has made major advances, particularly in areas dominated by machine learning and more specifically deep learning. These include natural language processing, computer vision, content generation and recommender systems. Artificial Intelligence is already having a significant impact on many industries, including healthcare, energy, finance, transportation, and manufacturing, and is also playing an increasingly important role in our everyday lives, from virtual assistants to online recommendation systems. The symbolic legacy of AI is also very significant with roots in mathematical logic, linguistics, and psychology. Currently, symbolic approaches open avenues for explainability and transparency in AI systems.

Besides the fundamental need for large amounts of high-quality data (for the correct application), the growing influence of Artificial Intelligence calls for a human-centric approach with advances in the trustworthiness of the delivered tools, chiefly the interpretability of predictions and decisions, generalization to unseen and even unpredictable situations, and robustness to biased data or unethical results.

Nowadays, Artificial Intelligence has powerful algorithms that can approach very difficult tasks, only doable by humans until little more than five or ten years ago, with astounding quality. Although the success of current neural and statistical approaches is almost blinding, there is a very important legacy of symbolic methods. They matter not only to the human dimension of AI, but also to the possibility of powering non-symbolic solutions with new cognitive layers that can be engineered and designed.

The growing dissemination of AI solutions and AI agents as enhancers of human capabilities, artificial co-workers or artificial experts, boosts the importance of human-AI interaction and of the trustworthiness of AI counterparts. The myriad of different interaction scenarios motivates research along many lines, such as human modelling (including the theory of mind), human-AI collaboration (including human oversight), interaction, usability and user experience, information visualization and visual analytics, explanations and verification of AI processes and results.

The power of current and future AI also requires the mitigation of AI risks and implications. AI solutions and deployment must be ethical by design, following European and International guidelines that defuse as much as possible any potential harm. The ongoing and foreseen transformation of human tasks and jobs requires anticipation and reflection by all the players.

From an algorithmic point of view, the current moment of AI is strongly influenced by the emergence of large models built using deep and reinforcement learning. These approaches are fundamentally statistical and extremely data-thirsty. At the same time, they can capture refined patterns due to highly powerful estimations and are highly reusable. While their stochastic nature dispenses human intervention and obliterates the knowledge engineering bottleneck, the need for labelled data is still demanding and costly. On the other hand, their statistical nature and complexity make them highly opaque and hard to scrutinize.

Research Challenges

A) Build highly valuable and reusable AI resources

- Algorithms are the central piece in AI development. The combination and modification of classical and modern AI approaches in their symbolic and subsymbolic flavours is the essence of the answer to every current AI challenge. Dealing with different types of inputs and combining them in different regimes, from static to streaming, is very important.
- More than simply processing information, AI algorithms and systems use and produce models that represent knowledge. Models are increasingly an important output of AI. Producing reusable, expandable and refinable models poses a number of important challenges. Developing live and responsive models such as digital twins is a challenge not only for AI but for other domains as well.
- Models become complex and mutable, raising hard questions of how to continuously evaluate and manage them, using human centred and automated approaches. AutoML approaches enable the automatic selection and assessment of models and algorithms.
- Data is a highly valuable asset. Producing, collecting, curating, managing, disseminating, accessing and learning from datasets or data sources are transversal challenges essential to AI development. Data augmentation and the production of artificial data mitigate the lack of data in many scenarios.
- Intelligent systems require development and deployment pipelines that integrate AI and non AI components taking into account interaction with humans in challenging contexts. Such pipelines can be made reusable and are an important asset.

B) Exploit models and algorithms for advanced tasks

- Pre-trained large models have the ability to solve problems they haven't been trained for. They can be exploited as is, in a zero-shot manner, or with some further training, as in few-shot, placed in AI pipelines, combined and stacked, used for obtaining representations with different levels of abstraction (probing), reused in completely new domains and queried using natural language, prompting, instead of artificially coded programs.
- Exploiting models as complex entities, and almost natural phenomena, represents a number of challenges which themselves lead to the understanding of the models, their algorithms, and to further developments.
- Symbolic algorithms and models, including network science approaches, do not compete with neural approaches for predictive ability, but can be used in specific cases, when there is little data, when there is external knowledge to convey, when communication with humans is important. The exploitation of neuro-symbolic approaches or the use of symbolic methods per se for more than optimising prediction error are important research paths.
- The development and validation of AI systems or of information systems with AI components.

C) Produce AI models that humans can inspect, understand, learn with and contribute

- Human-AI interaction will become increasingly complex, requiring the combination of different specialities from computer science and human sciences. The development of effective collaboration between AI systems and humans requires sophisticated modelling, trustworthiness and explainability.
- Enabling humans to inspect AI algorithms, pipelines and models is important for avoiding and correcting errors, increasing safety and trust. Verification of systems and programs becomes more complex than with ordinary algorithms. Visualisation becomes a very important tool.
- It is important to anticipate and mitigate the risks and the impact of AI systems in society and in individuals. Privacy, safety, freedom, employment and general wellbeing must be taken into account in every step of AI development, starting from conception and continuously in deployment.

D) Learn models and deploy AI Efficiently

- The data thirst of current AI solutions and the fact that data is more often than not an expensive asset motivates research in more data-economic approaches. To face these challenges it is important to study new ways of exploiting and generating data as well as new algorithms that are able to propagate feedback from the environment as in reinforcement learning.
- New frameworks for machine learning can be based on alternative approaches, such as photonics, that combine the paradigms of extreme learning machines, reservoir computing and diffractive neural networks towards the deployment of all-optical processors and A.I. platforms, with advantages in processing speed, scalability, and energy efficiency.

E) Enhance perception in dynamic, noisy, and multi modal scenarios

- The work on the development of intelligent decision support systems combines audio-visual data understanding with any additional information available, coming from sensors or other external sources, to enhance the analysis and the decision process as well as the efficient handling of the large amounts of data produced.
- Enhancement of the analysis and the decision process, as well as the efficient handling of the large amounts of data produced, through the development of intelligent decision support systems that combine audio-visual data understanding with any additional information available, coming from sensors or other external sources.
- How to adapt the (deep) machine model's learning ability to the challenging conditions presented by audio-visual data focusing on: Compression and acceleration of Deep CV; Explainable and uncertainty aware deep learning architectures; Multimodal learning; Efficient annotation Learning; Open World Learning; Domain Adaptation; Domain knowledge and data integration.
- Bringing together the semantics of text, knowledge bases, ontologies, sound and images for multi-model Machine Learning and AI systems.

4.2 BIOENGINEERING

Steering Committee: Ana Maria Mendonça, Hélder Oliveira and João Paulo Cunha

Presentation of the Domain

The Bioengineering Scientific Domain of INESC TEC aims to promote scientific knowledge in bioengineering through fundamental and practical research, advanced training, and innovation. It focuses on several areas of research and development and is supported by a diverse staff of highly multidisciplinary researchers and students.

Bioengineering is a rapidly growing and evolving scientific domain at the intersection of engineering and the life sciences. It combines fundamental engineering principles, practices, and technologies in medicine, biology, and environmental and health sciences to provide practical solutions to problems in these fields. The domain includes (but is not limited to) the development of mathematical theories and models, physical, biological, and chemical principles, computational models and algorithms, and devices and systems for clinical, industrial, and educational applications.

With this vision, efforts are directed towards achieving the following objectives:

1. To generate interdisciplinary knowledge enabling innovation and technology transfer with economic impact;
2. To develop novel bioengineering methods and tools for the prevention, early detection, and diagnosis of diseases, ageing-related impairments, rehabilitation, occupational health and wellness, and environmental-biology interactions;
3. To advance the progress of cutting-edge innovations in engineering, medicine, biology, and other health and environmental sciences and then introduce them to the global market of the future; 4. To promote internal synergies and strategic partnerships involving different Centres of INESC TEC, clinical partners, research institutes, MedTech companies, and startups, and foster an extensive network of international cooperation with the best R&D Centres in the field.

Research Challenges

A) From Macro-to-Nano Scale Biosensing

Biosensing has been in a rapid evolution towards smaller and smaller scales, turning biosensing into a widespread commodity, many times connected to the internet by design and opening novel domains & opportunities to innovate in bioengineering.

The aim of this challenge is the design & development of novel biosensors (e.g. bio-electrochemical, optical and photonic micro & nano biosensors & actuators, etc.) to approach macro-to-nano life sciences environments such as wearables and snap-to-skin biosensing solutions for sports performance or the chronic disease management, implantable sensors and actuators/stimulators for adaptative modulation in neurological diseases (e.g. Parkinson's or epilepsy), cell & sub-cell activity micro & nano sensing in different disease models or environmental hazardous volatile components monitoring for protecting "connected" workers in their hostile work environments (e.g. firefighters, miners, etc.).

B) Novel Technologies for Personalized Health & Wellness

Nowadays we are collecting ever larger amounts of health information and having more and more computer power but we are not using this availability to its full potential for promoting personalised and precision solutions to today's health challenges such as cardiovascular diseases, diabetes or Alzheimer's disease.

Genomics is generating data at an unprecedented scale by assaying molecular data from a large set of individuals in a time and cost-effective way. While this opens new avenues for research and treatments, it also poses many challenges in order to handle the volume of data and speed of analysis that is required. To tackle some of these problems, we expect to apply cutting-edge genomic data science including AI and machine learning techniques, but also develop novel data analysis strategies. Different omics data will be combined with other multi-modal

data, including wearable and health sensors and clinical data, to obtain an integrative view of the physiological state of the individuals. Data will be analysed at different levels of granularity, to understand the mechanisms that lead to complex phenotypes and diseases. We expect to understand unmet clinical needs and apply the acquired knowledge for patient benefit.

Methods and tools to integrate and harmonize knowledge will be brought together with computational models to produce digital platforms leveraging personalized health research. The goal is to empower medical research with the necessary computational framework to determine treatment pathways adapted to each individual.

In this RC we aim to combine large-scale data collection (from electronic patient records to genetics and proteomics) with human-centred technology design to contribute to new approaches to these health challenges and help patients better manage their health and humans live healthier & happier lives. Several competencies of INESC TEC are & will be involved in this RC, from Health informatics & Computational Biology to Bionics, Wearable and Implantable technologies.

C) New Challenges in Medical Signal & Image Analysis

Based on two decades of R&D with worldwide recognition, we aim to approach new challenges in medical signal and image analysis, contributing with novel approaches the following sub-challenges:

- Cancer Image Analysis
- Cardiac Image and Signal Analysis
- Brain Imaging
- Eye Image Analysis
- Lung Image Analysis

D) BioRobotics & Human-Machine Symbiosis

Within the biorobotics challenge we aim at novel and innovative approaches:

- to develop surgery, molecular biology automation, and biological-inspired robots and exoskeletons
- to fuse robots with humans “in-the-loop”, brain-computer interfaces (BCIs) and affective computing
- in keeping biometrics algorithms computationally efficient and guaranteeing privacy, transparency and explainability
- with generalisation capabilities to unseen or under-represented types of data, analyse attributes embedded in data assuring the veracity and detecting incorrect output predictions
- to design and provide representations invariant to the domain of the sample making results more interpretable

4.3 COMMUNICATIONS

Steering Committee: Manuel Ricardo and Rui Campos

Presentation of the Domain

The Communications Scientific Domain is at the forefront of developing cutting-edge wireless communications technologies central to pioneering next-generation communication systems. INESC TEC aims to advance communications research across various sectors, including industry, energy, smart cities, mobility, health, the maritime domain, and agriculture. The research group focuses on developing advanced communications solutions that meet the evolving demands of these fields.

The forthcoming wave of mobile and wireless communications will revolutionise the landscape through ubiquitous multimodal sensing and localisation, service-oriented software architectures, the deployment of autonomous systems, including drones and high-altitude platforms, pervasive artificial intelligence, and the integration of edge and cloud computing. These technologies are key to facilitating on-demand virtual and physical networks, thus enabling a seamless, interconnected world.

The dual goals of addressing the need for bandwidth-intensive, latency-sensitive applications and bridging the connectivity gap for the unconnected, whether machines or humans, drive the scientific domain. The domain's primary challenge is the development of communications systems that are inherently context-aware and can be deployed on demand in both terrestrial and non-terrestrial settings. This entails the development of systems capable of dynamically adjusting their operations to suit the communication context, factoring in aspects such as the physical environment, energy limitations, the entities involved in the communication process, and the specific requirements of the users or machines.

By focusing on these objectives, the researchers aim to contribute significantly to the research and development landscape in wireless communications, pushing the boundaries of what is possible in communications technology. We anticipate that the work will profoundly influence the creation of innovative solutions essential for the progress of various industries, guaranteeing that forthcoming generations of communication systems will be more adaptable, efficient, and able to satisfy the varied demands of our increasingly digital world.

Research Challenges

A) Autonomous Communications Systems

Communications networks are the nervous system of the digital world in which we are and will be immersed. Next-generation communications systems need to be self-manageable, self-controllable, and self-adaptable towards fully autonomous communications networks operating similarly to other autonomous systems such as autonomous cars.

The ever-increasing complexity of the underlying technologies, including an ever-increasing number of parameters that can be controlled and whose optimization according to the context is yet to be explored, is not compatible with the human-in-the-loop anymore. Also, there is a need to make communications efficient and scalable from multiple perspectives including performance, energy consumption and privacy.

This complexity leads to an increasing need for novel solutions that take advantage of advanced optimization techniques and the computational capacity available, either in the cloud or in the edge, as the means to self-manage, self-control, and self-optimize the network operation dynamically and in real-time.

In this research challenge, we aim to investigate new fundamental communications solutions that support the digital world of the future in a sustainable and secure manner. This will be achieved by means of:

- Developing mobile, adaptive networking infrastructures for agile and flexible network coverage and capacity reinforcement using robotic platforms.
- Creating wireless network digital twins enabling fast, flexible, and energy-efficient evaluation of “what if” scenarios and the training and validation of novel AI/ML-based communications algorithms without the burden and resource-inefficient training and testing in real testbeds.
- Developing new security mechanisms, algorithms and protocols providing increased levels of communication confidentiality, integrity, and availability from PHY layer to APP layer, considering an

increasing amount of input data, the physical environment where the communication is taking place, the wireless medium over which the communicating is being accomplished, as well as the challenges of increasingly decentralized/distributed communication scenarios.

- Developing machine learning models for intrusion detection of encrypted malicious traffic against a backdrop of human- and machine-generated legitimate traffic in the context of zero-trust networks, via training with legitimate traffic only or with both legitimate and malicious traffic.
- Developing mechanisms to exploit the advances in distributed renewable energy sources and energy flexibility to integrate communications infrastructure and power distribution systems towards energy-aware networking.
- Novel approaches for learning to adapt baseband processing to the communication context and environment, including multi-standard, multi-mode support (e.g., radio, optical), free frequency bands, interference patterns, spectrum sharing, and the state of the hardware platform (e.g., power supply availability, computational power) towards a more energy efficient computing at the edge.
- Photonic integrated circuit design and programmable photonics for mmWave fibre/wireless communications towards a seamless integration of optical and wireless networks and Quantum Key Distribution (QKD) for truly secure communications.

B) Communications for Extreme Environments

Airborne, underwater, underground, and industrial communications have been attracting growing interest in the research community. Underwater wireless networks have been considered for military and commercial applications including ocean data collection, disaster prevention, border surveillance, and environmental monitoring. Unmanned aerial systems can assist humans in extreme or difficult-to-reach environments as well as provide cost-effective wireless coverage and capacity for devices without infrastructure coverage. Underground wireless networks can enable applications such as precision agriculture, pipeline leakage detection, mine disaster rescue, and concealed border patrol. Satellites can improve communications, namely in remote areas (e.g., offshore) and ongoing monitoring of Earth phenomena ranging from weather and climate to disaster management. Industrial communications have been relevant for communicating with the users and devices on the shop floor and more recently with the robotic platforms such as Autonomous Ground Vehicles (AGVs) operating there as well, where wireless communications become crucial.

Underwater, aerial, underground, space, and industrial wireless networks share common core research challenges that arise from the harsh nature of the propagation medium (absorption, reflection, diffraction, and scattering), the inaccessible nature of the environment, and the tight Quality of Service (QoS) requirements in the case of industrial wireless communications, in many cases used to replace wired solutions. As a result, conventional communications and networking techniques cannot be applied in extreme communication environments like these mainly due to the unavoidable impairments suffered by using traditional wireless technologies and the limitations of operating far from the power grid.

In this research challenge, we target the development of communications solutions for extreme environments such as the ocean, industry, natural and manmade disaster scenarios, and space. This will be accomplished by means of:

- Developing multi-tier communications approaches for extreme environments, including integrated communications across multiple media such as space, air, underwater, and underground.
- Investigating robotic-borne wireless networks enabling mobile, adaptive networking infrastructures in extreme environments such as air, water surface, underwater and underground by taking advantage of robotic platforms for carrying the communications nodes (e.g., AUVs, ASVs, UAVs).
- Creating network digital twins enabling fast, flexible, and energy-efficient evaluation and training and validation of novel AI/ML-based algorithms without the time-consuming, highly costly, and resource-inefficient training and testing in real testbeds and environments.
- Developing robust and high data rate underwater communications taking advantage of short-range acoustics and multimodal approaches combining acoustics, optical and radio simultaneously and

considering multiple input parameters such as water salinity, water turbidity and background acoustic noise.

- Developing communications solutions for industrial environments, including cabled, hybrid and full wireless using multi-technology and multimodal approaches (e.g., radio, optical).
- Using geometric and probabilistic constellation shaping techniques for more resilient, energy-efficient, and adaptive optical wireless underwater.
- Developing free-space quantum communications solutions for high-security wireless communications.

C) Obstacle-aware Communications

Communications and sensing have evolved as separate scientific fields. This is envisioned to change with the advent of wireless communications in the millimetre-wave frequencies and up to the sub-THz and visible light frequencies, characterised by line-of-sight operating ranges, which could benefit from visual data to accurately predict the wireless channel dynamics such as anticipating future received power and blockages as well as constructing high-definition 3D maps for positioning.

Computer vision applications will become more robust against occlusion and low luminosity if helped by radio-based imaging, such as the high frequency radio signals generated by large reconfigurable intelligent surfaces that can also provide high-resolution sensing.

This new and emerging joint research challenge relies on a range of technologies in the fields of wireless communications, computer vision, sensing, computing, and machine learning, and is aligned with the research trend on Joint Communications and Sensing (JCAS) towards mobile perceptive networks.

We aim at developing novel communications solutions that incorporate network and environment sensing by design, towards perceptive networks. This will be carried out by means of:

- Designing reconfigurable electronics transceiver architectures and signal processing algorithms for large antenna arrays up to 110 GHz, enabling accurate beamforming and spatial noise-shaping, towards real-time digital control of antenna array radiation patterns suitable for environment sensing, localisation and obstacle-aware communications.
- Photonics-enabled communications and sensing devices: novel algorithms and hardware architectures based on radio-over-fibre and optical-wireless interfaces enabling wireless communications and RF sensing and localisation with large antenna arrays up to the sub-THz.
- Designing obstacle-aware robotic-borne networking solutions ensuring line-of-sight communications for agile and flexible coverage and capacity reinforcement in urban scenarios and indoor environments, using computer vision and sensing techniques for environment-aware positioning of the airborne infrastructure nodes.

4.4 COMPUTER SCIENCE AND ENGINEERING

Steering Committee: Ana Alonso, Ana Paiva, Hugo Paredes, João Canas Ferreira and Manuel Barbosa

Presentation of the Domain

The field of computer science and engineering is facing significant scientific and technological challenges, especially in the wake of the ongoing digital transformation. The pervasiveness of computer systems brings about new and often unforeseen challenges that defy our knowledge and best practices.

These challenges arise from the sheer complexity and scalability of computer and software systems, and the ever-increasing demand for their performance, interoperability, security, privacy, dependability, and sustainability.

The incredible progress being made towards the widespread use of digital sensing and instrumentation technologies along with the sheer computing power at our disposal reinforces our resolve to effectively and efficiently collect, filter, curate, store, process, visualize and analyse the massive volumes of data generated.

As our reliance on information systems grows, there is a rising need for these systems to be trustworthy, fast, always available, and ethically responsible. Software development, verification, and testing have become crucial aspects in the critical path of any digital system, underlining the paramount importance of ensuring quality throughout the entire process.

The whole computing pipeline is becoming more complex, which poses additional challenges in ensuring reliability and performance. Therefore, research on computing architectures and non-functional aspects of software is essential for achieving the scalability, interoperability, and efficiency required for sustainable digital systems.

Research Challenges

A) Advancing the Software Development Ecosystem

Software systems are becoming increasingly complex, with unprecedented scale, integrity requirements and shorter time-to-market. In addition, they are increasingly developed in volatile, uncertain, complex, and ambiguous conditions. In this context, it is essential to create new methods, techniques and tools to advance the software development ecosystem, including processes, development tools, and education. This is to be achieved as follows:

- Designing tools and techniques to evaluate and improve the interaction between developers and software development tools in next-generation development environments.
- Creating new approaches, techniques and tools to improve the developer experience, along the software development life cycle by providing quicker, better and more informative feedback about the several quality aspects of the software being built; easy integration with traditional development and quality assessment tools; and suggestions, recommendations, and guidance on how to improve those quality aspects (e.g. liveness, smart-assistance, AI-based co-piloting tools, immersive environments).
- Develop new techniques and tools to support and ease the maintenance phase of software systems. This can be achieved by automatically generating new test cases to exercise novel system parts and using traceability information to calculate the subset of existing test cases that are impacted by changes.
- Improve the education of future software engineers, with didactic approaches and learning-supporting tools, targeting all phases of the software development process, from formal requirement specification to programming and testing.
- Empowering more people with simpler software development approaches and tools to enable them to design and build their own applications addressing their personal and professional needs.

B) Ensuring Software Correctness

Functional correctness is one of the key aspects of software quality: ensuring that software is free of defects and does precisely what is supposed to do, and no more (avoiding potential liability gaps). Our goal is to devise new methods and tools to ensure correctness in the increasingly complex software systems that are being developed nowadays, namely large-scale concurrent and distributed systems and cyber-physical systems that operate in uncertain and hostile environments. We will also target emerging computing paradigms where future software systems will be developed, particularly quantum computing platforms. This is to be achieved as follows:

- Designing scalable rigorous methods, calculi, and logic to ensure and verify program correctness at all levels of the software development process.
- Improving structured and formal requirements specification languages to diminish ambiguity and enable research on the automation of the software development process, namely on the deployment of synthesis procedures to repair incorrect programs or automatically generate invariants to support program verification.
- Designing techniques and tools to increase the effectiveness and efficiency of software testing where traditional testing techniques are difficult to apply (for example, distributed or AI/ML driven systems) and taking advantage of HPC environments.
- Contributing to innovative concurrent high-level and domain-specific programming languages, APIs and compilers targeting the whole spectrum of parallel and distributed computing, by raising the abstraction level of current approaches.
- Improving the scalability and usability of formal design techniques and tools, to enable the verification of complex distributed and cryptographic protocols directly by the domain experts, without the need to resort to (scarce) formal methods experts.
- Integrating rigorous formal analysis and user-centred design practices in software design techniques and tools to enable both formally proving user-centred requirements during early design stages and prototype evaluation.
- Creating foundations and rigorous mathematical methods for emerging computing paradigms, including Quantum Computer Science, Quantum Software Engineering, Post-Quantum Secure Systems and Cyber-Physical Systems.

C) Managing the Increasing Complexity of Critical Information Systems

The way information is produced and consumed has a profound impact on society, both in personal and professional contexts. Two central problems arise from this information abundance: managing complexity and managing information quality and relevance.

Managing complexity is a challenge that arises from both the infrastructure and access points of view. With so much information available, it can be difficult to manage the underlying infrastructure that supports it, including storage, processing, and distribution. Ensuring that these systems can handle large volumes of data while still operating efficiently and effectively is crucial.

At the infrastructure level, where complexity results from factors such as its size, diversity of software and services, multiple data sources, differences in administrative domains, compliance with laws and regulations, and other challenges related to functionality and application domains, non-functional system characteristics play a critical role in ensuring the trustworthiness and sustainability of these systems. Non-functional system characteristics refer to aspects of computing systems that are not directly related to their core functionality, but rather to how well they perform in terms of scalability, performance, interoperability, dependability, security, energy efficiency, as well as quality, quantity, and confidentiality of information they process.

The second central problem arising from information abundance is accessing and managing the quality and relevance of the information organisations and individuals use and are exposed to. With so much information available, it can be challenging to find the specific data or content that one needs, and this is crucial for maximising productivity and efficiency. Even more difficult, is to ensure that the information being used is of high quality and relevance. This is particularly true in the era of fake news and misinformation, where it can be challenging to distinguish between accurate and inaccurate information.

The overarching challenge when dealing with multi-objective solutions and often conflicting requirements lies in being able to provide the best balance for each specific application or service at hand, which requires a deep

understanding of the many variables at play, and composable multidisciplinary approaches and solutions. To this end, we envision the continued need to focus on improving:

The non-functional aspect of data management systems and infrastructures on:

- Heterogeneous data management and cross-sector applications on public and private infrastructures, such as cloud computing and HPC centres, while realising their interoperability and enabling control of the information life cycle.
- Data management systems underpinning data-centric and privacy-preserving applications such as machine learning, analytical, and database frameworks.
- Systems of the Edge-to-Cloud continuum and cyber-physical systems as these systems evolve towards distributed and virtualised architectures.
- Standard cluster management and task scheduling tools to prioritize energy efficiency in Cloud and HPC centres.

Information management through:

- Representation models, information governance frameworks and policies, until the level of global communities.
- Information life-cycle control in organizations by enhancing the authenticity and traceability of data provenance.
- Tools to support the different stages in the data management process, along with interoperability protocols.

Access to information through:

- Studies of users' information needs and their interactions with information systems, by contributing to relevance estimation algorithms, ranking algorithms, and the development of novel mechanisms for human information interaction.
- Increasing the efficiency and effectiveness of visual analysis and exploratory visualisation of complex and multidimensional information.
- Ameliorate the communication of complex narratives, through information extraction and representation techniques, and interactive visual storytelling models.

D) Designing and Deploying Heterogeneous Computing Architectures

Processor architectures moved from single-core to multi and many-core including heterogeneous accelerator devices such as ASICs or FPGAs, with many of the dimensions of flexibility offered in the past by software to be shifted to hardware components. However, the future is looking towards new applications on the edge and IoT applications, including the use of AI and ML algorithms, stricter time constraints, and more power-efficient computation to address economical and sustainability concerns.

Therefore, as the performance requirements of these modern applications continue to increase, heterogeneous systems offer a way to achieve the required performance while minimizing power consumption and cost. Heterogeneous systems will provide a way to tailor hardware to specific applications, where the hardware meets the application demands, and where the software effectively utilizes the hardware.

The design of these novel computing systems needs to consider the holistic vertical continuum of hardware and software, to cope with these emergent applications. The increase in the complexity of systems, the requirements on high performance of autonomous systems, and the dependability and cybersecurity requirements. This comprises a challenge that spans from the digital component, through the instruction sets and compilers, and up to the languages and APIs. Within this hardware-software continuum, we focus on:

- Developing bio-inspired mixed-signal microelectronic circuits to improve power and area efficiency through event-driven computational architectures.
- Designing heterogeneous hardware platforms: methods and tools for design space exploration of accelerators, to optimize performance, power consumption, and area.

- Integrating CPUs with application-specific accelerators: this involves addressing challenges in interface design, memory hierarchy, coherence and consistency, programming model, and performance optimization.
- Devising novel compilation techniques to decrease the effort of scheduling and mapping computations to heterogeneous targets.
- Improving performance and predictability of computing systems, by appropriate management of HW and SW resources and components, including models for prediction of performance and energy efficiency of a heterogeneous application at design time.

E) Improving Computational Systems for a better Human-Technology Symbiosis

Human-technology symbiosis is a close and mutually beneficial relationship between humans and machines, mutually enhancing their capabilities. Humans and machines are increasingly collaborating, by sharing information, goals, and tasks, fostering a symbiotic relationship to empower and complement each other.

Digital environments, combining immersion/presence, collaboration, interaction, and narrative, provide rich and engaging experiences for users, in the context of learning, entertainment, workplaces, and industry, raising challenges for their integration with everyday information systems and processes.

This research challenge aims to improve computational systems to enable a better relationship between humans and machines, combining data, operations, processes, and awareness. It is focused on:

- Empowering humans with contextual awareness in increasingly complex extended reality systems, for areas such as education & training, information analysis, exploratory visual analysis, and decision-making processes.
- Integrating effective user-centred and co-creation design practices in computational systems and tools, to increase their effectiveness, adoption, and impact.
- Empowering domain and human-factors experts in the use of state of the art model-based tools for automated verification, in particular in the context of safety-critical system, enabling them to model systems, define safety requirements, perform analysis and interpret the results.
- Empowering non-technical people in authoring activities, incorporating new interaction paradigms, supported by extended reality, natural user interfaces, new AI tools, and multimodal systems, enabling them to design and build personalised solutions.
- Leveraging multisensory stimulation and haptics to attain perceptually equivalent scenarios for extended reality systems.
- Reinventing symbiotic processes for learning, work, and well-being in digital environments, including serious games, gamification, and extended reality, optimising user experience.

4.5 POWER AND ENERGY SYSTEMS

Steering Committee: Clara Gouveia, João Abel Peças Lopes and Ricardo Bessa

Presentation of the Domain

The Power and Energy Systems Scientific Domain envisions supporting society's full and enduring decarbonisation by adopting a multidisciplinary strategy that acts on the whole energy value chain by planning and operating it across multiple energy carriers, infrastructures, and users in an integrated, interconnected, and digitalised energy ecosystem. This will be anchored on combining model-based and data-driven methods for modelling, optimising, and controlling energy systems while proposing novel policy and regulatory solutions. Research outcomes include concepts, models, methodologies, and tools helpful in addressing the decision problems of citizens, communities, multi-utilities, system operators, regulators, policymakers, and government bodies, divided into four research lines:

1. Cost-effective decarbonisation and digitalisation of energy systems: designing near-100% renewable systems and optimising integrated energy systems; facilitating secure data sharing in the energy sector (energy data spaces).
2. Evolving and de-centralising energy-driven business models and markets: redesign and regulate wholesale electricity markets to coordinate with local markets, including support mechanisms such as capacity payments.
3. Resilience and reliability of energy systems: models and tools for assessing the long-term adequacy of interconnected systems under climate change; models and tools for assessing power system dynamic robustness in converter-dominated grids.
4. Smart control architectures and centres of the future: coordinated operation between electricity markets, Transmission System Operators (TSO), and Distribution System Operators (DSO); decentralised protection, automation, and control systems based on virtualisation and distributed computation at the edge; trustworthy AI solutions to support system operations.

A laboratory infrastructure for smart grids and electric vehicles enhances the research and innovation capabilities of the group by providing technological support for the development and validation of theoretical concepts.

Research Challenges

A) Cost-effective decarbonization and digitalization of energy systems

An efficient and sustainable energy system is crucial for global climate targets and a sustainable future as they provide critical services like electricity, heating/cooling, and transportation.

Renewable energy systems can generate carbon-free hydrogen and ammonia as critical to decarbonize other economy sectors:

- H₂ utilization in fuel cells (e.g., mobility);
- NH₃ utilization in chemical industry (e.g., fertilizers);
- H₂/NH₃ utilization as renewables storage (to generate carbon-free electricity again).

Digital technologies should be integrated in energy systems operation and planning to further increase the integration of clean energy sources.

Main challenges

- New mathematical models for emerging technologies like electrolyzers and thermal storage
- Novel methods must be developed to optimize the integrated management of multiple energy networks and vectors
- Managing advanced digital infrastructure for power systems
- Designing 100% renewable systems

The main goal regards the development of new models, methods and tools to:

- 1) Optimize the operation of electrolyzers to maximize the use of renewables and provide system services.

- 2) Develop advanced control solutions to manage natural gas networks when incorporating renewable gases (biogas and H₂).
- 3) Enable the implementation of P2P solutions associated with seasonal energy storage to guarantee security of supply.
- 4) Improve the integrated management and control of multiple energy networks, considering high shares of renewable electricity and gas production (in electricity and gas networks, respectively).
- 5) Aggregate multi-vector resources' flexibility for optimal participation in electricity, gas and carbon markets.
- 6) Design and operate 100% renewable systems for green hydrogen and ammonia production.
- 7) Implement reference architectures to facilitate secure data sharing in the energy sector – energy data spaces.
- 8) Design and develop interoperability frameworks that rely on open standards to ensure the compatibility of equipment and systems, while safeguarding the privacy and cybersecurity of users.

B) Evolving and de-centralizing energy-driven business models and markets

Electricity markets have proven to be effective tools to:

- Improve the efficiency in the production and pricing of electricity commodities such as energy, flexibility and capacity.
- Provide appropriate economic signals to consumers and producers to induce them to adapt their short- and long-term behaviours to existing and expected demand and supply.

In the past - these markets were based on large, centralized conventional generation plants producing and adjusting their schedules to follow inelastic and unaware energy demand, together with the provision of the necessary reserves to the system.

Now - we are now facing a shift towards a distributed and decentralized energy system, characterized by:

- mass electrification
- the increase of distributed generation from clean and hard-to-dispatch renewable primary sources
- the development of new distributed energy resources

This rapid evolving environment is posing new technical and market challenges for their efficient integration.

The main challenges are:

- 1) Redesign and regulate wholesale electricity markets to integrate new resources and market players and assess their impact.
- 2) Develop and regulate new business models and local markets for collective self-consumption and energy communities, seamlessly integrated into existing wholesale markets and capable of fostering decentralized electricity trading and local renewable generation to empower end-customers in the energy system.
- 3) Unlock existing distributed flexibility to contribute to a better operation of the electricity system through more flexible and near real-time resource management systems and markets.

C) Resilience and reliability of energy systems

Transitioning from fossil fuels to sustainable energy sources under climate change can create vulnerabilities to severe weather events, resulting in energy shortages and damage to existing infrastructure.

- Severe weather events such as extreme heat, cold waves, storms, and dust clouds can reduce thermal and hydro power, make photovoltaic power unavailable for extended periods, and lead to a lack of wind power.
- The progressive electrification of consumptions can also cause significant sudden surges in demand.

Conversely, digitalization of power systems presents new opportunities to enhance system reliability and resilience by developing planning and operation plans based on forecasts, real-time monitoring and control, and predictive maintenance strategies.

- Investing in infrastructure that can withstand severe weather events is essential to ensure the resilience of power systems.

- Flexible and responsive power systems are essential for ensuring the security of electricity supply, e.g., demand response, local energy islands.
- Another critical element of a flexible and resilient power system is the use of energy storage technologies.

By leveraging all these opportunities, power systems can become more efficient, reliable, and resilient, ensuring a stable and sustainable supply of electricity for consumers.

The envisioned research challenges are:

1. To develop models and tools for the assessment of the long-term adequacy of interconnected systems under climate change and extreme weather affecting bulk energy consumption.
2. To develop methodologies for establishing reliable and resilient expansion plans for coupled energy networks (electricity and gas) in converter-dominated systems.
3. To analyse the ability of the existing flexibilities in local energy grids for improving the continuity of supply during contingency events.
4. To leverage data-driven models to monitor the asset condition and to define optimal maintenance plans.

D) Smart control architectures and centres of the future

Electrical networks are under transformation as the ongoing decarbonization and digitalization introduces new assets and system devices (e.g., PMUs, IEDs).

These changes directly impact the control centres and architectures of power systems with the need for higher interaction with neighbouring transmission networks, integration of weather-based energy resources, new market products, active distribution networks, microgrids, wider availability of data.

Supervision systems in control rooms have grown unreasonably to remain cognitively manageable and redesign of human machine interactions becomes necessary.

Grids ageing infrastructure combined with the proliferation of DER in MV and LV networks, and cybersecurity risks, also motivates the development of new control architectures.

The main challenges to address are:

- 1) more numerous, complex, and coordinated decisions to make;
- 2) more uncertainty to consider and more anticipation needed;
- 3) human operator cognitive load would continue to increase and might saturate.

The envisioned research challenges are:

- 1) Promote coordinated operation between electricity markets, TSO and DSO, within an increasingly complex network and market operation context:
 - a. Dealing with both long-term and short-term operation restrictions imposed by future flexibility services;
 - b. Considering automatic and decentralized control and human assisted operation.
- 2) Assist human operators via a proactive collaboration in robustly operating the flows over a power grid, avoiding blackouts because of overloads, while minimizing energy losses, as well as operator's cognitive load.
- 3) Structure the decision-making process, and design it explicitly for making decisions over tasks and not for monitoring (i.e., to avoid operating systems with information overload).
- 4) Let human operators become "navigators", defining forecasted trajectories over time and choosing options ahead of time rather than reacting in real-time.
- 5) Distributed and decentralized protection, automation and control, benefiting from virtualization and distributed computation at the edge. Namely:
 - a. Protections adaptive to network operating conditions and to the distributed energy resources connected;
 - b. Dynamic control area definition could help improve the efficiency of network control strategies.

4.6 PHOTONICS

Steering Committee: Diana Viegas, Nuno Silva and Pedro Jorge

Presentation of the Domain

The Photonics Scientific Domain explores optical phenomena as a unique toolbox for cutting-edge science and technology, exploiting symbiotic S&T for a sustainable research model. Fundamental research, on the one hand, gives rise to novel sensing systems and inventive technology. On the other hand, using emerging technology to enable innovation in real-world applications, materialising the impact of science, and diversifying funding opportunities. This generic vision is materialised in the research challenges for the next five years:

1. Developing small systems for biological and chemical sensing: committing to creating new optical solutions (from transducer mechanisms to signal processing) that can do biochemical sensing without labels or reagents, suitable for biomedical, environmental, and industrial uses that need robust and accurate sensing.
2. Photonic sensing for extreme environments: we aim to design light-based sensors that can function in harsh environments such as space and the deep sea. By combining strategies for ultra-high sensitivity, such as the Vernier Effect, and remote sensing, we are committed to developing sensor devices that can assess critical applications in real time and with durability.
3. Optical systems and devices for analogue quantum simulations: We will use nonlinear optical systems to build analogue quantum simulators and computing platforms. We are also working on a new way to overcome the problems with von Neumann architectures for quantum simulation and make it easier to connect optical information devices.

In addition to the direct impact on S&T, the group activity will contribute to the development and training of a new generation of highly specialised human resources with a unique set of competencies and critical knowledge at the national level, positively impacting the organisation while also fostering the emerging industry of photonics (e.g., spin-offs)

Research Challenges

A) Photonic-based platforms for environmental monitoring, medical diagnostic and industrial applications

This challenge addresses the development of photonic based diagnostic systems, using label free and reagent less sensing technologies, aiming for miniaturization, handling simplicity, speed of operation and long-term stability.

- Fabrication of optical devices based on advanced micro and nano technologies combined with microfluidic channels for high precision detection.
- Development of ultra high-sensitive spectral sensors functionalized with specific chemical and biological receptors for monitoring gaseous and liquid environments.
- Implementation of fully automated systems with development of dedicated optoelectronic interrogation devices and user interfaces in industrial applications for real time monitoring.

B) Photonic sensing for extreme environments

Real-time monitoring of large structures and environmental systems has become increasingly crucial due to the growth of human activities and the resulting environmental changes. Optical fibres, originally designed for communication purposes, can be installed in extreme environments, both on land and sea, making them a viable and sustainable solution to monitor external changes.

To address these challenges, new technologies utilizing distributed measurement techniques and linear or non-linear effects have been developed, which enable the measurement of various parameters such as temperature, deformation, pressure, vibration, or acoustics. Furthermore, the new generation of techniques must allow for the remote transmission of measurement data over long distances, up to 100 km, using all-optical amplifiers with low noise.

The development of high-performance optical tools and techniques can significantly increase the safety, efficiency, and sustainability of operations in extreme environments, including space and deep sea. It will also enable early detection of any potential problems, allowing for timely corrective actions to be taken. This can ultimately lead to cost savings, reduced downtime, and increased operational life of structures or systems.

C) Optical systems and devices for analogue quantum simulations

This research challenge explores the use of light as a multipurpose channel to encode, transmit and process information, leveraging on interference and nonlinear effects as processing elements. For the medium term, we envision a path in two distinct directions, intertwined in the competencies (e.g. wavefront shaping, high-performance computing and data analysis) and subjects (free space and nonlinear optics):

- Towards a top of the class analogue simulator of quantum fluids
 - Improving the versatility and circumventing the limitations (effective simulation time) of current setups.
- Towards a transparent framework to bridge optical computing and the end user
 - Explore neuromorphic paradigms easier to implement in the optical domain (e.g. Extreme learning machines, Reservoir Computing and Diffractive neural networks) to deploy a transparent and accessible platform for the end-user.

4.7 ROBOTICS

Steering Committee: António Paulo Moreira, Bruno Ferreira and Eduardo Silva

Presentation of the Domain

The Robotics Scientific Domain is at the forefront of developing real multi-domain robotics. It combines intelligence, autonomy, and usefulness seamlessly across various uses on land, in the air, on the water, and underwater. INESC TEC leads the way in developing new and creative scientific methods that connect different areas, resulting in a cohesive foundation for robotic systems.

The focus on advancing autonomy is central, specifically empowering robots to operate effectively in complex and dynamic environments across multiple domains. This involves creating and maintaining intricate environmental maps, reacting swiftly to unforeseen events, and enabling unattended operations over extended periods. Researchers at INESC TEC effectively and collaboratively tackle the unique challenges of different environments, allowing robots to independently navigate and adjust to every terrain, such as land, air, water surface, or underwater.

The increasing interaction between people and robots is equally significant in all areas. INESC TEC's robotics research seeks to transform programming and communication interfaces, enhancing the simplicity and availability of assigning tasks to robots for operators from diverse backgrounds, regardless of the operational domain. This is essential for smooth and effective collaboration and communication, lowering risks, and enhancing security in various settings.

In each target domain, researchers at INESC TEC investigate new types of robotic action that go beyond conventional limitations. By doing so, they introduce innovative solutions tailored to the unique challenges of ground, air, water, and undersea applications, enabling them to interface with flexible objects and manipulate objects from moving platforms. This interrelated investigation pushes the limits of conventional applications in each discipline and broadens the scope of what robotics is capable of.

As robotics expands into new fields and operational scenarios, INESC TEC recognises the importance of innovative design methodologies spanning diverse environments. The goal is to streamline the deployment of robotic technologies, guaranteeing the effective and cohesive harnessing of multi-domain robotics' transformative potential across a wide range of applications.

Research Challenges

A) Increase the autonomy of robotic systems

The operation of robotic systems in more complex and dynamic environments and for long term or permanently requires higher levels of autonomy of such systems, that will only be obtained by addressing the different stages of the sense-perceive-plan-act cycle. The following specific challenges directly contribute to achieve such gains in autonomy:

- Improvement of positioning accuracy of robotic systems operating in GNSS denied environments, including the proposal of novel landmarks and algorithms to position them.
- Establishment of navigation and guidance methodologies that allow smooth transitions between global localization and local/relative localization methods.
- Definition of distributed simultaneous localization and mapping strategies that are robust to communication failures and delays.
- Definition of trajectory planning methodologies for active perception and adaptive sampling, for single or cooperating robots.
- Establishment of optimization and task allocation algorithms that are fast enough to be applied in real-time to cope with very dynamic situations.
- Definition of novel mapping strategies that scale well with the extension of operation environments and duration of missions, for both single robots or heterogeneous robotics teams.
- Endow robots with failsafe mechanisms and ability to operate in degraded modes to cope with subsystem failures.

B) Improve manipulation and other physical interaction capabilities

We aim to address the state-of-the-art of robotic manipulation and other scenarios where a robot interacts physically with the environment. This will advance along three major lines: the first related to achieving a final relative position, as in the case of coupling or docking, the second related to the manipulation of flexible objects and the last addressing the use of manipulators from mobile platforms.

In the first line, the research challenge addresses:

(1) trajectory planning to simultaneously ensure observability of the target and pose constraints, while considering DoF limitations; (2) control of actuators subject to physical constraints that dynamically affect their performance.

In the second line, research challenges are associated to:

(1) perception – definition of novel models and algorithms to cope with the changing shape of objects; (2) grasping – incorporation of shape deformation models in motion planning and feedback control loops; and (3) assembly operations – path planning algorithms to consider deformation of objects to avoid entanglements.

In the third line research challenges address:

(1) coordinated control for the simultaneous motion of base and end effector; (2) mobile manipulator planning and control systems to effectively reject terrain induced disturbances; and (3) control of actuators mounted on floating or underwater platforms.

C) Enhance human-robot collaboration

Most recent technological and scientific advancements allow stand alone robots to perform tasks with an high degree of autonomy and the difficulties associated with robotics are well-known and have reached a certain level of maturity. However, the inclusion of the human element disrupts this determinism and factors such as the user's mental model, emotional state, and perception influence robot behaviour. Therefore, this challenge aims the development of new algorithms, methodologies and tools that allow robotic systems to synergistically and dynamically collaborate with humans.

To achieve such a goals, the following topics will be addressed:

- investigate algorithms for human real-time action/posture recognition and tracking, to improve natural and safe collaboration between robotic system and human
- investigate methods and tools for the transparency and explainability of robot actions/intentions through the use of emergent technologies, such as virtual and augmented reality, and advanced use of software based human computer interfaces.
- develop algorithms and systems which will empower the robot with human knowledge and skills, through the use of high-level programming, teleoperation and shared control methods.

D) Design sustainable robotic systems

This challenge aims at the design (that includes methodologies for the conception, development and deployment) of advanced robotic systems that break the limitations of common robotic platforms. The sustainable development of robots that, for example, can go deeper, can perform differentiated tasks with minimal turnover time or can be deployed in the scale of hundreds requires the scientific development addressed in the following three topics.

Modular and reconfigurable robots, pursuing the sustainable development of modular and reconfigurable robotic systems either through brief setup or autonomously. An integrated approach is foreseen combining mechanical, electrical, communications and software aspects to achieve high impact modular robotic systems. Robotics software development present challenges that go beyond existing software development practices. The challenge here is to have robots that can be deployed faster, safer and in a larger scale, through the investigation of robot specific software development techniques: Continuous development/continuous integration, Formal analysis of safety of robotics software and finally novel communication distributed computation architectures.

New robotic platforms and companion systems challenge is the scientific driven development of robotic systems that break the limitations of common platforms through the design. This is achieved through (1) the enhancement of existing robot platforms, to go deeper or to extreme environments, p.e. (2) through the conception of novel robots, such as legged, cable robots, and finally through the development of differentiated companion devices, such as end effectors (for agriculture pruning, p.e.), or advanced docking stations (for industrial, aerial and maritime robots also in marsupial configurations).

4.8 SYSTEMS ENGINEERING AND MANAGEMENT

Steering Committee: António Lucas Soares, José Pedro Rodrigues, Lia Patrício and Maria Beatriz Oliveira

Presentation of the Domain

Systems engineering and management research seeks to advance the design, implementation, and improvement of systems for decision support, human-centered operations, intelligence, technology management, and innovation.

Major challenges arise from optimization in complex organizations and networks at multiple levels, customer-centric service design, and technology-based innovation management and policy, targeting improvements in business performance, productivity, innovation, resiliency, and economic, social, and environmental sustainability.

Research Challenges

A) Transitioning Socio-technical systems towards sustainability

Research challenge

Grand societal challenges require radical shifts in socio-technical systems, requiring research on:

- understanding the role of businesses and industries in sustainability transitions, and
- designing system innovations for transitions towards sustainability,

This research brings together service science, technology and innovation management, and public policy research for technology leveraged transitions of key socio-technical systems

Research Questions

- How can firms innovate business models based on flexibility, self-sufficiency, or servitization for sustainability transitions?
- How can innovation management practices evolve through the lenses of Responsible Research & Innovation for sustainability and impact, with a focus on circular value chains, open innovation and co-creation practices?
- How can firms develop new value propositions and service offerings for ecosystem transformation?
- How can firms and policy makers facilitate the effective adoption and diffusion of technologies for sustainability transitions?
- How can firms and policy makers develop strategies for citizen cocreation and engagement with sustainability transitions?

B) Developing Responsive and resilient end-to-end Value Chains

Research challenge

The prevailing current global supply chain models impose several challenges (including over-dependencies and logistics issues). Recent crisis (such as the COVID 19 pandemic and the war in Ukraine) have demonstrated the fragilities of those models, both in terms of resilience and sustainability (environmental, social and economic).

Research Questions

- How can digital technologies contribute to reduce the critical dependencies and weaknesses resulting of current global supply chain models, including the identification of current and future severe disruptions?
- How can digital technologies contribute to manage the trade-offs and enhance the synergies that characterize the relationship between sustainability and resilience practices in complex value chain environments?
- How can end-to-end supply chain visibility, supported by emerging technologies, contribute to the development of resilient and sustainable supply chains?
- How can digital technologies facilitate joint innovation activities to increase the circularity of products, processes, and overall SCs?

- What is the impact on the organizations' end-to-end performance (w.r.t. these challenges) to integrate and interface Marketing and Operations?

C) Managing Systems under uncertain, complex and dynamic environments

Research challenge

Managing and supporting decisions in continuously complex environments with multiple stakeholders and overarching goals (e.g., sustainability) brings additional challenges to the research on these methods.

Research Questions

- How to acknowledge, incorporate and intrinsically seize the properties of uncertain and dynamic settings in system modelling, not only as far as data is concerned, but also assumptions and scope?
- How to model complex relationships, including multiple stakeholders with multiple goals and incentives?
- How to improve and significantly fasten the decision-making process to tackle an uncertain and dynamic setting, through innovative solution methods and algorithms?
- What benefits can be derived from multi-disciplinary approaches (namely, the hybridization with qualitative and strategy-oriented decision-making models with state-of-the-art algorithms, or with enhanced risk assessment and management tools) in complex and dynamic applications such as urban mobility?
- How can AI methodologies be used to optimize critical parameters' trade-offs in designing adaptable production systems?
- How can hybrid simulation models and Digital-Twin-based approaches contribute to more effective operational management in Uncertainty and Complex Manufacturing Environments?
- How to design and manage innovative, more resilient, inclusive and sustainable urban mobility services (for people and freight) in the context of the smart city and the sharing economy?
- How to design and manage innovative global, more sustainable logistics and freight circular transportation services, based on synchro-modal operations and inter-modal hubs?

D) Engineering Human-Centred Systems for Sustainability and Resilience

Research challenge

Demands for sustainability and circularity raise specific challenges to IIS such as trust, and confidentiality from one side, and systems adoption and user engagement on the other side.

The exponential growth of digital technologies applied to manufacturing foster the challenge to create awareness about the socio-technical strategies for technology adoption.

Research Questions

- How to design inter-organisational information systems, particularly industrial digital platforms that support collaboration, information management and collective action to foster and implement circular and sustainable business strategies?
- How to manage industrial data and information in individual organizations and value chains and networks to foster knowledge and unlocking value creation from data?
- How to assess the impact and derive design propositions for information systems based on emerging technologies leading to the creation of organizational capabilities that foster competitiveness and sustainability?
- How to leverage technology and data to create transformative services for value co-creation and system transformation?
- What are the factors that influence the adoption of green and emergent technologies?
- What are the drivers and barriers to the adoption of emergent technologies in the context of Industry 5.0?

5 TEC4 INITIATIVES

5.1 Overview

TEC4 (TEChnologies FOR...) is an organisational approach designed to structure the **market-driven** innovation process, complementing the naturally occurring **science-driven** research conducted within Research Centres. This approach fosters a **balanced** and **integrated** knowledge-to-value chain.

Short-term objectives of TEC4 initiatives include:

- Developing innovative, knowledge-based solutions and services with high export potential;
- Leveraging internationally competitive research and innovation capabilities;
- Contributing to the resilience and growth of the Portuguese economy.

Long-term objectives encompass:

- Identifying scientific and technical challenges across diverse fields;
- Harnessing the full potential of INESC TEC in application domains relevant to businesses;
- Establishing and sustaining **virtuous innovation cycles** within each TEC4.

Each **TEC4** focuses on a **specific market segment** and fosters **cross-cluster, multidisciplinary projects**. They actively collaborate with businesses to develop solutions for technology transfer. Each TEC4 also maintains a **strategic agenda** aligned with its market domain, addressing:

- Stakeholder perspectives;
- Strategic roadmap and associated technological roadmap;
- R&D infrastructure evolution to maintain state-of-the-art capabilities and support the roadmap;

TEC4 application areas are aligned with European, national, and regional priorities, fostering internal R&D competencies around socio-economic pillars. Additionally, attracting **international partners** supports INESC TEC's internationalisation strategy, facilitates access to international partners for national companies, and fosters foreign direct investment.

Performance measurement for each TEC4 primarily considers:

- **Level of recognition and activity** within its market (including direct contracts with companies and stakeholders);
- **Number of inter-Centre collaborations generated.**

TEC4s are not directly involved in project development. Once an opportunity is identified, negotiations occur with relevant Centres, which then manage and execute the project.

Typically, a TEC4 comprises:

- **A defined market domain** represented by businesses and associations;
- **A group of INESC TEC Centres** with multidisciplinary expertise relevant to the market domain;
- **R&D infrastructure** supporting scientific and innovation activities and providing added-value services to businesses.

Each TEC4 follows a structured implementation plan encompassing the following stages:

- **Identification of market segments** where INESC TEC competencies can create value;
- **Assessment of market needs** to identify internal research lines with the highest potential impact on businesses;
- **Evaluation of R&D infrastructure** (laboratories, equipment, demonstration facilities, etc.) to support value-added services for businesses;
- **Identification of potential partners and stakeholders** who can contribute to the TEC4 and its innovation cycle;
- **Definition and alignment of the strategic agenda** for each TEC4 and creation of its advisory board.

The current TEC4 organisation comprises:

- Five established TEC4s:
 - TEC4AGRO-FOOD: Focuses on the agro-food and forestry sectors;
 - TEC4ENERGY: Addresses energy-related activities and the energy economy;
 - TEC4HEALTH: Targets activities and the economy related to health and well-being;
 - TEC4INDUSTRY: Concentrates on production technologies, manufacturing, distribution, logistics, and retail;
 - TEC4SEA: Focuses on sea-related activities and the maritime economy.
- **TECPARTNERSHIPS:** Primarily dedicated to promoting and supporting businesses in all other sectors, exploring new market segments, and incubating potential new TEC4s until they reach a sufficient maturity level.

TEC4s are dynamic organisational models that require periodic evaluation and adaptation to the evolving economic landscape.

5.2 Main achievements in 2023

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

	TOTAL
COMPANIES MEETINGS/CONTACTS	848
NATIONAL COMPANIES MEETINGS/CONTACTS	565
New entities	178
Entities already existing in our database	387
INTERNATIONAL COMPANIES MEETINGS/CONTACTS	283
New entities	175
Entities already existing in our database	108
PROPOSALS	
DIRECT CONTRACT SUBMITTED PROPOSALS	96
Mono centre proposals	86
Inter centre proposals	10
INESC TEC Global value (K€)	9 059
DIRECT CONTRACT ADJUDICATED PROPOSALS	42
Mono centre proposals	35
Inter centre proposals	7
INESC TEC Global value (K€)	3 158

EUROPEAN PROGRAMS SUBMITTED PROPOSALS	39
Mono centre proposals	28
Inter centre proposals	11
INESC TEC Global value (K€)	31 987
EUROPEAN PROGRAMS ADJUDICATED PROPOSALS	13
Mono centre proposals	8
Inter centre proposals	5
INESC TEC Global value (K€)	2 993
NATIONAL I&D SUBMITTED PROPOSALS	3
Mono centre proposals	3
Inter centre proposals	0
INESC TEC Global value (K€)	259
NATIONAL I&D ADJUDICATED PROPOSALS	3
Mono centre proposals	3
Inter centre proposals	0
INESC TEC Global value (K€)	823
EVENTS PARTICIPATION (conferences, trade fairs, etc.)	239
EVENTS ORGANISATION (conferences, trade fairs, etc.)	32
INTERNAL MEETINGS	247
NEW STRATEGIC PARTNERSHIPS	16

5.3 TEC4AGRO-FOOD

Coordinator: Filipe Neves dos Santos

Business Developer: André Sá

TEC4AGRO-FOOD Presentation

TEC4AGRO-FOOD



**INESC TEC's Initiative
for Agro-Food and Forestry**

**Co-shaping the digital (r)evolution
in Agro-Food and Forestry**



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 treatment, 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:

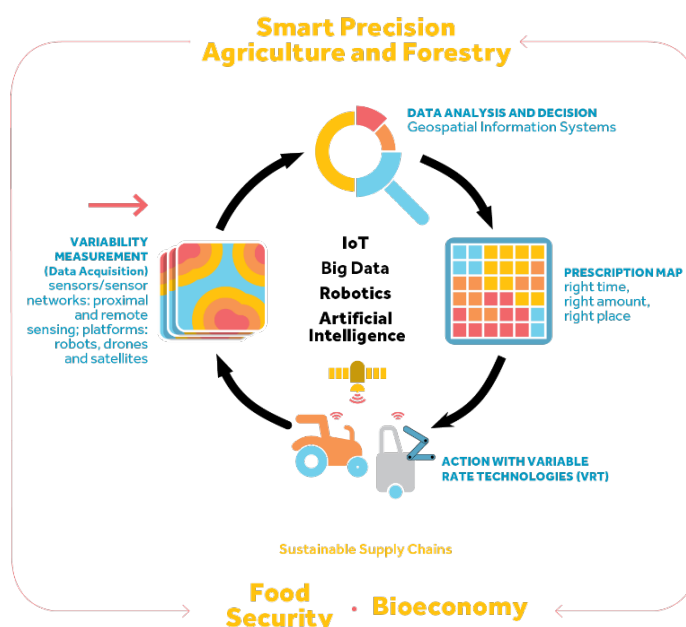


Figure 5.1 - Precision Agriculture/Forestry Action Cycle

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, namely through TRIBE - Laboratory of Robotics and IoT for Smart Precision Agriculture and Forestry, the most active one.

Main achievements in 2023

Continuing to follow the overall strategy of full implementation of portfolio projects and redouble efforts with companies and at international level, as well as the strategy defined in the TEC4AGRO-FOOD's Strategic Plan (with the exception, of course, of the establishment of a strategic partnership with the Volcani Centre, due to the situation in Israel), in 2023, 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 has reached a sustainable position regarding research and innovation programmes, namely Horizon Europe. It should also be highlighted the increased visibility (press, events, etc.) and the contribution to the public policies (RIS3 and CoLABs - INESC TEC participates in 4 CoLABs in the scope of TEC4AGRO-FOOD).

TEC4AGRO-FOOD's main achievements in 2023 are presented below:

- National Programmes approvals:
 - ✓ (RRP Agendas) BLOCKCHAIN.PT - WP 1 (262.5k€) (CRIIS);
 - ✓ (DIH) SFT-EDIH (166.7k€) (CRIIS);
 - ✓ **(RRP Initiatives Portfolio) Tools4AgriEnergy (393.3k€) (INESC TEC coordinator) (CPES).**
- European Programmes approvals:
 - ✓ (PRIMA Section 2) (first stage) RE-HYDRAM1 (99.1k€) (CAP and CITE).
- R&D Services and Consulting approvals:
 - ✓ Works_TechAgrob (InovTechAgro) (CRIIS);
 - ✓ **Estaleiro40 (Amorim Florestal) (CESE e CRIIS) (in collaboration with TEC4INDUSTRY).**
- Internal Seed Projects approval: MyVet (20.0k€) (CAP and CRIIS);
- INESC TEC projects' external events:
 - ✓ Workshop SMART FERTILIZERS (with Herculano);
 - ✓ AgWearCare end-of-project seminar;
 - ✓ ROBOCARE Final Workshop (with Amorins Lda);
 - ✓ InOlive - Final Project workshop;
 - ✓ SMARTAGEING - final workshop;
 - ✓ **Synergy Day Robotics and IoT for Vineyards** (with InovTechAgro, Sogrape and ADVID).
- Events: **World FIRA 2023; AgroIN 2023 (sponsor as "RTO Partner"; Filipe Santos keynote speaker);** Biond Conference - Sustainable and Precision Forestry (Reinaldo Gomes keynote speaker); **AGROGLOBAL 2023;** Workshop Innovative Projects of the Agro-Energy Transition Flagship Initiative - Tools4AgriEnergy project (José Villar keynote speaker); IInd Fundação Agricultural Innovation Fair - "Agricultural robot startups and industry majors: happy marriages?" (Filipe Santos keynote speaker); Agrifood Open Day 2023 (Reinaldo Gomes keynote speaker).
- Prizes:
 - ✓ (EUSPA myEUspace COMPETITION) Oriooos (10.0k€) (CRIIS);
 - ✓ **EARTO Innovation Awards 2023: My NPK Impact Expected - 3rd Prize.**

5.4 TEC4ENERGY

Coordinator: João Peças Lopes

Business Developer: Nuno Campos

TEC4ENERGY Presentation

The main objective of TEC4ENERGY is to support the transition towards a decarbonised economy by promoting research, development, and innovation (R&D&I) activities in the energy sector. By bringing together various stakeholders including R&D institutions, businesses, and associations, TEC4ENERGY aims to increase collaboration, synergies, and critical mass in order to successfully tackle the main challenges faced by the energy industry in the future. The initiative aims to stimulate the growth of energy-related industries and support the necessary transformations required for a sustainable and low-carbon future.

TEC4ENERGY collaborates with industry through advanced consultancy services, contract-based R&D activities, and strategic partnerships, aiming to drive innovation, support the energy sector in overcoming limitations, and contribute to the transition towards a decarbonised economy both nationally and internationally. The division focuses on leveraging their expertise, resources, and experience to implement successful projects, advanced training and contracts with the industry within the energy sector, addressing the specific needs and limitations of businesses and technologies.

The benefits that TEC4ENERGY can derive from the strong recognised expertise of INESC TEC in Power Systems include credibility, knowledge and experience, networking and connections, technology transfer, and collaboration opportunities. The activities of TEC4ENERGY are aligned with the EU's goals of addressing societal challenges, promoting innovation, and transitioning towards a more sustainable and decarbonised energy sector.

Overall, TEC4ENERGY plays a crucial role in driving innovation in the energy sector by identifying and leveraging projects that address the limitations of existing market solutions. Through its multidisciplinary and collaborative approach, TEC4ENERGY contributes to the advancement of knowledge and technology in the field of energy, benefiting both industry stakeholders and society as a whole.

Main achievements in 2023

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 in Portugal and abroad, promoting the development of projects that involve several Centres within INESC TEC.

Taking into consideration the main achievements in the energy sector, 2023 was a consistent year in what regards new flagship projects. It can be highlighted the approved European funded projects, TwinEU, CleanEnergy4EUIslands2, AI4RealNet and AOWINDE, representing a total of 650 k€, where TEC4ENERGY played a relevant role in the initial contacts and in the preparation of the proposals.

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 2023, 57 national direct R&D contract proposals were prepared within the energy field (41 of which successfully approved and 15 still waiting for decision). These national direct R&D contract proposals amounted to 2.4 M€. The 41 approved projects led to a total of raised funds in the amount of 1.2 M€, of which we can highlight SmartAmmonia (with SmartEnergy), RAM_PLAN_GREEN_PORT (with EEM), PV_Acores23 (with Força Açoreana), Eolica_offshorePT (with APREN), PQ_Industrial_UPACs (with Bondalti) e CampusREN2024 (with REN).

At international level, some direct R&D and consultancy proposals with companies were leveraged, such as GE Vernova, Lightsource BP, Enerparc GmbH, Copenhagen Offshore Partners, China Three Gorges – Europe, Q ENERGY Europe GmbH and IberBlue, that constitutes a total of 1.5 M€.

In total, TEC4ENERGY has successfully leveraged in 2023 a set of national, international and EU funded projects, including pluriannual propositions, involving INESC TEC R&D Centres as C-BER, CITE, CPES, CRAS HASLab and LIAAD, that will lead to a total of expected income for INESC TEC of about 1.9 M€.

5.5 TEC4HEALTH

Coordinator: Miguel Coimbra

Business Developer: Carlos Alexandre Ferreira

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)* information and analytics systems for healthcare; *v)* 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 (cancer (breast, lung, colorectal, prostate, pancreas, oesophagus/stomach, cervical, bladder, and neuroblastoma), 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), CBER (Biomedical Engineering Research), CEGI (Management and Industrial Engineering), CTM (Telecommunications and Multimedia), HumanISE (Human-Centered Computing and Information Science) and LIAAD (Artificial Intelligence and Decision Support).

Main achievements in 2023

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

Internal:

- Contact points: promotion of regular talks with each point of contact from the different centres, aimed at understanding desires and needs, ensuring appropriateness in the presentation of new opportunities for R&D projects;
- New subsectors: characterisation and study of new opportunities in the nutrition, urban well-being, tourism and humanitarian actions, hospital equipment, and logistics sectors;
- TEC4 materials: creation of TEC4Health content, including an institutional pamphlet outlining our intervention in the healthcare sector, a website page, and reporting in INESC TEC's CRM system.

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), Centro Hospital Universitário de Santo António (CHUSA), IPO Porto and Centro Hospitalar Vila Nova Gaia/Espinho (CHVNG/E);
- Research Institutes: Strengthening collaboration with ISPUP and I3S;
- Representing INESC TEC: Health Cluster Portugal general assemblies and Smart Health Network [6] and EARTO Health Working Group [3];

- New leads: meetings with approximately 50 new entities and reconnection with those with whom there was prior relations;
- Companies (highlight of new strong connections): opportunities in sectors such as telemonitoring, deficiency, mental health and medical devices;
- Promoting INESC TEC: HIMSS, Horizon Europe Brokerage and Informative Events (EU) [6], ENEEB, international delegations' visits to INESC TEC [2], *Semana da Bioengenharia*, 2nd WHO Digital Health Symposium, Global Health Fórum, EIT Health Morning Health Talks and CEMTEX;
- Lectures: Networking visits in the United Kingdom and France, *Inteligência Artificial em Saúde: pros e contras*, EMBC, *Seminário Científico IPO Porto* and BHI;
- Participation in the consultation and review of the European Commission's funding programs.

Projects:

- HfPT Project: internal and external facilitation of the development of our national mobilising project for health within the RRP;
- European: dissemination of information and opportunities, support in proposal submissions, and brokering to enable the inclusion of INESC TEC researchers and their research lines in consortia targeted for various European Commission programs (*i.e.*, Horizon Europe, Mission Cancer EU4Health, European Health Data Space, IHI, EIC, and EIT Health);
- Services and Consulting: seizing market opportunities and collaboratively developing proposals with the lead researcher to address the requests and challenges at hand.

In the year 2023, the mobilising agenda of the RRP in the healthcare sector, HfPT, where the intervention and mobilisation were largely facilitated by TEC4Health, had its beginning. Another highlight was the reinforcement of INESC TEC's presence in European health projects, with several promotion efforts for submissions, resulting in funded projects (such as Phase IV AI). HumanISE, CTM, CBER, CAP, LIAAD, CITE, and CRIIS are involved in these funded projects. Being present at one of the largest digital health fairs, HIMSS, which took place in Lisbon in 2023, was also a good decision that opened some leads.

The pursuit of more European funding and contract research opportunities with companies will continue in 2024.

5.6 TEC4INDUSTRY

Coordinator: Américo Azevedo

Business Developer: António Almeida

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 towards a more competitive and sovereign national industrial ecosystem. In this sense, the TEC4INDUSTRY presents a double role 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.

Main achievements in 2023

In 2023, TEC4INDUSTRY not only prioritised seizing national opportunities linked to the Recovery and Resilience Plan (RRP) to optimise the utilisation of domestic funds and enhance national sovereignty in advanced production technologies but also strategically positioned INESC TEC within prominent European consortia, particularly focusing on the application of AI in Manufacturing. This dual focus aimed to drive the twin transition in manufacturing while actively participating in European initiatives to bolster our institution's presence and influence in cutting-edge technological advancements.

Industry and Innovation Lab (iiLab)

2023 was the year of the kick-off of the new iiLab infrastructure in the PORTIC building. TEC4INDUSTRY had an important role in defining and designing use cases for industry based on internal technologies and promoting collaborations and innovative services with national technology companies. The creation of the Advisory Board, composed of companies such as Simoldes, Adira and Flupol will be essential to the guidance of operations and strategic decisions. Moreover, TEC4INDUSTRY has been working to define advanced training modules capable of taking advantage of the iiLab infrastructure and define technical requirements for its implementation.

Plan Recovery and Resilience (RRP)

In 2023, TEC4INDUSTRY played a pivotal role in driving forward the RRP agendas, marking a significant milestone in our collaborative efforts. With a focus on fostering seamless collaboration among various research centres and technology companies, TEC4INDUSTRY spearheaded the implementation of robust governance models. These models ensured meticulous monitoring of results and demonstrators' progress while facilitating the proactive formulation of action plans. Moreover, TEC4INDUSTRY assumed a crucial responsibility in orchestrating INESC TEC's involvement in other RRP-related endeavours, such as the TestBed initiative and efforts toward industry decarbonisation. Notably, INESC TEC leads the NOS TestBed 5G & Digital Transformation industry vertical, embarking on 12 pilot cases within iiLab, leveraging a dedicated 5G infrastructure. iiLab is a pioneering research facility boasting a fully operational 5G installation that tests and demonstrates advanced digital technologies. Similarly, our involvement in the RRP decarbonisation project within the food industry underscores our commitment to designing a digital roadmap for decarbonisation across the food value chain. This positions INESC TEC as a forefront research institute in championing sustainability through digitalisation in the industry.

Horizon Europe Proposals

Throughout 2023, TEC4INDUSTRY made significant strides in facilitating the participation of INESC TEC research teams in leading EU consortiums. Notably, TEC4INDUSTRY played a pivotal role in championing the involvement of INESC TEC teams in the AIM-NET consortium—a pan-European collaborative network dedicated to promoting the widespread adoption of AI in the manufacturing sector. This proactive engagement resulted in our direct support for preparing and submitting numerous proposals under Horizon Europe, aimed at driving innovation and tackling key challenges across various domains. These proposals encompassed a wide array of critical research topics, including drivers and success factors for advancing towards Industry 5.0, pilots for fostering an innovative human-centric industry, strategies for enhancing resiliency in value networks through modelling and manufacturing as-a-service, approaches for remanufacturing at both the factory level and within value chains,

initiatives to promote the adoption of advanced technologies among SMEs, and the utilisation of AI for human empowerment. As a result of our concerted efforts, we successfully secured funding for several Horizon Europe projects, underscoring our unwavering commitment to innovation and research excellence. Among these EU-funded initiatives is the Renée Project, which explores flexible remanufacturing approaches employing AI and advanced robotics to establish circular value chains within the EU industry. Additionally, the Rise-SME project focuses on enhancing the resilience of industry supply chains to bolster SMEs. In contrast, the PEER project aims to develop the hyPER ExPeRt collaborative AI assistant tailored for the manufacturing and retail sectors. These accomplishments reflect the collaborative spirit and dedication of various research centres within INESC TEC, working together to drive impactful innovation and shape the industry's future across Europe.

New Services Offer

In addition to our active involvement in research projects, we have expanded our portfolio to offer a diverse range of consultancy services meticulously crafted to address the distinctive needs of our partners. Among these services, we have tailored consultancy packages to facilitate the seamless implementation of digital technologies for new factory construction. Drawing upon expertise from various research centres, our consultancy spans data maturity, automation and robotics, cybersecurity, data analytics, artificial intelligence, smart logistics, and lean manufacturing. Another vital aspect of our consultancy services entails designing and conceptualising innovative and intricate production and logistics systems, coupled with robust support in calculating return on investment (ROI). Throughout 2023, we maintained our commitment to providing consultancy services in digital transformation and roadmap design for manufacturing. Notably, we introduced a new dimension to this service, delivering advanced consultancy tailored to digital transformation strategies for robotisation. This expanded service offering encompasses technological aspects and addresses the requisite organisational, procedural, and capability changes. Lastly, the TEC4 industry prioritises the commercialisation of INESC TEC technologies, aiming to effectively bridge the gap between research and market applications.

Event Participation and Speaking Engagements

Throughout the year, our proactive engagement in many industry events and speaking engagements served as a cornerstone for driving innovation and fostering collaboration within our ecosystem. Noteworthy among these engagements are the following key events: The RRP Hi-Rev workshop provided a platform for insightful discussions and strategic deliberations; Organisation of the webinar "Digital Twin: A Decision-Making Tool", featuring prominent companies such as EFACEC and Infinite Foundry, facilitated a deep dive into the practical implementation of Digital Twin technologies; The Workshop on Logistics 4.0, hosted by APLOG and featuring industry leader Luís Simões, catalysed exploring cutting-edge advancements in logistics; We played a pivotal role as speakers in events like "Pioneering the Future of Furniture" organised by Paços de Ferreira Municipality, demonstrating our thought leadership in shaping the future of various industries; Our presence at the EIT Alumni Connect Barcelona further bolstered our networking and collaboration efforts on an international scale. Additionally, TEC4INDUSTRY participated in public events hosted by tech companies such as Glartek and JPM, where we actively contributed as speakers and moderators, respectively. Our active involvement in prominent industry exhibitions like the International Fair EMAF 2023, where we showcased INESC TEC technologies through a dedicated stand, further solidified our presence and impact. From a scientific standpoint, the TEC4INDUSTRY team demonstrated its academic prowess by publishing research findings in esteemed international conferences such as FAIM 2023, the inaugural symposium "Artificial Intelligence in Manufacturing" by AIM-NET, and renowned events like PRO-VE and ISM 2023.

5.7 TEC4SEA

Coordinator: Eduardo Silva

Business Developer: Carlos Pinho

Communication, dissemination and continuous engagement: Ana Paula Lima

TEC4SEA Presentation

The TEC4SEA initiative addresses the Blue Economy sectors, stimulating related industries and partners to overcome the future challenges in these sectors incorporating INESC TEC contributions and know-how. To this end, TEC4SEA brings together entities of the quadruple-helix (academia & research, business, civil society, and policymakers) in order to increase 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 confronted with numerous challenges and global transitions. From specific regional and national challenges to the Horizon Europe and Mission's objectives, the new European vision targeting 2050, all Blue Economy sectors are confronted with innovation demands. 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.

Main achievements in 2023

The main achievements of TEC4SEA during 2023 were:

INTERNAL

- Continued the internal consolidation with different centres, adapting to the continuous changes, pursuing relevant impact in the Blue Economy sectors as well as in society;
- Strengthened the articulation with the work team to reduce barriers between the centres and the TEC4SEA, as well as enable the execution of several actions, tasks, and projects. Develop a continuous work of synchronisation, strategy and priority alignment;
- Continued the internal awareness and alignment with the medium-term strategy and action-plan (2030), fostering current and future strategic opportunities (e.g., H.E., EITs, national programs, and direct contracts with industrial partners).

EXTERNAL

- Promoted and disseminated the resources and capacities of the TEC4SEA Infrastructure, fostering R&D+i and subcontracting opportunities;

- Developed and pursued national and international mechanisms to establish INESC TEC Sea domain as a Centre of Excellence;
- Consolidated INESC TEC position in the Ocean Renewable Energies test site of Aguçadoura;
- Identified and established close collaboration mechanisms/protocols with international leading organisations (e.g., Sintef Norway and GCE Ocean, DMEC, EMSA, ISA, UN);
- Continued consolidating international relations (e.g., Europe, South Korea, and the USA).

The centres involved in TEC4SEA projects during 2023 were the following: CAP - Applied Photonics; 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; CTM - Telecommunications and Multimedia.

Projects:

- RRP: Supported the successful accomplishment of all Sea related initiatives within the “Plano de Recuperação e Resiliência”, leveraging these projects and corresponding impact with complementary initiatives (e.g., H.E., PT2030, Mar2030) and strategic partners in the domain (e.g., IPMA, Portuguese Navy, ISA).
- European and National: dissemination of information and opportunities, support in proposal submissions, and brokering to enable the inclusion of INESC TEC researchers and their research lines in consortia targeted for various European Commission programs (i.e., Horizon Europe, PT2030, Mar2030). In 2023, 14 R&D European proposals were prepared within the Sea field, 5 of which were successfully approved namely POCTEP AOWIND (100k), SUNRISE (120k), BlueEx (715k) BioProtect (228k). These R&D contract proposals amounted to 1.2 M€.
- Services and Consulting: seizing market opportunities and collaboratively developing proposals with the lead researcher to address the requests and challenges at hand. In 2023 one direct R&D and consultancy proposal with China Three Gorges – Europe company was submitted and approved.

5.8 TECPARTNERSHIPS

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

TECPARTNERSHIPS Presentation

Our mission is to explore new market activity sectors 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: A sector of economic activity that uses data networks as tools to enable B2B, B2C, C2C, or M2M interactions. Focus on providing services based on artificial intelligence and consumer understanding.

Financial: Financial sector (banks and insurance) and its technological ecosystem (Fintech, Insurtech, etc.). It is promoting data processing and analysis technologies, as well as customer interaction.

Construction: In the sector of digitalisation process, INESC TEC will offer process planning, digital automation, digital twin, energetic efficiency evaluation and AI.

Space: A sector in strong development with new opportunities from ESA, EU Programmes, national initiatives, and New Space activities. High potential for all INESC TEC's Domains.

Defence & Security: The sector gained renewed interest due to war in Ukraine. First EU R&D Programme (EDF) and Horizon Europe Cluster 3 - Security Calls are considered entry point for long-term industrial collaborations. Potential application area for all INESC TEC's Domains.

Public Administration: Under strong digital transformation process. High application potential for Computer Science.

Mobility: Diverse market, with several branches: aeronautical, railway, ports, automotive and soft mobility. EU Specific Programmes covering all branches and a strong national focus on railway, create industrial collaboration opportunities.

Main achievements in 2023

Participation in networking events:

The team made a significant effort to participate in the following networking events, either national or international, with B2B sections and with stands:

- European Network of Defense Related Regions ENDR, Lisboa 02/03/2023
- Techinnov Paris 28/03/2023
- AG AED, B2B Sessions, Lisboa 28/03/2023
- Seminário Indústria Automóvel – Porto 13/04
- Portugal Railway Summit 2023 – Entroncamento 03-04/05/2023
- SMI2G - Security Mission Information & Innovation Group Event 2023 – Paris 10-11/05/2023
- Meet Your Security End-Users – Lisboa 17/05/2023
- Congresso Europeu ITS - Lisboa - 23/05
- Speed-Match 2023 International Networking Event, online 24/05/2023
- AED DAYS 2023 - Oeiras - 30/05-02/06 – (stand)
- ARTE23 High Visitors Event, Campo Militar de Sta. Margarida - 02.06 – (stand)
- Horizon Europe Cluster 3 InfoDay & B2B, online 27-28/06/2023
- EDF InfoDay & B2B, online – 28-29/06/2023

- QSP Summit – EXPONOR - 28 a 29 de junho – (stand)
- SEGUREX, FIL, Lisboa 12/10/2023
- Portugal Smart Cities Summit, FIL, Lisboa 12/10/2023
- GREENET Brokerage Event for HE Cluster 5 – 2024 calls, online 18/10/2023
- Les Rendez-vous Carnot 2023 – Lyon – 18 e 19/10 – (stand)
- Inovação e Modernização Tecnológica do Exército - Taguspark Oeiras - 22-23.11 - (stand)
- Lei de Programação Militar – Espaço Industry Day – Lisboa 24/11/2023
- Observação da Terra para Municípios – Guimarães 28/11/2023
- AG AED, B2B Sessions, Lisboa 29/11/2023

Interaction with businesses and results:

Building on the previously compiled list of technology-based companies aligned with our strategy, in 2023 we conducted 272 meetings with national and international businesses and associations, including 124 with new entities and 109 with international organisations.

These meetings resulted in the identification of 60 new leads (44 international). A total of 11 proposals were submitted, with a combined value of €2.3 million.

Highlights:

- Approval of DIGITALbuilt, the National Digital Innovation Hub for the construction and railway sectors, one of the selected by the EU.
- Preparation of proposals for businesses interested in the PT2030 program.
- Establishment of an internal working group for the European GAIA-X initiative.
- Involvement in several European proposals in EDF and Horizon Europe Cluster 3 (Civil Security).

Implementation of the Internationalisation Strategy in France:

Progress Summary

- **Membership:** Registered as a member of the CCILF (French-Portuguese Chamber of Commerce and Industry);
- **Tax Incentives:** Renewed CIR (Research Tax Credit) approval for 2023 and 2024;
- **Prospection results:** 3 finalised service proposals (totalling €140k) and 1 lead processed;
- **Networking and Visibility:** Participated in 3 major B2B events: "Techinnov", "SMI2G" and "Les Rendez-vous Carnot", with a joint stand with SAL;
- **Business Development:** Explored established contacts and analysed potential leads.

The most relevant transversal activities were:

- CRM – TEC4 monthly reporting using CRM reports;
- Business Development training section (LIAAD);
- INESC TEC's Innovation subsite updated, focusing on TEC4 activities.

6 RESEARCH AND DEVELOPMENT CENTRES

6.1 CTM - CENTRE FOR TELECOMMUNICATIONS AND MULTIMEDIA

Coordinators: Filipe Ribeiro and Rui Campos

Presentation of the Centre

The Centre for Telecommunications and Multimedia (CTM) consists of about 100 researchers working on scientific and technological challenges related to Artificial Intelligence (AI), Bioengineering (BIO), Communications (COM), and Computer Science and Engineering (CSE) scientific domains. 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:** To research and develop advanced systems and technologies that enable autonomous communications systems, media knowledge extraction, and immersive ubiquitous multimedia applications.

In 2023, CTM accomplished its mission, within the AI, BIO and COM scientific domains, by directing its activities towards 4 main areas of research: Optical and Electronic Technologies (OET); Wireless Networks (WiN); Multimedia and Communications Technologies (MCT); Visual Computing and Machine Intelligence (VCMI). CTM contributed to research in neuromorphic computing and planar antenna array design for sub-THz communications as well as in wireless communications for dynamic and extreme scenarios. The CTM's expertise in machine learning and 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 over the content.

Research outcomes in 2023

The main broad research achievements obtained by **CTM in 2023** were:

- 51 articles published in relevant scientific journals, 90% of them in Q1 and Q2 journals;
- 3 PhD theses and 54 MSc theses successfully defended;
- Organisation of 7 international events (2 special sessions, 5 workshops) with hundreds of participants;
- Awards: 9 FCT PhD scholarships, best MSc thesis award from APDC, best paper award in Workshop on ns-3, best poster award in RecPad 2023, first prize in Image CLEF Challenge 2023 and SCCM Datathon 2023;
- CTM Open Day 2023 targeting companies and Summer Internships with 44 students;
- Start of the coordination of 2 Horizon Europe projects in 6G (CONVERGE and TERRAMETA);
- Organisation of industry panel in IEEE GLOBECOM 2023, a flagship conference from IEEE ComSoc.

The main research achievements obtained by the **OET Area** were:

- **Proposal of a novel system topology and algorithms for self-localisation** where a receiver with an antenna array utilises the angle-of-arrival from fixed battery powered beacons to self-localise.
- **Discovery of dissipative quartic solitons of a distributed model for mode-locked lasers** in the presence of either positive or negative fourth-order dispersion, which allows the generation of ultrashort pulses with high energies.
- **Non-invasive method for the in vivo evaluation of the diffusion properties** of chemicals and agents in biological tissues.

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

- Obstacle-, traffic- and energy-aware placement algorithms and queue management in flying networks, enabling significant gains in network performance and resource efficiency;

- Position-based Machine Learning Propagation Loss Model (P-MLPL), enabling the creation of fast and more precise digital twins of wireless networks in ns-3;
- Energy-aware approach for high performance multimodal underwater communications, combining the seamless integration of RF and acoustic communications with the use of data mulling;
- Trajectory-aware Rate Adaptation, and Rate Adaptation-aware positioning for flying networks, enabling joint optimisation of PHY Rate and Position for Wi-Fi-based flying nodes.

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

- **DECEIVER - Dataset of Acting Emotions on a Valence Arousal Space**, including a comprehensive collection of various physiological recordings meticulously curated to facilitate the recognition of a set of five emotions.
- **Data2MV - A user behaviour dataset for multi-view content**, containing 1M gaze fixation information for multiview scenarios.
- **Cross-domain analysis for visual scene processing and visual representation**, providing a novel and holistic view of the full process ranging from the automatic analysis of visual scenes to the rich, flexible and virtual representation of the knowledge.
- **Benchmark-based analysis for video anomaly detection**: an experimental-based review that deconstructs state-of-the-art premises and provides new perspectives for the assessment of proposals and new ways forward.
- **A DL view-selection mechanism in multiview scenarios**, based on viewer's focus of attention.

The main research achievements obtained by the **VCMi Area** were:

- **Symmetry-based regularisation improving robustness to domain-shift**, a unified view of different regularisation methods that incorporate domain-known symmetries in the ML model.
- **High-fidelity generation of Synthetic medical data**, synthesise artificial lung images from corresponding positional and semantic annotations using two generative adversarial network.
- **Probabilistic Interpretable Comparison (PIC) Score for Optimal Matching Confidence in Single- and Multi-Biometric Recognition**, provides optimal matching confidence and can also optimally combine multiple samples in a joint PIC score which further increases the recognition.
- **Coherent Concept-based Explanations in Medical Image**, framework explains its decision in terms of human-interpretable concepts and their respective contribution to the final prediction.

Innovation outcomes in 2023

The main broad innovation achievements obtained by **CTM in 2023** were the following:

- CTM researchers organised one internal advanced training on the SLURM platform;
- CTM implemented a 4-day week pilot from June to November within the context of the national initiative launched by the Portuguese government;
- Six direct contracts with national and multinational companies.

The main innovation achievements obtained by the **OET Area in 2023** were the following:

- Patent submission protecting the concept of using memristors for controlling unit cells from reconfigurable intelligent surfaces enabling the size scaling without compromising the power consumption.
- Provided 6 contributions to the standards group ISG THz, from ETSI, related with use cases for RIS-based THz communications and sensing.

The main innovation achievements obtained by the **WiN Area in 2023** were the following:

- **Patent submission of a Network Traffic Generation Model based on GANs**, with different applications such as for digital twins of wireless networks and realistic synthetic load tests in real networks;
- **Position-based Machine Learning Propagation Loss Model (P-MLPL)**, enabling the creation of fast and more precise digital twins of wireless networks in ns-3.

The main innovation achievements obtained by the **MCT Area in 2023** were the following:

- **BART – A Biosignal Processing Toolbox**, an open-source software package for biosignal data recording and annotation.

The main innovation achievements obtained by the **VCMI Area in 2023** were the following:

- A CAD system for automatic dysplasia grading on H&E cervical whole-slide images, using a ML algorithm to assist pathologist on their tasks;
- AI-based software for image retrieval and morphing, helping to promote a safer and evidence-based clinical decision for patients proposed for locoregional treatment, making it easily applied in clinical practice anywhere in the world.

Activity Overview

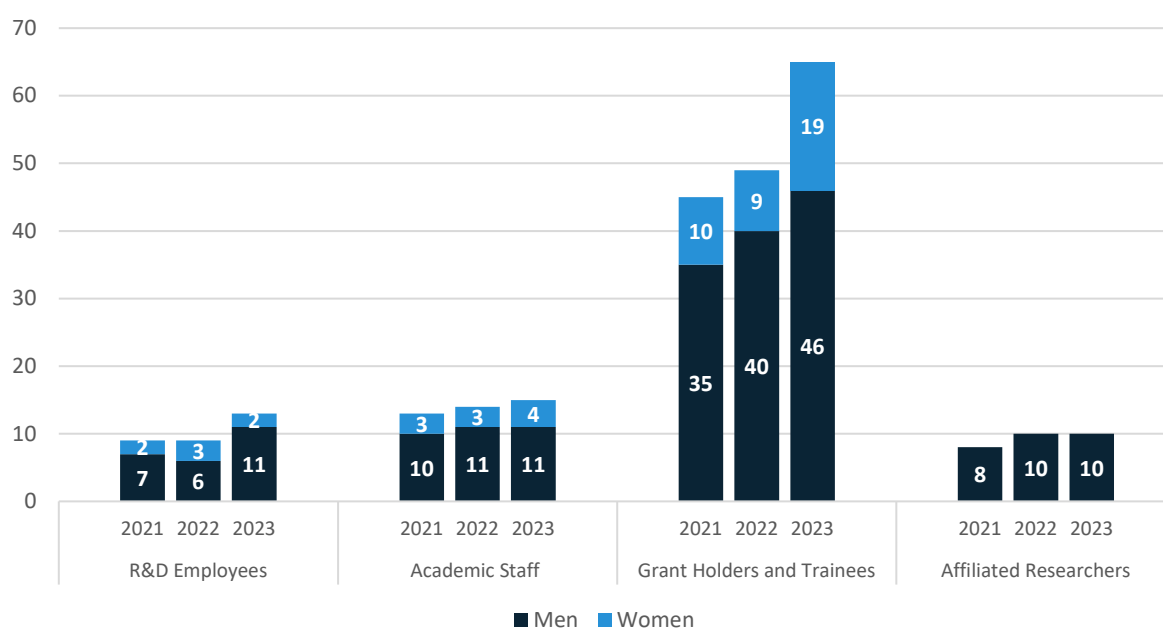


Figure 6.1 - CTM - Research team evolution

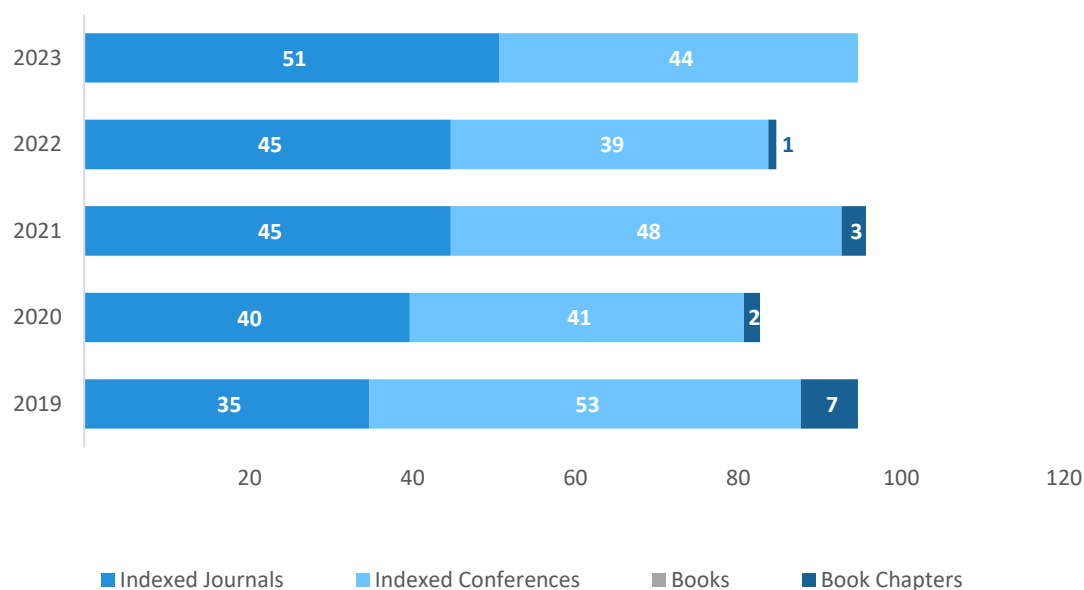


Figure 6.2 - CTM - Evolution of publications by members of the Centre

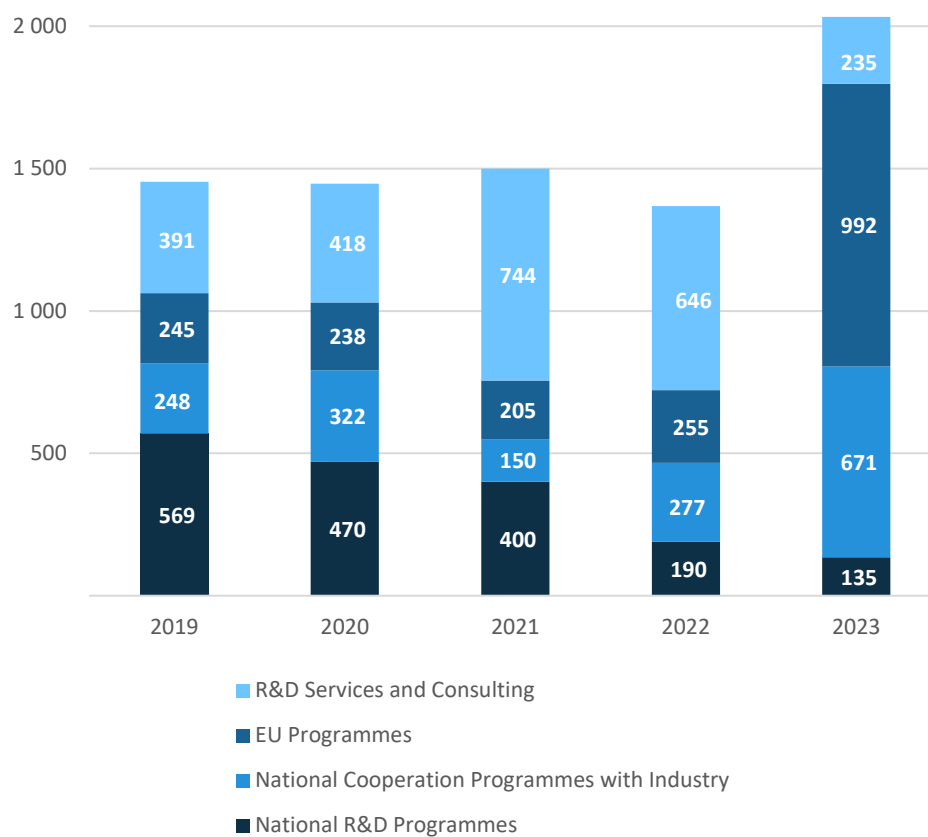


Figure 6.3 - CTM - Project funding evolution (k€)

6.2 CAP - CENTRE FOR APPLIED PHOTONICS

Coordinators: Paulo Marques and Ireneu Dias

Presentation of the Centre

CAP accomplishes its mission by directing its activities towards 4 main areas of research: integrated optics and microfabrication, optical sensors, comprising physical and chemical/biosensors, and quantum optical engineering. This organisation is non-hermetic and the development of solutions implies multidisciplinary 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, supporting advanced laboratory lectures of MSc and PhD teaching programs.

Research outcomes in 2023

Integrated Optics and Microfabrication

The work on micromachining of ULE continued with the fabrication of improved cavities being machined on bulk glass, namely the fabrication of curved surfaces to reduce losses and improve interference visibility.

The design of flow focusing devices was started and the device geometry was planned, with laser exposure programming, with concrete results in 2023.

A set of improved procedures to achieve the complete filling of long, uniform and glass embedded 3D metallic electrodes for optical signal processing were developed.

The upgrade of the current thin film deposition system based on RF Magnetron Sputtering technology was initiated, enabling enhanced material deposition control and expanding parallel utilisation capacity, enabling the integration with microfluidics and microfabrication by laser direct writing technique.

Physical sensors

A white light interrogation system was developed for precise absolute temperature measurements, boasting a readability of 1 kHz. Resolutions as fine as 100 microkelvin have been achieved through the utilisation of a reference cavity in integrated optics, fabricated on glass exhibiting zero thermal expansion within the temperature range of -10 °C to 40 °C.

Study and characterisation of azobenzene films for polarimetric sensors applications.

Start of activity in the distributed measurement and detection of acoustic waves in OPGW cables and submarine cables. Field tests to monitor an OPGW cable and the GEOLAB submarine cable were implemented, using a DAS system.

Investigation and theoretical analysis using COMSOL of nanoplasmonic-based optical fibre sensor configurations, that enable simultaneous multiparameter measurements, including refractive index, optical dispersion, and temperature, by engineering coupled multiplasmonic resonances.

Biological and chemical sensors

Fabrication of highly sensitive sensors with high resolution for different parameters, employing plasmonic materials to induce Surface Plasmon Resonance effects and fabrication of photonic crystals to stimulate Bloch Surface Waves, on both planar substrates and surrounding optical fibres.

Combination of plasmonic and ferromagnetic materials exploiting the magneto-optic effect for refractive index sensing, thereby enhancing sensitivity, and improving the detection limit for specific targets.

Study of hybrid configuration incorporating thin films with specially developed gold and silver nanoparticles with a wide range of sizes and shapes, spanning from the visible to the infrared spectrum. This configuration was experimentally validated in planar substrates and optical fibres to assess the suitability for biological applications.

Development of pH sensors employing layer-by-layer technique using long period fibre gratings and SPR configurations.

Full automation of optical tweezer system was achieved and the possibility to probe in real time events of biomolecules was demonstrated.

Quantum Optical Engineering

In the Development of photonic based platforms for environmental monitoring, medical diagnostic and industrial applications, significant advances were made in the subjects of sensor fusion, data processing, and mineral identification, aligned with the objectives previously set.

As for Optical systems and devices for analogue quantum simulations, in 2023, a new in-silico and experimental methods for optical computing solutions based on free-space and speckle interferometry were developed and deployed. Moreover, novel theoretical models for optical computing involving nonlinear optical media, incorporating a study of optical computing architectures, such as diffractive neural networks were also developed. Finally, observations of quantum-like dynamical instabilities and a proof-of-concept cutting-edge solution for increasing the effective simulation time of our physical platforms were achieved.

These results underscore the centre dedication to the development of cutting-edge optical systems and devices for analogue quantum simulations, contributing to the broader understanding and application of optical computing and simulation techniques.

Innovation outcomes in 2023

Development and implementation of a temperature sensor system for space applications with microkelvin resolution.

Development of a continuous high-power laser for thermoelectric applications as one of the final goals of the Wiptherm project in real-time tests conducted at São Jacinto Base.

Development of a graphical interface to facilitate the simulation of plasmonic structures, incorporating advanced multilayer simulation tools specifically designed for exciting surface waves.

A cost-effective optical interrogation system, optimized for low size, low cost, and a wide wavelength range, for characterizing various types of fiber optic sensors (long period fiber gratings, Fabry-Perot cavities, SPR and LSPR-based), for potential applications in in-situ environmental monitoring and integration into critical infrastructures.

Patent EP3765833A1 Device and Method for Detecting and Identifying Extracellular Vesicles in a Liquid Dispersion Sample was Granted in 29/11/2023 and Licensed to Spinoff Company iLoF.

An innovative multimodal knowledge distillation framework for which we submitted a patent application and that was distinguished with an innovation prize (BIP proof 2023).

Activity Overview

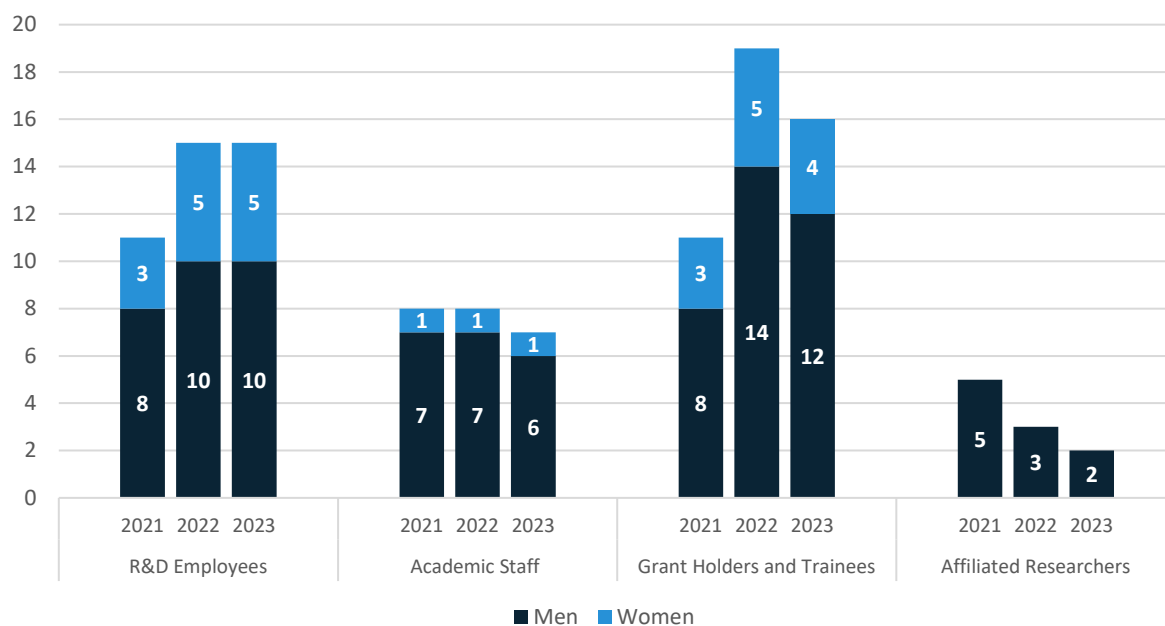


Figure 6.4 - CAP - Research team evolution

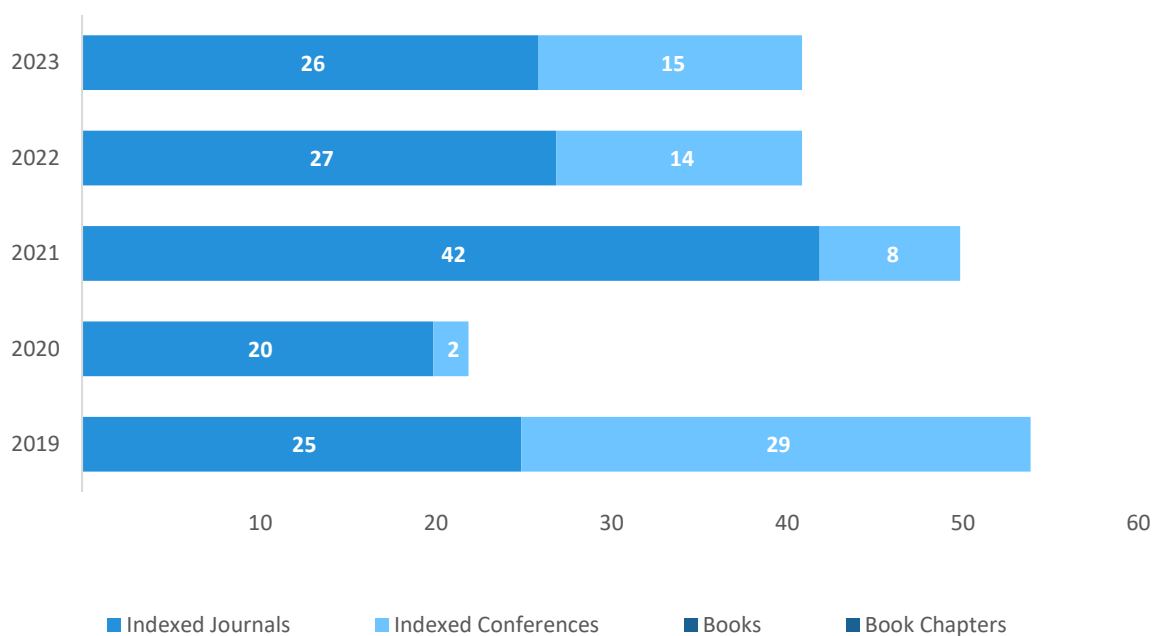


Figure 6.5 - CAP - Evolution of publications by members of the Centre

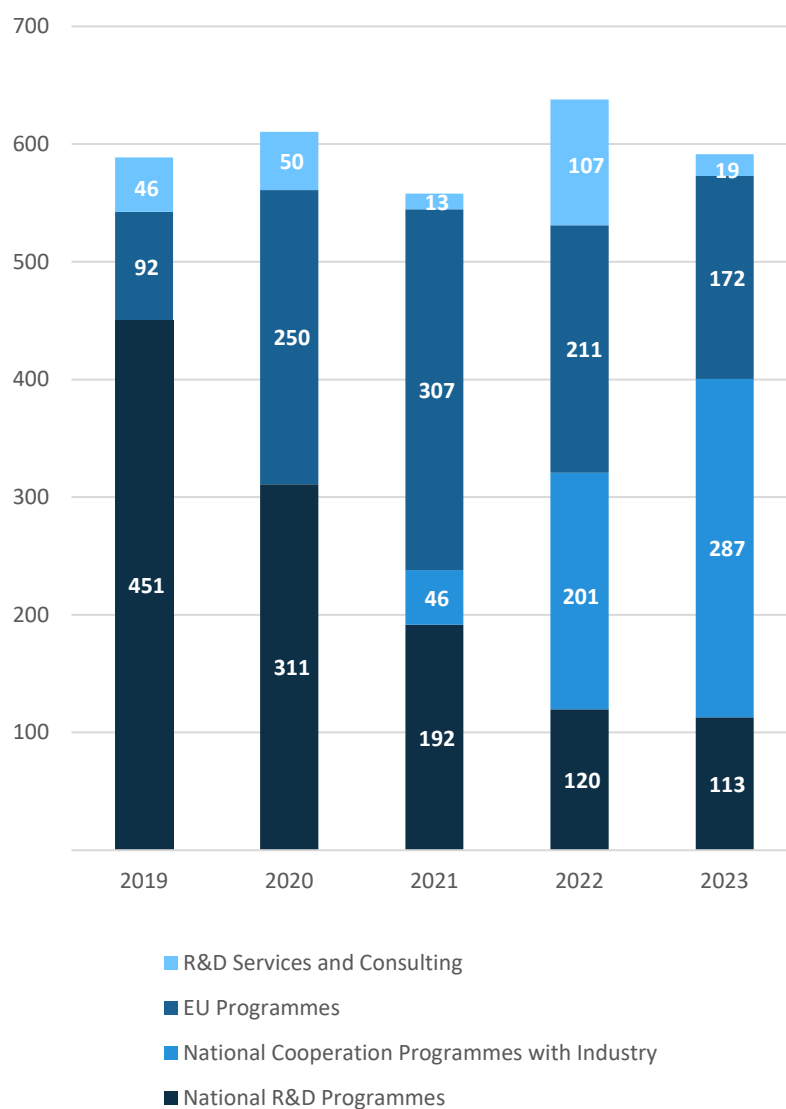


Figure 6.6 - CAP - Project funding evolution (k€)

6.3 CRAS - CENTRE FOR ROBOTICS AND AUTONOMOUS SYSTEMS

Coordinators: José Miguel Almeida and Nuno Cruz

Presentation of the Centre

The Centre for Robotics and Autonomous Systems (CRAS) brings together around 80 researchers on scientific and technological topics associated with field robotics and autonomous systems. CRAS aims to be a world reference in field robotics and autonomous systems. It is already internationally recognised for its innovative robotics solutions for operating in complex environments - relevant examples are underwater environments and deep-sea waters.

CRAS has a unique scientific focus on multi-sensor perception, navigation, positioning, and sensor fusion competencies. CRAS fulfils its mission by directing its activities towards four main research areas: navigation and control (RL1), interaction with the environment (RL2), perception and mapping (RL3), and platforms and operations (RL4).

CRAS's activities are mainly at TRL levels 5-8, which are associated with the design, development, and integration of robotic platforms with increasing autonomy. These activities have contributed to deploy innovative solutions in multiple fields of application, such as security, protection and defence, underwater mining, environmental monitoring, deep sea exploration, and infrastructure inspection. These activities are organised into four innovation topics: prototyping and scaling up robotic systems (INOV1), navigation and mapping (INOV2), development of components for robotic systems (INOV3), and underwater acoustics for positioning, navigation, and communications (INOV4).

Research outcomes in 2023

In 2023, CRAS researchers published 23 journal papers in 1st or 2nd quartile scientific journals, along with many others that were presented and discussed in prestigious international conferences. At the same time, there was a continuous 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 members delivered invited talks during visits to partner institutions, and a Senior researcher was invited to integrate the Scientific Advisory Board of a HEU ERA-Chair project. During the year, the Centre received the visit of several international delegations, most of them with recognised scholars in robotics trying to establish partnerships.

In terms of the main research lines, there was a significant number of publications with a strong potential impact in the scientific communities. Most of the significant advances were along RL1 (Navigation and Control) and RL3 (Perception and Mapping), with the largest number of papers in Q1 journals. In RL1, there were significant advances in underwater localisation, with algorithms to optimise the placement of underwater beacons, the implementation of synthetic baseline to account for insufficient information, the planning of 3D trajectories to optimise energy consumption, and the coordinated control of heterogeneous systems. In RL3, the papers addressed the most demanding challenges in this area, including the design of specialised fiducial markers, the generation and processing of 3D point clouds, the fusion of multiple data sources, and the semantic segmentation of underwater images. The development of the specialised fiducial markers resulted in a patent. In terms of RL4 (Platforms and Operations), the scientific results are mainly presented in conferences and workshops, with journal papers addressing some more specific issues. In this case, there were a few examples of the optimisation of underwater propulsion, as well as innovative uses of aerial drones in large-scale industrial buildings.

Innovation outcomes in 2023

One of CRAS' greatest achievements in 2023 was the ability to respond to IPMA's (and Portugal's) request to inspect VME13 (a vulnerable area of the seabed, one of the mapped areas of the coast, whose acronym "VME" stands for "Vulnerable Marine Ecosystem"). Not only were developments made and a technological solution prepared in record time (less than two months from the initial request to the data collection operation), but an underwater inspection of a VME in deep waters (> 600m) was carried out for the first time with a robotic system developed entirely in Portugal. With operations at more than 20 miles from the coast for two weeks, with average waves of the order of 1.5 to 2.5m in height, breaking the operating records of the vessel "Mar Profundo".

The ATLANTIS project, which began in 2020, successfully completed in 2023, creating a unique test centre infrastructure. Led by the Centre and with the participation of EDP NEW, a test platform (Atlantis Test Centre) was set up in Viana do Castelo to demonstrate the technological innovations and autonomous robotic solutions - underwater surface and aerial - that are essential in the inspection and maintenance of autonomous robotic vehicles for visual inspection. The demonstration took place at Ocean Winds' Windfloat Atlantic wind farm, the only offshore wind farm operating in Portugal and the first floating wind farm installed in Europe, with three turbines and capacity to produce 25.4 MW.

Also in 2023, we took part in one of the largest national robotics exercises at the Navy's Operational Experimentation Centre (CEOM), where the twelfth edition of REPMUS - Robotic Experimentation and Prototyping Augmented by Maritime Unmanned Systems - took place. Over 12 days, the "Mar Profundo" Ship was used in the exercises, together with the TURTLE deep-sea robot and the EGIM environmental monitoring system, carrying out bathymetry operations and reconnaissance missions to support landing operations. As a result of various technological innovations introduced, a system based on underwater communication cables was tested, to which environmental sensors and information exchange stations with autonomous underwater vehicles are connected. These activities were carried out as part of the K2D (Knowledge and Data from the Deep to Space) project, a flagship project of the MIT-Portugal Programme, which the Portuguese Navy supported.

In addition to taking part in the exercise, our Centre exhibited some of its robotic technologies at its own stand, which was visited by the Chief of Staff of the Navy, Admiral Gouveia e Melo, the Portuguese Minister of Defence, Helena Carreiras, Vice Admiral Keith Blount, commander of NATO's Allied Maritime Command, and Vice Admiral Guy Robinson, of NATO's Allied Command Transition.

Another achievement, the result of innovations achieved under the NESSIE project, was the development of a fleet of technological solutions to reduce the high costs of inspecting and monitoring submerged maritime infrastructures. This project represented an innovative vision focused on integrating underwater robots with heterogeneous systems, aiming to investigate the technical-scientific uncertainties and competitive advantages that could arise from keeping these robotic platforms in place for multiple days.

Also in August 2023, a team from INESC TEC's Centre for Robotics and Autonomous Systems carried out a mission to the Arctic to collect environmental DNA samples in extreme environments. In this mission, the IRIS underwater robot and an autonomous eDNA sampler developed by INESC TEC were used in operation at sea in the area of the Norwegian polar station in Ny-Alesund, Svalbard.

Several workshops, seminars, and summer schools were organised by CRAS members to disseminate achievements and competences. Some of these had strategic relevance due to the target audience or the importance of the topic, for example:

- SOE'23 | Space, Ocean, and Earth Insights – a unique event to push the limits of science and technology in space and ocean-related research that took place during the GLEX summit.
- WAVES 2023 – Workshop on Advanced Vehicles for Exploration of the Seas – the first edition of a workshop discussing how robotic solutions can be used in specific problems of the Azores.

Activity Overview

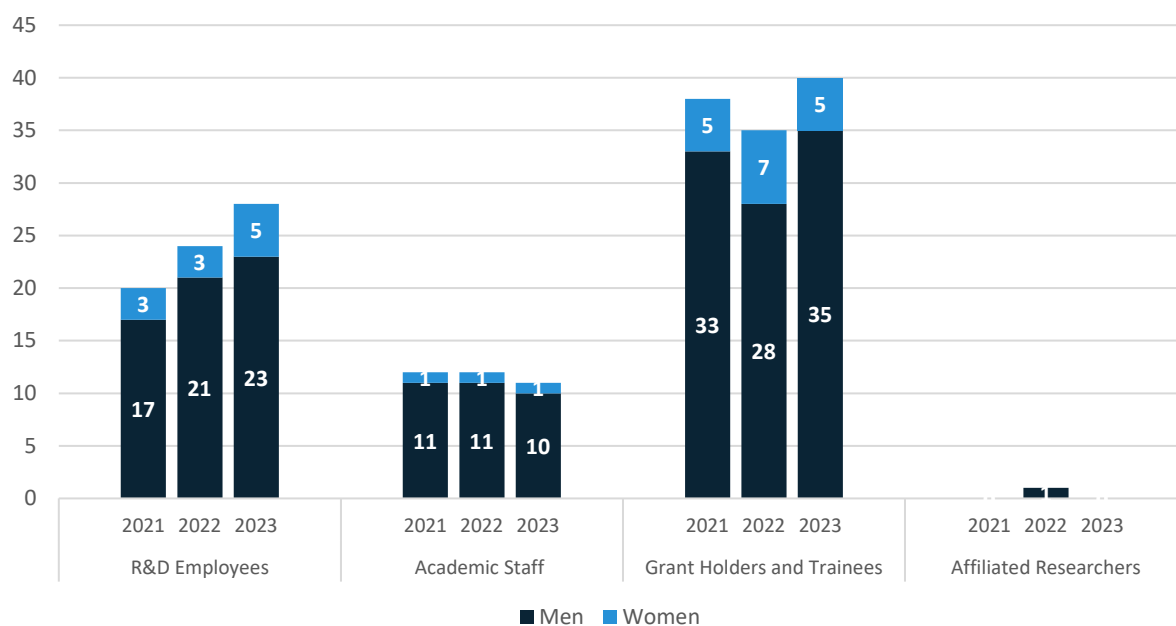


Figure 6.7 - CRAS - Research team evolution

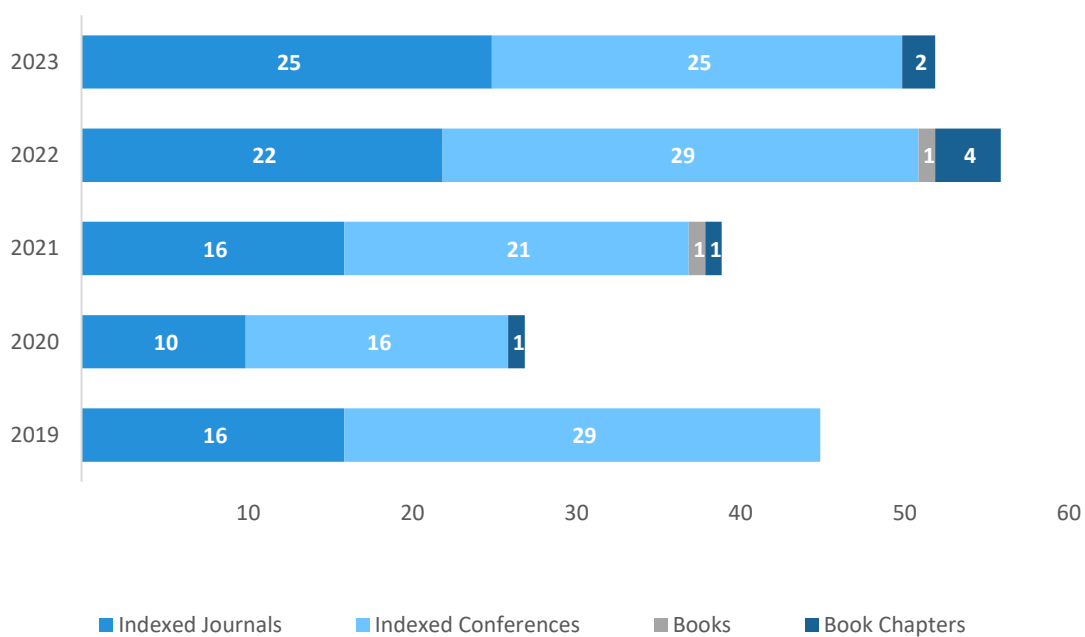


Figure 6.8 - CRAS - Evolution of publications by members of the Centre

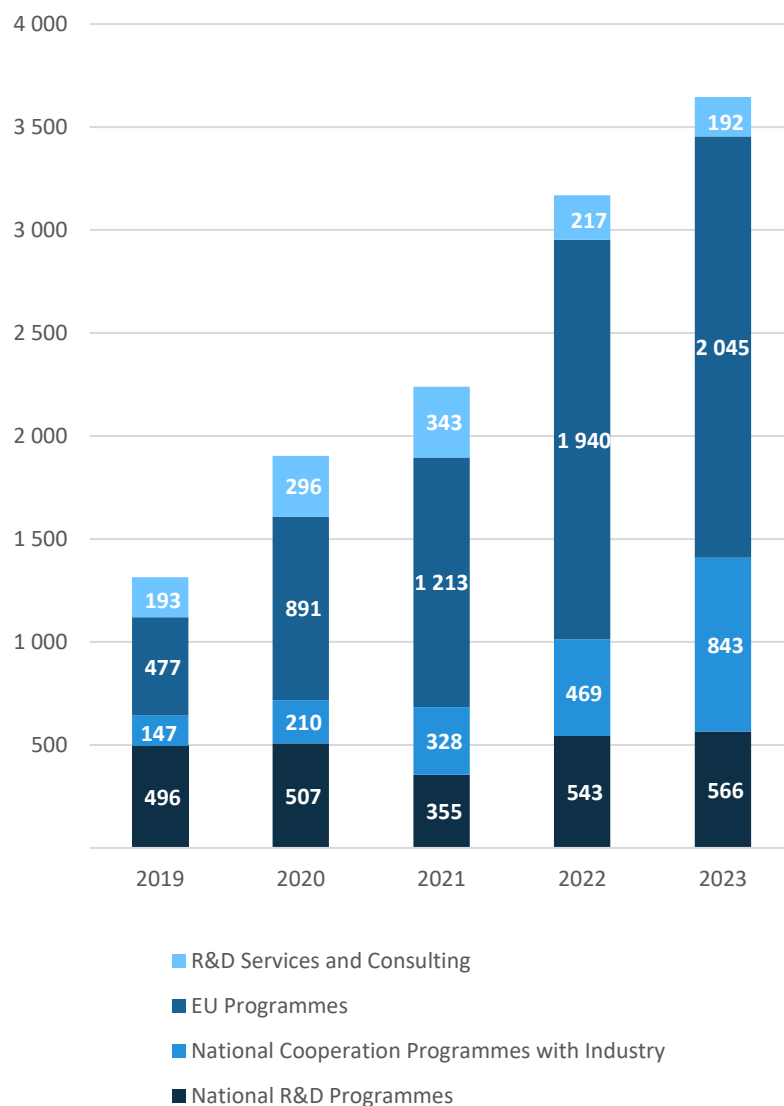


Figure 6.9 - CRAS - Project funding evolution

6.4 C-BER - CENTRE FOR BIOMEDICAL ENGINEERING RESEARCH

Coordinator: João Paulo Cunha

Assistant Centre Coordinator: Duarte Dias

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”. 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.

Research outcomes in 2023

Organisation, human and material resources: The planned R&D projects have been executed with small differences from the workplans main due to the difficulty on hiring new personal, which is always a challenge. After a successful 2022, C-BER continued to push on EU projects submission and also achieved another approval – AI4Lungs², a project coordinated by INESC TEC was approved and for the first time INESC TEC is now leading an EU project on the health area involving 18 partners with a total budget of 7M€. C-BER secured also 2 more projects regarding R&D and consulting services to companies. C-BER is being able to achieve funding for the main research lines, counting in 2023 with a total of 5 EU projects, 9 National projects and 3 services to external partners

In 2023 C-BER hosted 12 PhD theses (1,5 /PhD member) and 15 MSc theses (1.8 /PhD member) in several areas, mainly, Bioengineering, Electrical and Computer Engineering and Computer Science. From these, all 15 MSc were completed in 2023 and next year we hope to have some of the PhD students presenting their final work.

Publications: Among the 23 international journal papers published in 2023 (2.8 papers/PhD), ~75% of them in SCOPUS “1st Quartile” and the remaining ones in “2nd Quartile”, some high-impact papers are worth to be mentioned: IEEE Journal of Biomedical and Health Informatics³ on novel methods for Heart Murmur analysis (Q1,IF=7,7); Artificial Intelligence in Medicine⁴ on a spatial transformer network for abnormality detection in chest X-ray images (Q1,IF=7,5); IEEE Transactions on Visualisation and Computer Graphics⁵ (Q1, IF=5.2) and Springer’s Virtual Reality journal⁶ (Q1, IF=4.2) on our joint studies with HumanISE on human sensing physiological changes in multisensory virtual reality environment recurring to the MASSIVE lab at UTAD. Besides journal publications, C-BER also made a significant effort to publish in indexed conferences, with a total of 36 papers (4.3 papers/PhD)

Internationalisation: The AI4Lungs project mentioned above was a very important landmark on C-BER’s internationalisation with the participation of partners from 10 different countries. Furthermore, C-BER was very active on the CMU-Portugal program with one more member accepted in the CMU Portugal Affiliated PhD

² <https://www.ai4lungs.eu/>

³ doi: 10.1109/JBHI.2023.3275039

⁴ doi: 10.1016/j.artmed.2023.102737

⁵ 10.1109/tvcg.2023.3251188

⁶ 10.1007/s10055-023-00917-6

Program and another member on the same program doing a year at CMU under the supervision of Fernando de la Torre in the CMU Robotics Institute. PhD members of C-BER have 5 editor positions in high-ranking scientific journals: Nature/Sci. Rep., Frontiers in Signal Processing, Frontiers in Neuroscience, Medical Physics and Mathematics; and 1 as member of the Technical Area Committee on Signal and Data Analytics for Machine Learning, EURASIP – European Association for Signal Processing. Following the plan, we renovate EBRAINS' membership for 2024 to share and make use of high-level research infrastructures and services in the neuroengineering area⁷. The planned 7 international R&D 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 and in 2024 C-BER is planning several trips to these groups to reinforce the partnership, look for new project together and discuss new research lines.

Dissemination Actions: In 2023, our researchers were members in 25 Program Committees of International Scientific Events. Members of C-BER were very actively involved (Chair and co-Chair) in the organisation of 7 conferences, namely as responsible of the organising committee and general chair on the IEEE EMBS Portugal Chapter bi-annual conference held in Porto in June 22-23, 2023.

Innovation outcomes in 2023

Startups: C-BER has generated 3 spin-off startups in the last 5 years. Following the “intelligent Lab-on-Fiber” (iLoF) technology developed for several years that resulted in the creation, in 2019, of the startup *iLoF.tech*⁸ that licensed the advanced photonics analytics technology developed at INESC TEC to the area of healthcare (raising 10.9M€ so far and creating +30 highly qualified jobs in the Porto region), C-BER, in 2023, once again was in the genesis of one new (4th) spin-off startup to explore an evolution of this innovative technology to the *foodtech* area.

Innovation Infrastructures: According to the C-BER plan to improve Laboratories infrastructures, in 2023 C-BER equipped the BRAIN-Stim Lab with a new high-quality 64-channel viode-EEG system from Micromed[®]. Combining this with the MRI simulator and a new place for EEG cap preparation, we can ensure a high-quality workflow to conduct experiments on the neuroscience field and offer science services to this community.

Patents & IP Creation: C-BER continued to fill the patent pipeline during 2023. As a result of those actions, C-BER has 1 new patent applications and 2 internationalisations. One of these applications was a PCT application of one of our recent technologies on the non-invasive detection of pulmonary hypertension (PCT/IB2023/058675). Furthermore, we have submitted 1 technology disclosure (pre-patent descriptions), which is now being prepared for a patent application in 2024.

⁷ <https://www.ebrains.eu/>

⁸ <http://ilof.tech>

Activity Overview

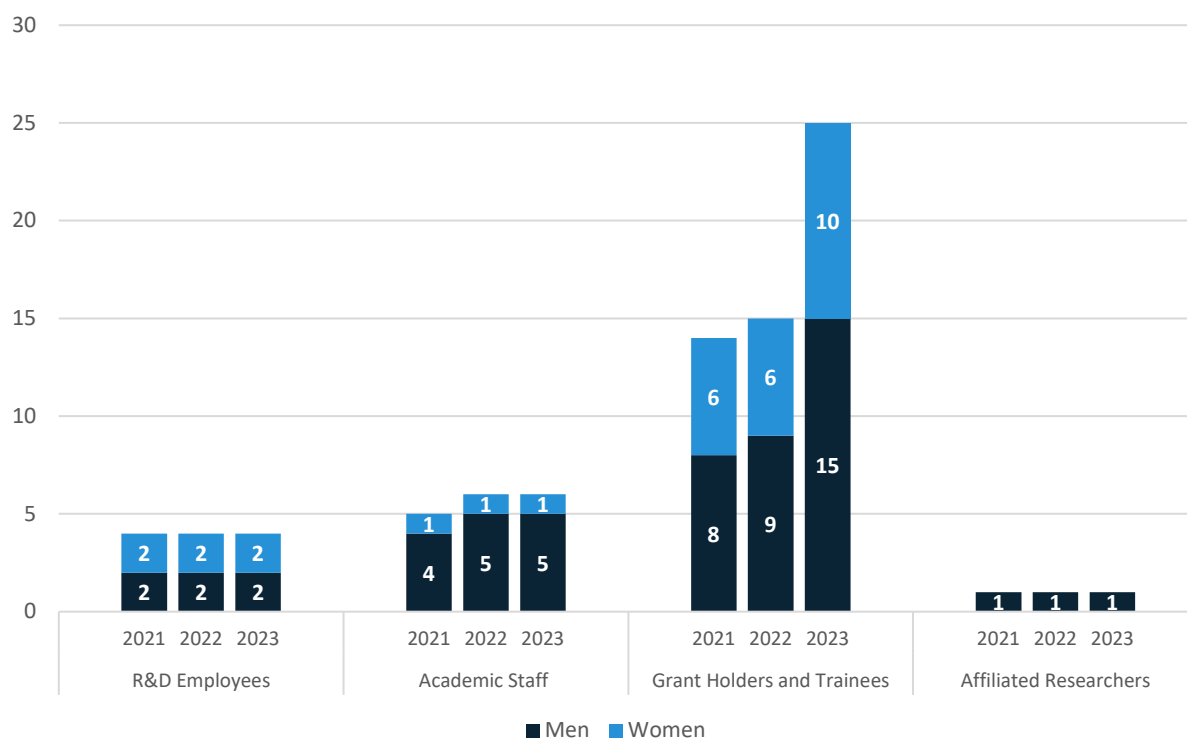


Figure 6.10 - C-BER - Research team evolution

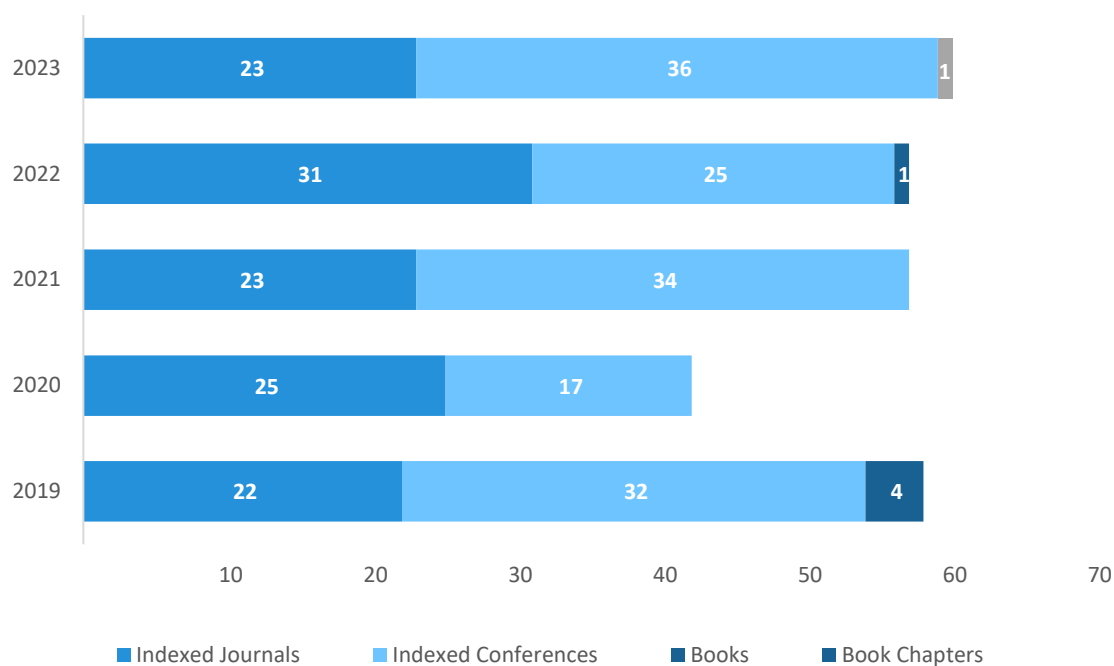


Figure 6.11 - C-BER - Evolution of publications by members of the Centre

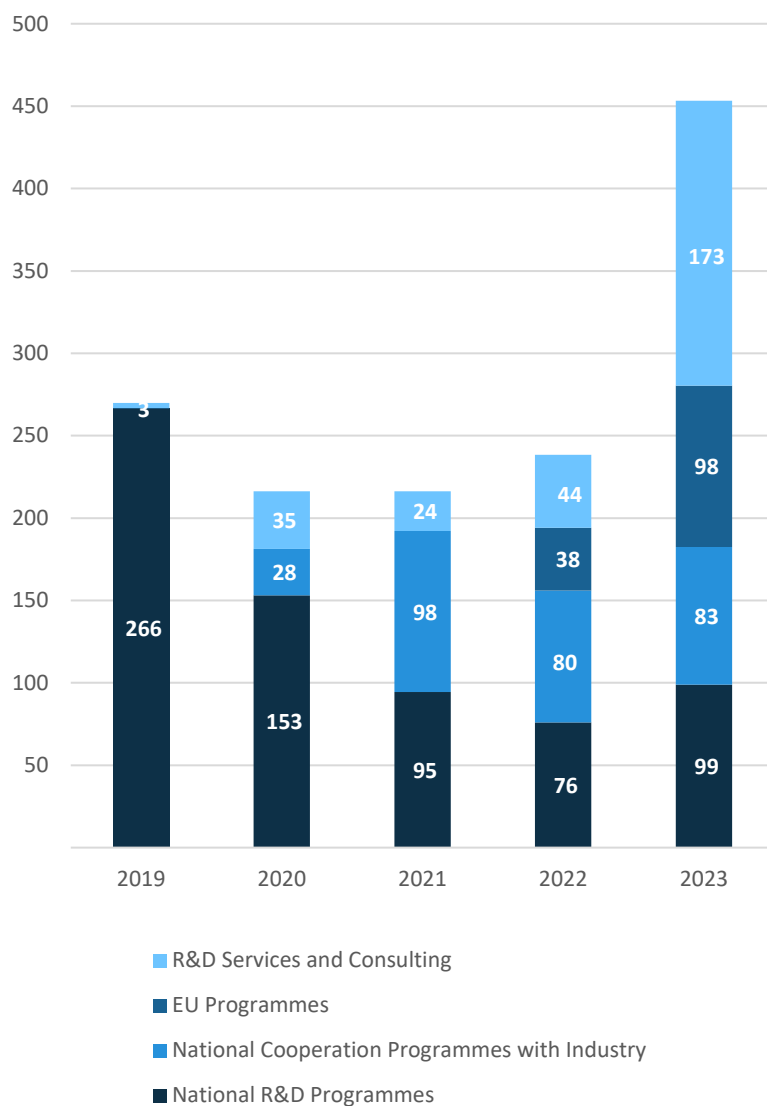


Figure 6.12 – C-BER - Project funding evolution (k€)

6.5 CPES - CENTRE FOR POWER AND ENERGY SYSTEMS

Coordinators: Manuel Matos and Ricardo Bessa

Assistant Centre Coordinator: David Rua

Presentation of the Centre

CPES fosters fundamental and applied science as well as innovation in new services and solutions and education to support a sustainable energy transition in multiple domains. CPES is leading the actions towards the reduction of GHG emissions, via the decarbonisation of the energy system, large-scale RES integration, electrification of the society and increased efficiency of the energy use.

This involves the combination of physical representations and data-driven methods for modelling and optimising energy systems, leveraging from emerging technologies like AI, blockchain and interoperability. Results include concepts, models, methodologies, and tools, useful for addressing the decision problems of citizens, communities, multi-utilities, system operators, regulators, policymakers, and government bodies.

Research outcomes in 2023

Finalisation of the Horizon 2020 Smart4RES project, which produced 6 journal papers and 1 patent request. In 2023, and in this project, a new methodology for flexibility management in electrical grids under forecast uncertainty was accepted for publication in IEEE Transactions on Sustainable Energy.

Collaboration with the Swiss Federal Office of Energy to develop a replicable framework for estimating compliance costs for different electricity market agents regarding requirements of the AI Act. This work was published in the Energy Reports journal.

Development of symbolic data-driven methods for optimal renewable energy bidding in the electricity market. This work was made in the framework of a co-supervision of PhD thesis with MINES ParisTech.

Development of a PV power plant digital twin for generating fault data, using machine learning techniques for fault location and classification. This work was presented in the IEEE Powertech.

Network-constrained bidding strategies to coordinate distributed energy resources in distribution networks. Two papers were published in SEGAN. Two open-source tools were made available in GitHub.

Attention mechanisms to improve forecasting performance, a new approach on the interpretability of deep learning techniques. This work led to a MSc thesis.

Different energy management algorithms for flexible resources in energy communities, transaction pricing and collective benefits sharing. Paper presented in EEM. Journal papers in IEEE TSG and Energy.

Research on Renewable Energy Communities for the agri-food sector has been started through the project Tools4AgriEnergy. One conference paper in EEM.

Consumer-centric markets were developed, considering the operation of the distribution network and the coordination with its different levels. This work led to one conference paper presented in EEM and two journal papers published in SEGAN.

Probabilistic model for quantifying the impact of demand flexibility on the long-term generation system adequacy via Sequential Monte Carlo Simulation. This work was developed in the framework of a PhD thesis and produced a journal paper published in IJEPES.

Methodology for design and evaluation of public policies based on the adoption of green hydrogen to store the surplus of renewable electricity. This work was developed in the framework of a PhD thesis.

Multi-objective methodology based on the Cross-Entropy method for recloser placement in distribution networks. This work was developed within the research work of an MSc thesis.

Methodology for Medium Voltage Maintenance Planning, under H2020 EUniversal project. It supports the DNO in selecting the most adequate period for maintenance, considering realistic loading conditions, the contribution of flexible resources and total costs. Work presented in CIRED 2023.

Coordinated flexibility needs assessment for Medium and Low Voltage networks, based on the identification of dynamic flexibility areas and operating limits for Low Voltage networks, considering data-driven sensitivity factors. Work presented in CIRED 2023 and IEEE PowerTech 2023 conferences.

New tool for the coordinated operational planning of transmission and distribution systems, considering the existence of resources that can be shared by TSO and DSO. Data privacy and tractability of the large-scale problem are preserved through mathematical decomposition techniques. The work was presented in IEEE PowerTech 2023 conference.

New methodology, designed within EU-InterConnect project, to determine the operational condition of the EU-connected transmission system based on data collected from the ENTSO-E Transparency Platform, combined with a risk-based assessment to suggest in a day-ahead basis how should an EU consumer increase or decrease its electrical energy use.

Under EU projects MAGPIE and NEXUS, CPES is developing open-source tools and models to help European ports transition to becoming clean, smart and green.

Innovation outcomes in 2023

Support to renewable energy promoters through the development of grid code compliance analyses and grid integration studies, in Portugal and in Cameroon.

Integration of a low voltage state estimation with the commercial platform of ENEIDA. Results presented in CIRED.

Maintenance and functional improvements of the load forecasting system developed for Elergone Energias.

Backend integration of INESC TEC methodology for deriving dynamic discounts for EV charging in Sonae MC supermarkets. This software will be demonstrated in real conditions (3 supermarkets) in 2024.

Probabilistic estimation of the quality of service (QoS) indices in electricity distribution systems. This work led to a MSc thesis.

Determination of loss profiles based on loss factors, following regulatory requests to the transmission and distribution system operators. The methodology proposed by CPES was accepted by the regulatory authority (ERSE) and the new loss profiles for 2024 were approved by ERSE for market usage.

Reengineering of CEVESA market simulator for the Iberian electricity market with new functionalities. This work led to two MSc theses and one conference paper (EEM)

Development and operationalisation of a digital platform (RECreation) for the operation of Renewable Energy Communities under the Portuguese regulation. Conference paper in EEM.

Development of a hybrid Battery dispatch as a service to CapWatt based on a local load forecast. Under the InterStore project. Deployment finished via database leveraging on EMS load forecast tool.

Consolidation of the PS-MORA model distributed version, including models for representing energy-limited resources for aggregators of electric vehicles, and for demand response. Software delivered to REN. The work led to a conference paper at CIGRE Ibero-Americano.

Establishment of new collaboration with GE Grid Automation unit, through direct contract, for the specification, development and testing of new grid control applications.

Implementation of an Interoperable Recommender, in InterConnect, an open-source software suite for predictive grid assessment and day-ahead hourly risk mapping that provides differentiated recommendations for more than 12 EU countries.

Development of an Energy Application, jointly with HASLAB, to provide an interface to end consumers, in which hourly recommendations for load increase or decrease are posted.

In the framework of an educational initiative in 23 schools about increasing energy efficiency and reducing energy poverty, with the support of the local electricity distribution company, CPES has developed a set of age-appropriate materials.

Activity Overview

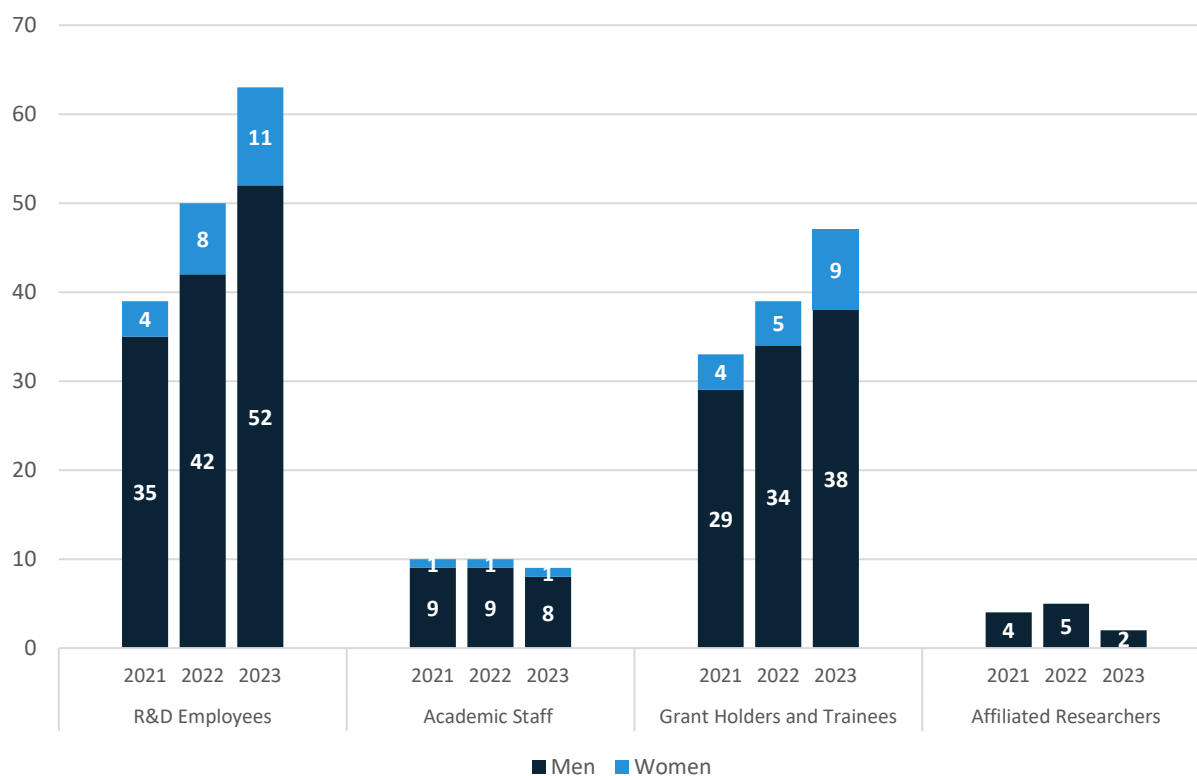


Figure 6.13 - CPES - Research team evolution

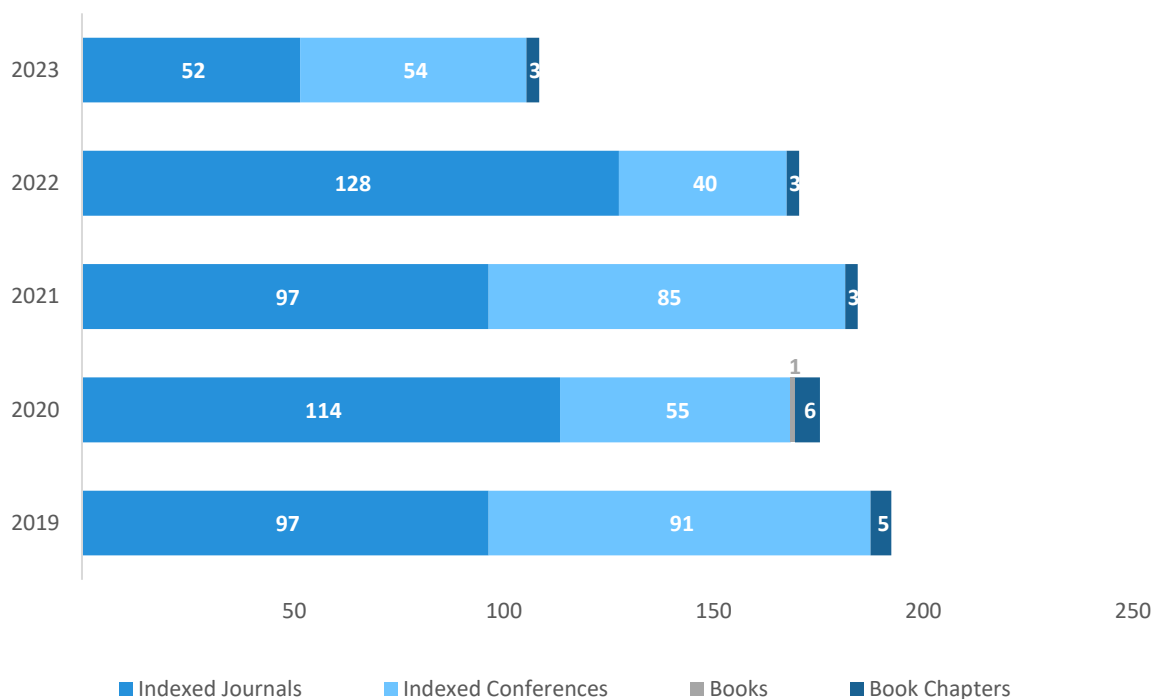


Figure 6.14 - CPES - Evolution of publications by members of the Centre

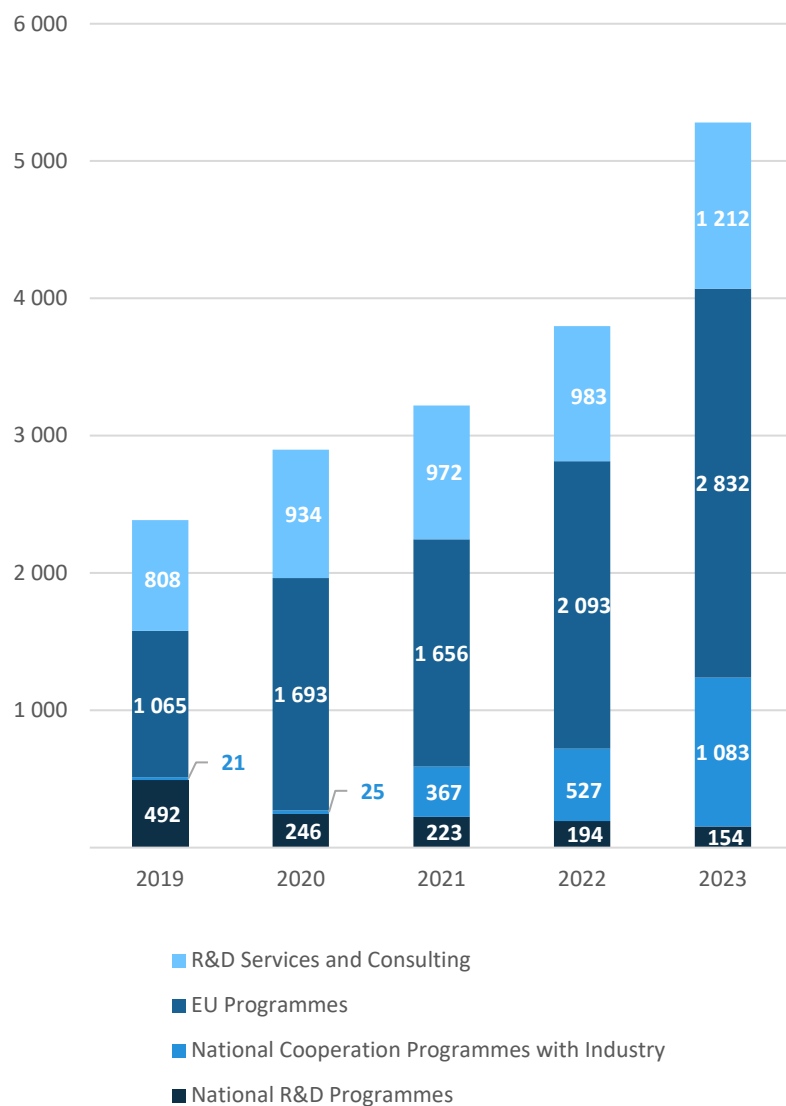


Figure 6.15 - CPES - Project funding evolution (k€)

6.6 CESE - CENTRE FOR ENTERPRISE SYSTEMS ENGINEERING

Coordinators: António Lucas Soares and Rui Rebelo

Presentation of the Centre

CESE is a multidisciplinary research centre contributing 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 developing industrial organisations' capabilities for an ongoing digital and green transformation. CESE's core scientific domain is Systems Engineering and Management, addressing five specific research lines: Manufacturing Design and Management, Supply Chain and Collaborative Networks Management, Industrial Information Systems, Technology Management in Industry and Transportation and Logistics.

Research outcomes in 2023

RL1. Manufacturing Systems Design and Management. In the *design of adaptable production systems* dimension, an approach to dynamically balance multi-manned assembly lines deep using reinforcement learning was developed, resulting in a publication. In the *management* dimension (planning and scheduling), we continued the development of a reference framework to support decision-making in planning and scheduling for complex operations environments. In the *continuous improvement* dimension, pursuing the goal of structuring methodologies to help organisations advance their continuous improvement systems a value-oriented framework for return evaluation of industry 4.0 projects was developed and published.

RL2. Supply Chain and Collaborative Networks Management. Continuing research on how the configuration of supply chains needs to change to face the complexity and uncertainty of current environments, we performed and published a study of the impact of the fit between supply and demand uncertainty and supply chain responsiveness on the performance of Portuguese companies. The ReSChape project developed a model that allows companies and supply chains to identify strategies to increase their social, environmental, and economic sustainability and their ability to be ready, respond and recover from unexpected events. The actions identified demand the participation of a broad set of actors, including policymakers. In the project SoTeIn Factory, we studied the R-Strategies' roles for circular supply chains. We presented the results at a conference and submitted a systematic literature review to a journal. In supply chain decision support systems, we designed a decision support system based on simulation/optimisation for Managing Disruptions in a Biomass Supply Chain.

RL3. Industrial Information Systems. In *digital enterprise architectures*, we continued developing and publishing new concepts around digital twin architectures: semantic asset administration shell towards a cognitive digital twin and a digital twin platform-based approach to product lifecycle management. Also, in the context of the Transformer 4.0 project, which ended in 2023, we published the paper "Making Sense of Digital Twins: An Analytical Framework" at the PRO-VE2023 conference, which won the Best Paper award. One of the most relevant results of this project is a proof of concept of a digital twin-enabled platform ecosystem that was delivered and validated by the company. A previous result of the CircThread project, a methodology for designing a digital platform ecosystem supporting the circular economy, was presented, and published at an international conference. In *industrial data and information management*, we continued developing software components for implementing Data Spaces in several projects. Finally, in the *design and impact of IIS* we are still working in a systematic literature review on digital transformation in industry through the lens of sociotechnical systems.

RL4. Technology Management in Industry. We continued researching the main drivers and barriers in Technology Management and developing strategies for adopting Human-Centred technologies. A study on overcoming the barriers to manufacturing digitalisation exploring the public policies across EU countries was published. In addition, we continued to develop frameworks and models to design new schemes for technology adoption and training in emergent technologies. In this scope, we developed and published a digital maturity model for Industry 4.0 based on the technology-organization-environment framework.

RL5. Transportation and Logistics. In terms of MaaS (Mobility as a Service), we continued to explore the design of innovative mobility services based on the co-creation of solutions and on digital platforms, addressing the new e-commerce challenges and current environmental concerns. In this context, we studied social media as a source of mobility intelligence through NLP approaches. Also, the research on the topic of last-mile logistics resulted in three publications on new and emerging trends for sustainable last-mile urban distribution and sustainability on

last-mile logistics. In terms of inter-modal logistics and transportation systems, we continued to develop a framework to support decision-making in intermodal freight operations and global supply-chains, through the use of synchro-modality in transportation networks and global supply-chains.

Innovation outcomes in 2023

As part of the adoption of i4.0 technologies in industry, CESE has implemented internal logistics simulation models to validate technical solutions in terms of mobile robotics, route management systems, operational efficiency and operator accident assessment. These simulation models accurately model the behaviour of logistics systems, helping to design the best routes work in process and including route management algorithms with collision avoidance systems. The analysis of the results of the simulation model allows the definition of roadmaps for the adoption of technology in the industry with a significant impact on the success of digital transformation projects.

In the context of augmented reality, it was possible to digitally enhance the operator on the shop floor in order to guide him during visual quality inspection processes, allowing him to detect and report non-conformities more quickly. The results achieved demonstrate potential benefits on the production lines, which are divided into 3 main categories: standardisation of processes; product traceability; empowerment of the operator in decision-making.

Advanced international consultancy in a high-performance metal forming industry in the design and implementation of proofs of concept in eco-efficient production planning has resulted in significant reduction of energy consumption and relevant economic benefits.

CESE played a key role in developing an interoperability platform that led to the release of an advanced logistics planning system, ForScope. This platform constitutes an innovative solution for managing the Portuguese forests, enabling the sharing of relevant information to support the planning and decision-making of the various players in the value chain and was tested in a pilot with Navigator and Trigger Systems. This project gave rise to two invention communications and a doctoral thesis entitled "The role of flexibility in forest-to-bioenergy supply chain risk management".

The SoTecIn project has reached an important KPI related to its first Open Call, receiving more than 120 applications (20% above KPI).

During 2023, CESE contribution to the iiLab was consolidated and became fully operational.

Activity Overview

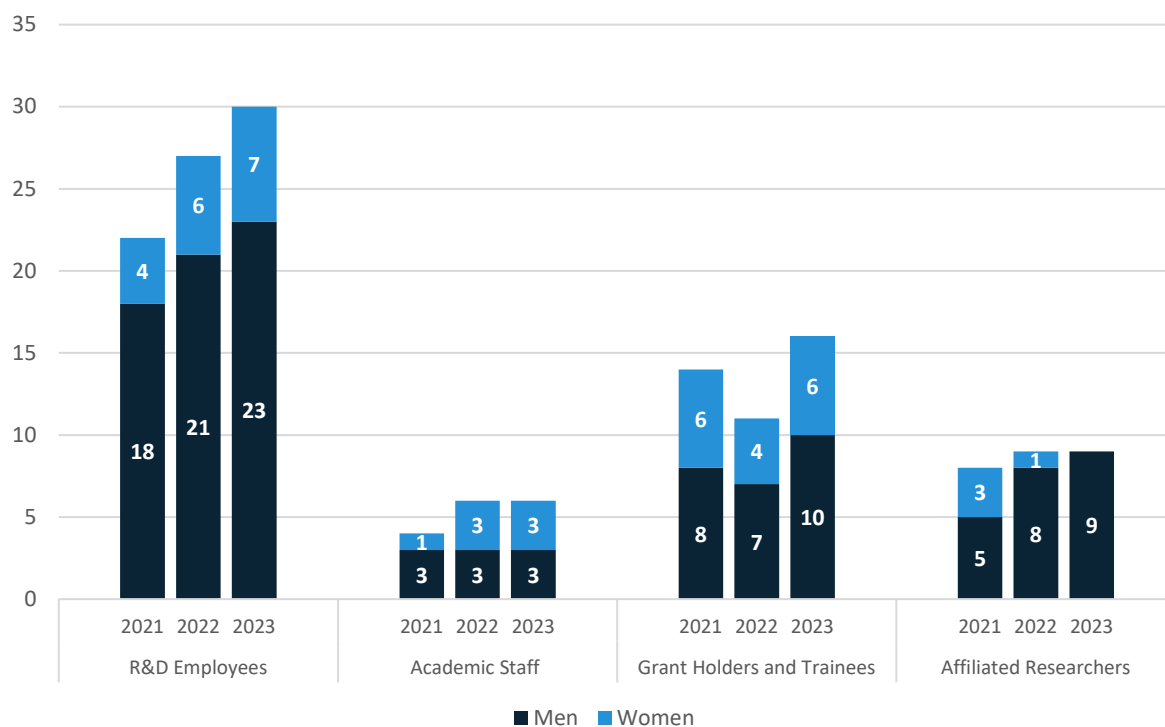


Figure 6.16 - CESE - Research team evolution

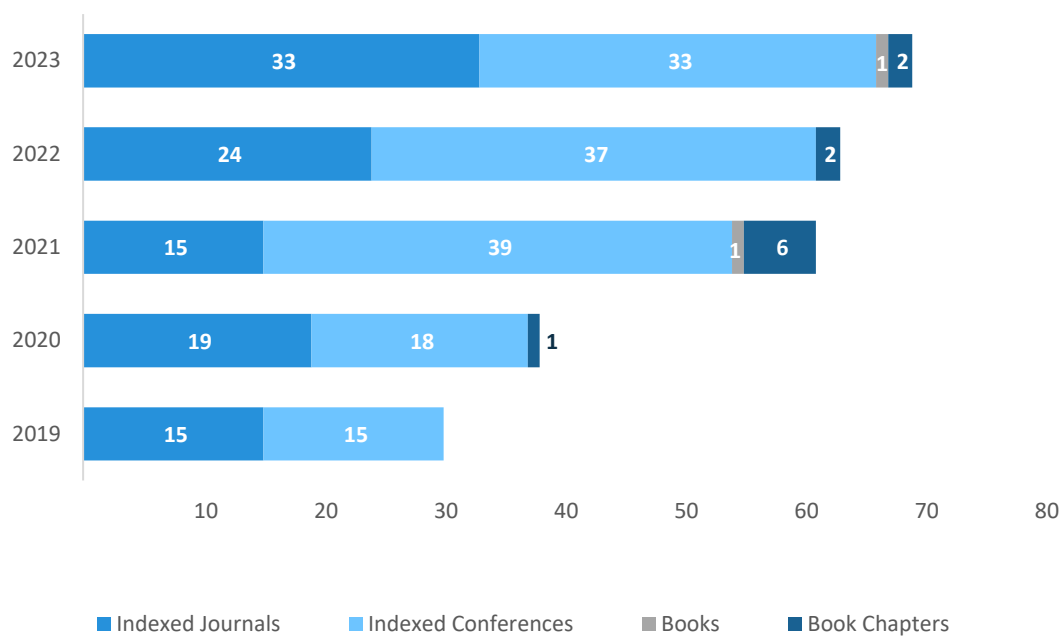


Figure 6.17 - CESE - Evolution of publications by members of the Centre

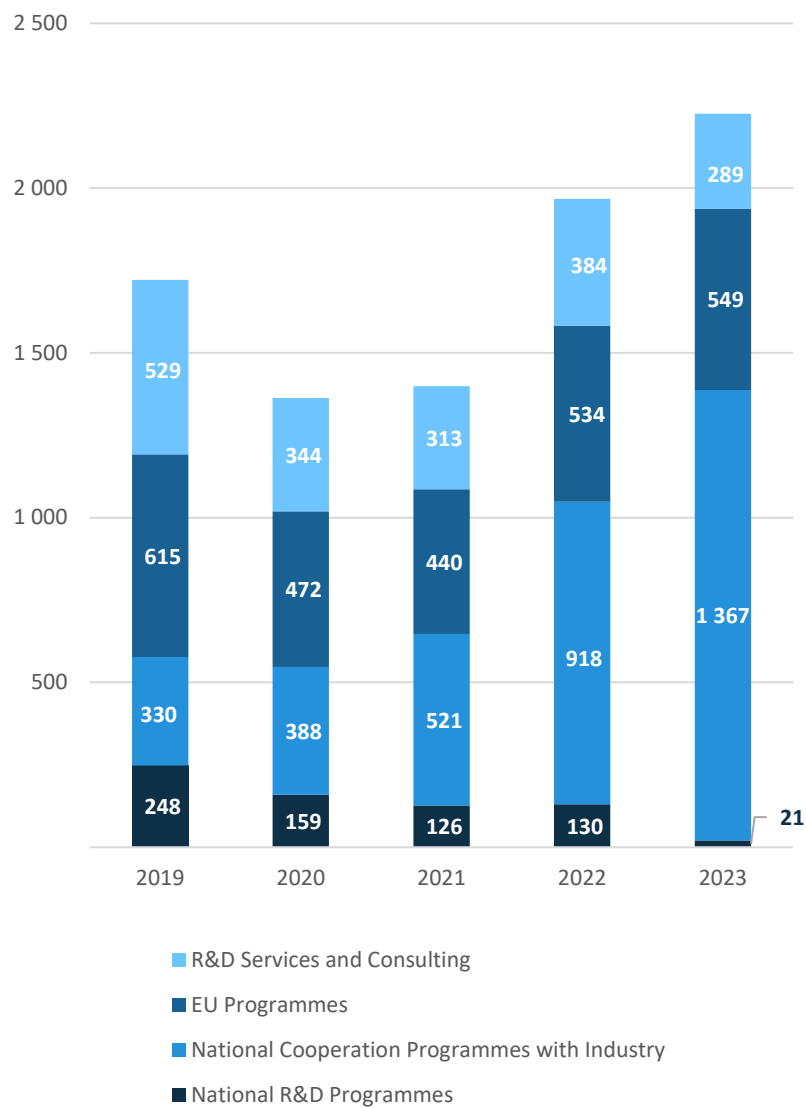


Figure 6.18 - CESE - Project funding evolution (k€)

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

Presentation of the Centre

The Robotics and Intelligent Systems Centre designs and implements innovative solutions within the areas of industrial, agriculture and forestry robotics and intelligent systems. It develops foundational robotics technologies within the Robotics Research Line and the Artificial Intelligence Research Line and applies these technologies through Design and Prototyping of Robotics systems that target the agriculture and industry in close articulation with TEC4INDUSTRY and TEC4AGRO and in cooperation with companies.

Research outcomes in 2023

The Centre presents 3 major Research Outcomes: RO1 is focused on robot autonomy, RO2 in manipulation and physical interaction and RO3 in the Design of Sustainable robotic systems. All these outcomes contribute to the Scientific Domain Robotics and to the Artificial Intelligence Domain.

RO1. Increase the autonomy of robotic systems: The Centre developed new methodologies related to the operation of mobile robots in increasingly challenging environments in dynamic terms via the improvement of the robustness of localisation systems used. In this vein the themes of 3D localisation, dynamic and long-term Slam, and calibration systems were explored. Improvements to the fleet management systems were added to enable more efficient operation of a more significant number of robots. Moreover, to sustain AMR's autonomy in stacker-type applications, an application based on Machine Learning is being developed to identify pallet pockets, ensuring precision and adaption of the robot's behaviour according to the geometry and positioning of the pallets. In agriculture and forestry sectors, the AgRobPP and VineSLAM (1 PhD completed) were upgraded and successfully implemented in the prototypes WETA and Modular-E, feeding different projects, such as the European projects SCORPION and NOVATERRA.

RO2. Improve manipulation and other physical interaction capabilities: CRIIS has successfully engineered an adjustable and modular system using deep learning and analytical methodologies for the detection, recognition, and localisation of objects. This system, when integrated with the robotic grasp planner, provides an efficient solution for pick-and-place operations in industrial settings. It exhibits the capability to operate in diverse environments, handle objects of varying textures and geometries, and utilise a range of grippers and sensors. Furthermore, the team has refined the pose estimation algorithms specifically for polyhedrons, eliminating the need for complex CAD models. On top of that the team has been working on the development of mobile manipulators tailored to the unloading of boxes from logistics transport containers.

RO3. Design sustainable robotic systems: Considering the emergence and integration of Cyber-Physical Systems within industrial operations, ensuring seamless interoperability with digital manufacturing systems remains crucial for maximising the efficiency of automated production processes. This research outcome focused on advancing the digital twin-based infrastructure by facilitating support, orchestration, monitoring, and integration of Cyber-Physical Systems (CPSs), fostering a broader range of practical industrial applications in many industrial domains. The successful realisation of this endeavour has resulted in enhanced tools, furthering interoperability with the Industrial Internet of Things (IIoT), vertical and horizontal integration, and the integration of Artificial Intelligence (AI), thereby solidifying the commitment to advancing industrial automation and robotics. Regarding novel robotic platform, WETA and Modular-E were upgraded with sensors, modelling and decision support tools to perform smart precision operations in the field, such as monitoring, precision spraying (considering Variable Rate Technologies), mowing and fertilisation, leading to a more sustainable, efficient and environmentally friendly production. Also, the incorporated safety systems allow a secure operation with humans' detection and avoidance. These prototypes were successfully demonstrated in operational environment. In the controlled environment agriculture, a greenhouse was built within DEMETER project, to which IoT solutions were incorporated to more long-term and depth tests on the developed technologies.

Innovation outcomes in 2023

INOV01. Mobile Robots Fleet Coordination: Development and implementation of a homogenous fleet coordination system (TRL 7). This system was developed to satisfy the needs of the TriHo and Produtech4S&C projects; the team created a coordination system capable of safely coordinating the movement and actions of multiple differential robots across several floors.

INOV02. Cloud-based Robotics: The innovation pathway of Cloud Robotics unfolds through three distinctive tracks of achieved innovation: (i) the establishment of a robust Continuous Integration (CI) and Continuous Deployment (CD) solution for robotics, empowered by cloud-based simulation, marking a significant milestone in ensuring continuous software validation and establishing a systematic CD infrastructure; (ii) the introduction of a web-based robotic toolkit, capitalizing on cloud-based simulation capabilities to enable developers to craft innovative robotic behaviours seamlessly, eliminating the necessity for direct hardware access through reliance on representative simulations; (iii) harnessing the scalability and computational power of the cloud to bolster robots in tackling computationally-intensive tasks, exemplified by AI methodologies for active perception and environment inference. Notably, a key achievement is a fruitful partnership established with Amazon Web Services (AWS) through the Open Clouds for Research Environment (OCRE) program, which has significantly contributed to the realisation of these initiatives, amplifying the centre's capacity for innovation and technological advancement in the realm of Cloud Robotics.

INOV3. Inspection, Control, and Embedded Systems: A prototype for quality control of aluminium alloy casting parts using computer vision, AI and robotics was created and installed at iiLab (TRL6).

INOV4. Agile Production using Robotics: The CRIIS mobile manipulator solution had its functionalities extended, based on the scientific advancements made regarding perception and grasping, being now able to perform the robust picking of multiple boxes of different shapes, colours, and dimensions, stored in pallets. This prototype is currently installed at iiLab (TRL 7) and will be demonstrated in a PT retail warehouse by the end of 2024. Furthermore, and as part of the PRODUTECH4S&C, a multi-purpose mobile manipulator was developed and demonstrated at the end user's facilities (TRL7). The solution can be used to (1) perform the geometrical inspection of machined parts while they are being transported between workstations and (2) support human operators during the assembly of complex structures in collaborative workstations. Regarding robot teleoperation, a solution to remotely control mobile robots over the 5G public communications network, including transmitting commands and video over this network, was also developed. This solution is now undergoing improvements to allow the remote control to be performed from a VR environment.

INOV5. Robotics and IoT for Agriculture and Forestry: The main innovation activities were related with the successful demonstration in operational environment (TRL 7) of WETA robot, within the conclusion of SCORPION project; development of the concept of Modular-E platform with the implementation of a new mowing and fertilisation tool; development of safety solutions for the agricultural robots; development and upgrade of IoT solutions such as long-term test of SMART TRAP, development of Smart Scissors (with a patent application), test of PhotonSense prototype, etc. All the robotic and IoT solutions were validated in several field tests and demonstrated in public events, from which the Synergy Day 2023 is highlighted.

Activity Overview

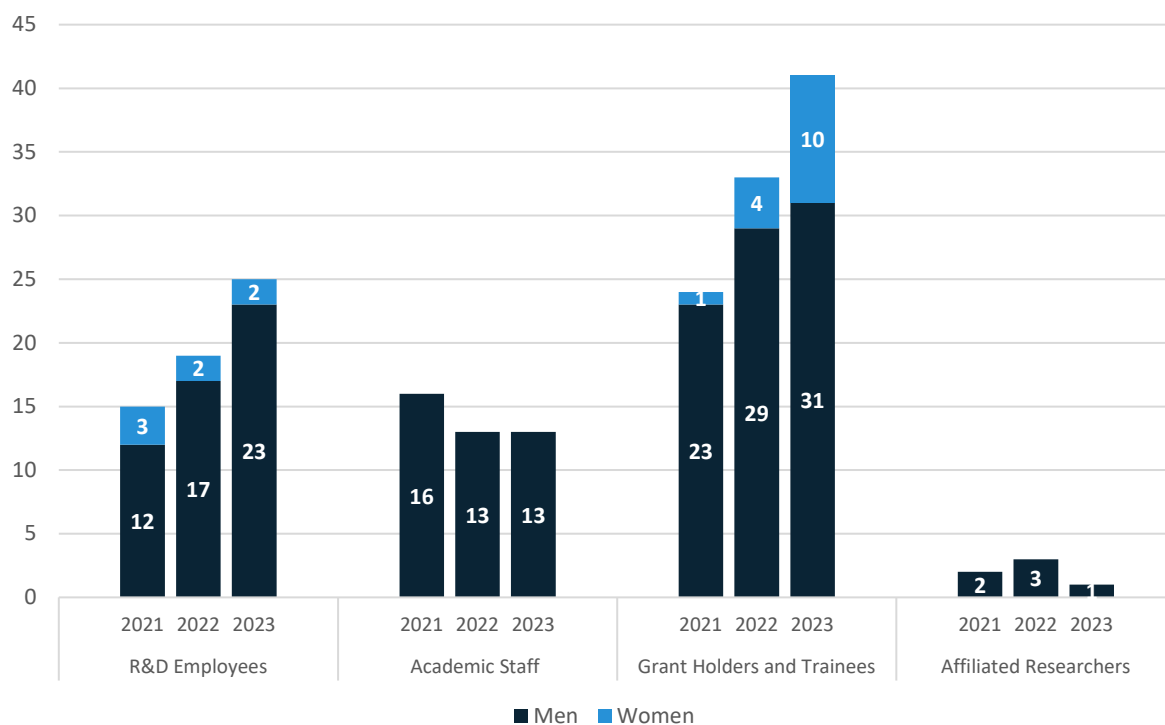


Figure 6.19 - CRIIS - Research team evolution

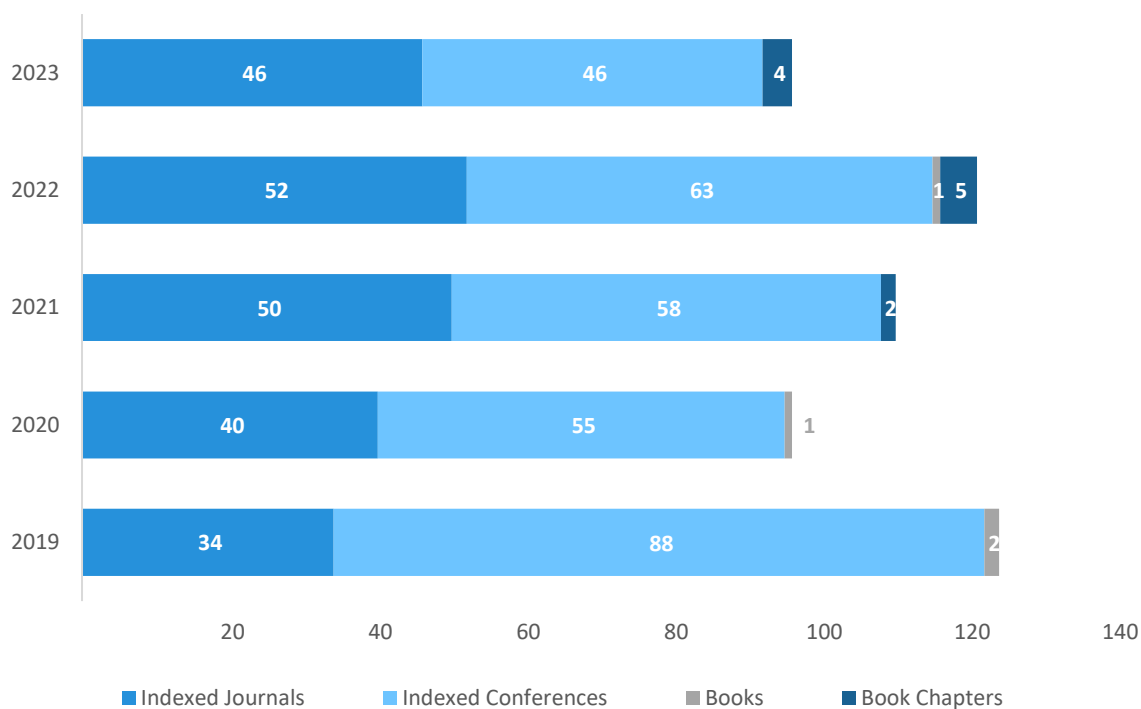


Figure 6.20 - CRIIS - Evolution of publications by members of the Centre

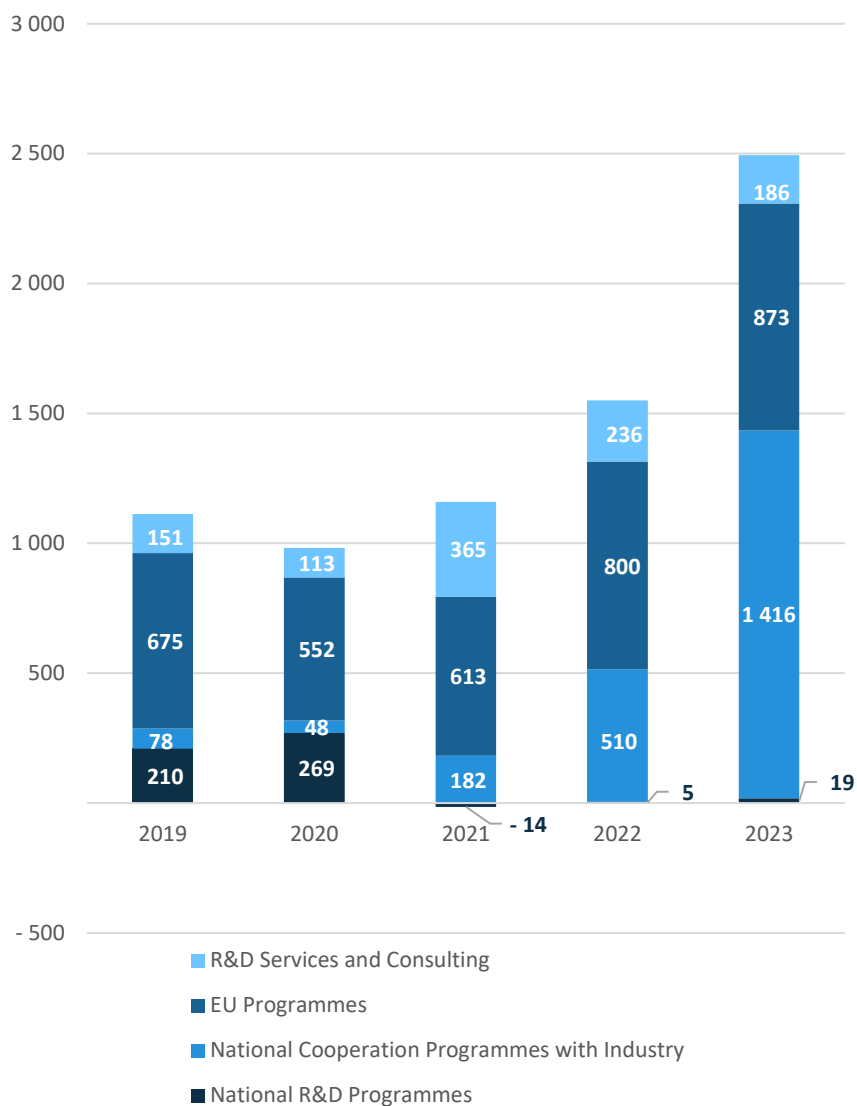


Figure 6.21 - CRIIS - Project funding evolution (k€)

6.8 CEGI – CENTRE FOR INDUSTRIAL ENGINEERING AND MANAGEMENT

Coordinator: Lia Patrício

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 are crucial.

Research outcomes in 2023

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-centered 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 2023, CEGI completed several national projects and made significant advances in ongoing projects, particularly the ones funded by FCT and PRR. CEGI published 61 articles in highly ranked journals.

Operations Research & Operations Management

In the area of production and operations management had major developments in 2023, comprising multiple projects. Intralogistics is an interdisciplinary field that focuses on optimising and automating internal logistics processes to improve efficiency and productivity. CEGI worked in 2023 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 **Produtech R3** (*Mobilising Agenda of the Production Technologies Sector for Reindustrialisation*). This project involves 2 Post-Doc and 1 PhD.

The exploratory FCT-funded project **MOSH** - *Modelling shared mobility: advanced demand modelling and learning for the sustainable shared mobility of the future* had major advancements, with the development and administration of a survey examining the factors of choice of mode of transportation. This project involves 1 ongoing PhD.

During 2023, the project **BeFresh** had significant developments. This project focuses on grocery retailing, developing policies for perishable products. In 2023, this project had, as on-going related work, 2 MSc, 1 PhD dissertations, and 1 Post Doc. In this area of retailing and through international collaborations, two key articles were also published in highly reputable journals.

EU-SCORES demonstrates the combination of offshore wind with wave and offshore solar PV energy, paving the way for bankable multi-source offshore parks. In 2023, CEGI made significant advancements in the development of a model to determine the optimal combination of renewable sources, their sizes, device types, and system locations. This project involves one Post-Doc and 1 PhD project.

Business Analytics

TRUST-AI has progressed in multiple fronts in 2023. The machine learning algorithms were fully developed, pushing the state of the art in genetic programming, and resulting in publications at top conferences in the field. Also, the counterfactual module had made important progress, being close to completion. Finally, the TRUST-AI platform was evolved into a second version, where it is possible to run additional analysis (including counterfactuals and what-if), and customisations for each use case have begun. A paper on the platform was submitted to an international journal, while several papers on the use cases are in progress.

The EU project **PEER** had its kick-off meeting in October 2023. INESC TEC became responsible for organizing the first consortium meeting in September 2024. In this initial phase, the project consortium has been defining the requirements of each Use Case (e.g., customer shopping basket history). Regarding this use case, the first steps are being performed to solve a first challenge consisting on locating products inside the retail store using picking

coordinates of physical customers. INESC TEC has already published a paper on solving the sequential decision-making problem associated with the retail use case.

Service Science

In the EU-funded smart city project POCITYF, which implements and tests Positive Energy Districts in eight historical cities, after conducting several cocreation workshops with citizens and stakeholders of the different cities, CEGI developed a new approach to develop strategies for citizen engagement with sustainable energy transitions, which has been implemented in eight European cities. This project involves 2 ongoing PhDs, and a new article was accepted in the Energy Policy journal.

CEGI has contributed to the FIRE-RES project with the design of a risk communication plan for leisure activities that aims to mitigate the ignition of rural fires originating from these activities, following a "mental models" approach. In 2023, the reference mental model was constructed based on literature and interviews with experts, and further interviews and field work with rural areas were conducted. The project involves one PhD, and the work was published in the International Journal of Wildland Fires.

Key publications

- Figueira, G., van Jaarsveld, W., Amorim, P., Fransoo, J.C. 2023 The Impact of Committing to Customer Orders in Online Retail, *Manufacturing and Service Operations Management*, 2023, 25(1), pp. 307–322
- Neves Moreira, F., Amorim, P., 2023. Learning efficient in-store picking strategies to reduce customer encounters in omnichannel retail, *International Journal of Production Economics*, 268, 10907
- Souza, M.E.B., Pacheco, A.P., Teixeira, J.G. 2023 Systematising experts' understanding of traditional burning in Portugal: a mental model approach, *International Journal of Wildland Fire*, 2023, 32(11), pp. 1558–1575
- Ali, S., Ramos, A.G., Carravilla, M.A., Oliveira, J.F. 2023 Heuristics for online three-dimensional packing problems and algorithm selection framework for semi-online with full look-ahead, *Applied Soft Computing*, 2024, 151, 111168

Innovation outcomes in 2023

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 2023. 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). Also, 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 project **Best Order 3** was concluded in 2023. 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.

Activity Overview

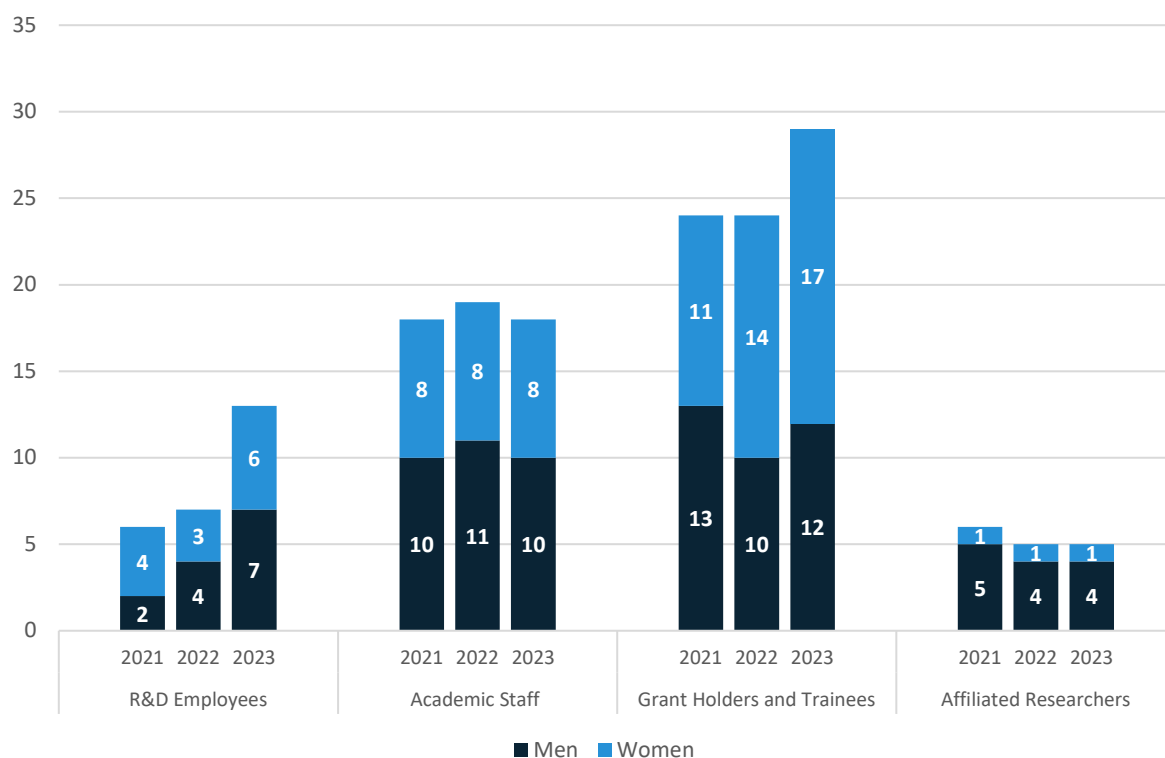


Figure 6.22 - CEGI - Research team evolution

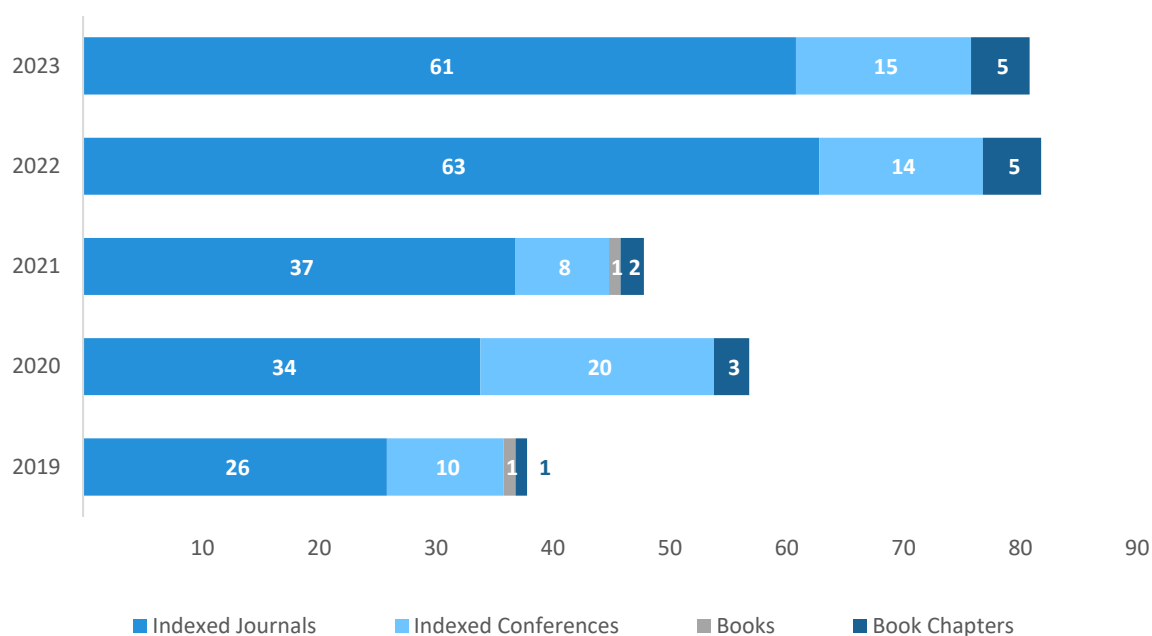


Figure 6.23 - CEGI - Evolution of publications by members of the Centre

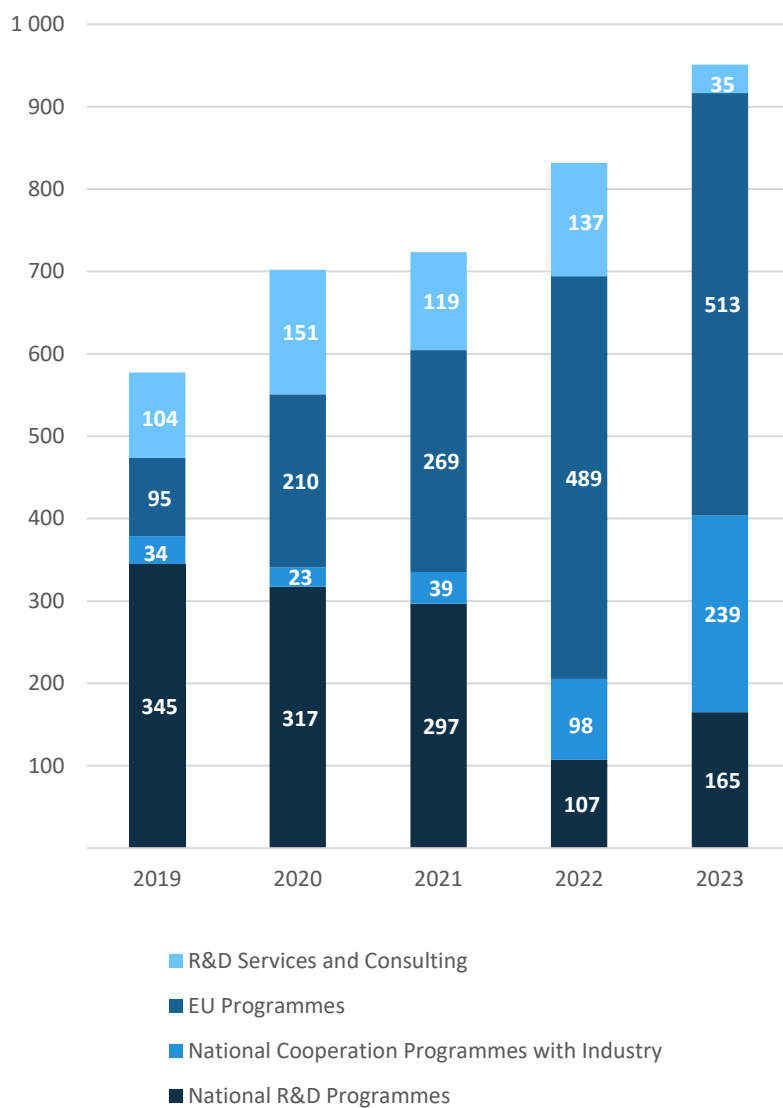


Figure 6.24 - CEGI - Project funding evolution (k€)

6.9 CITE – CENTRE FOR INNOVATION, TECHNOLOGY AND ENTREPRENEURSHIP

Coordinator: Alexandra Lobo Xavier

Presentation of the Centre

The purpose of CITE is to catalyse innovation for a Sustainable Future. By empowering individuals and organisations to innovate responsibly, we aim to build a future where economic prosperity is harmonised with social and environmental challenges. We aim to advance theories, methodologies, and models that underpin sustainable innovation, with specific emphasis on the following Research Lines (RL):

- **Innovation Management and Front End of Innovation (RL1):** Exploring strategies and frameworks to drive innovation from conception to implementation, ensuring sustainability is integrated throughout the process.
- **Technology Management and Policy (RL2):** Examining the intersection of technology, policy, and sustainability to foster responsible technological development.
- **Technology Entrepreneurship:** Spotlighting entrepreneurship as a catalyst for sustainable innovation, particularly emphasizing in: **(RL3) Business model innovation and (RL4) Co-creation Methodologies for Customer-Centric Innovation.**

During 2023, CITE participated in several R&D European projects and PRR projects, contributing significantly to advancing research and innovation initiatives. CITE's research activities have been strategically focused on several key areas aimed at maximising impact and fostering innovation: (i) developing methodologies and tools to support the efficient exploitation of key results from European projects. (FIRE-RES, AI4REALNET, Every1, Insectera); (ii) supporting the implementation of impactful open innovation campaigns (FIRE-RES, Sotecin Factory); (iii) driven research into novel business models aimed at facilitating the exploitation and valorisation of emerging technologies (NEXUS, Insectera).

CITE strengthens research and development (R&D) efforts by incorporating advanced models and tools into consulting services (EEN) and executive training programs (Turing II).

CITE promotes an entrepreneurial mindset through the Laboratory for Technological Entrepreneurship of INESC TEC (LET-In), offering accelerator programs, training, and mentorship for technology-based entrepreneurial projects.

Research outcomes in 2023

From R&D activities, CITE highlights the following outcomes:

- **Challenge Design Framework Workshop and Tools|RL4:** The framework was used in 11 global workshops, leading to the co-creation of 17 key challenges that shape the Open Innovation Campaign (OIC- FIRE-RES).
- **Open Call workbook|RL4:** The workbook, used in OIC-FIRE-RES, has been very successful. It attracted 80 applicants from Europe addressing challenges in extreme fire management events.
- **Responsible Research and Innovation Assessment Tool|RL1:** The tool is poised to enhance the accountability and ethical considerations of R&D activities, contributing to more responsible innovation practices (FIRE-RES).
- **Strategic Stakeholders Map Methodology|RL1, RL4:** The methodology addresses the critical aspect of effective stakeholder engagement in exploitation activities. This framework lays the groundwork for comprehensive stakeholder involvement, ensuring alignment and buy-in throughout the innovation process (NEXUS, AI4REALNET).
- **Collaborations:** CITE maintains an active participation in National and International Technical Committees for Innovation Management, (CT169) and (ISO TC 279) by participating as a national expert **(RL1)**. CITE is also present in the Food-Waste National Task Force **(RL1,2,3)**.

These achievements underscore CITE's commitment to driving impactful research, as well as its dedication to fostering collaboration, knowledge exchange, and responsible practices within the research community. Moving

forward, CITE remains steadfast in its pursuit of the advancement of scientific knowledge in the domain of Technology and Innovation Management.

Innovation outcomes in 2023

From innovation activities, CITE highlights the following outcomes:

- **LET-In:** During 2023, CITE coordinates two international accelerator programs – EIT Jumpstarter 2023 and EIT Ukraine. Under these 2 programs, CITE provides expert training and mentorship to 20 early-stage entrepreneurial projects.
- In collaboration with SAL, CITE developing an Internal Entrepreneurship Program aimed to support the entrepreneurial initiatives and spin-offs of INESC TEC researchers. The program is scheduled to launch in 2024.
- **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. The journal is indexed in SCOPUS since January 2021. Since the first issue, 279 articles were published.
- **EEN Portugal and Consulting Activities:** CITE assisted 25 unique SMEs in their innovation journey.
- **Ecosystem development and collaboration:** CITE actively engages with industry, academia, government agencies, and other stakeholders to build a vibrant innovation ecosystem. During 2023, CITE was active in three thematic groups from EEN: (i) Automotive, Transport and Mobility, (ii) Women Entrepreneurship, and (iii) Proximity and Social Economy. Additionally, CITE participated in the launch of the European campaign of EuOSHA in Portugal, focusing on "Healthy Workplaces in the Digital Age."
- **Executive Training and Capacity Building programs:** By participating in Turing II project, CITE deliver a capacity-building, upskilling blending learning program that can be taken by participants to develop their company-specific transition pathway. For this program, CITE created two learning paths available on SkillMOVE, the EIT Manufacturing's e-learning platform. They cover the topics of "Developing a Sustainable Value Proposition in Industry 5.0" and "Responsible Innovation for Sustainable Manufacturing."

Activity Overview

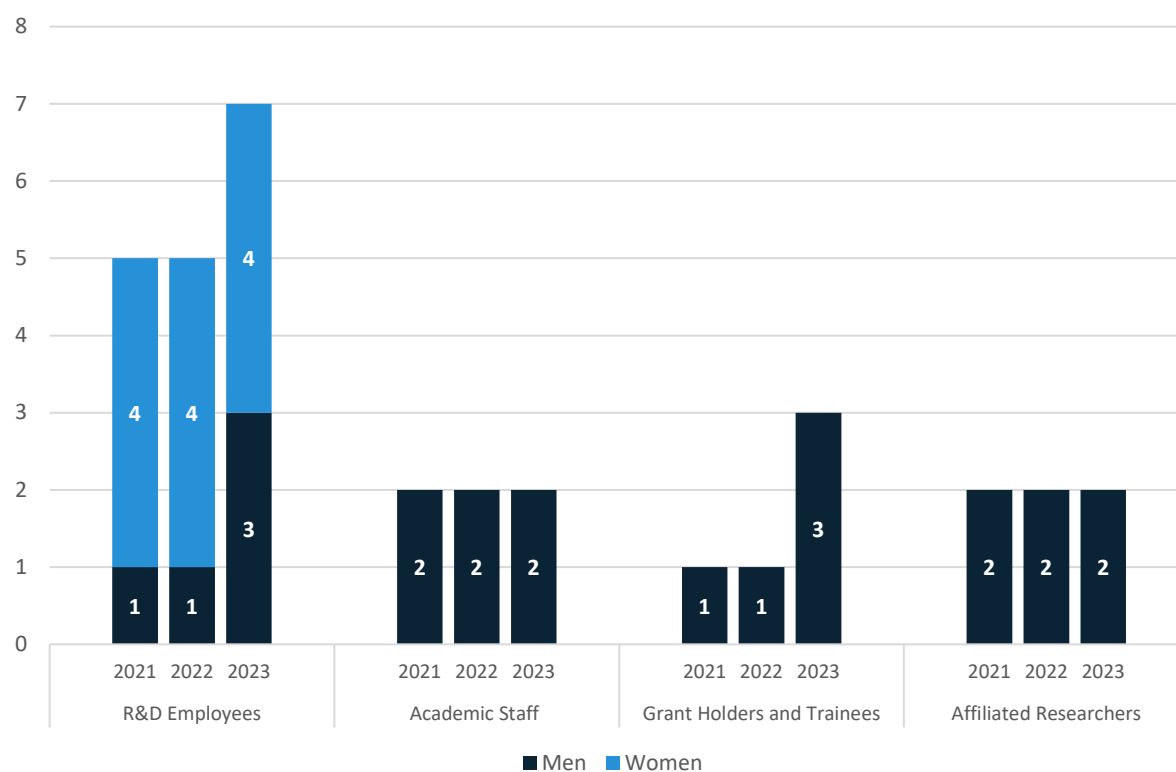


Figure 6.26 - CITE - Research team evolution

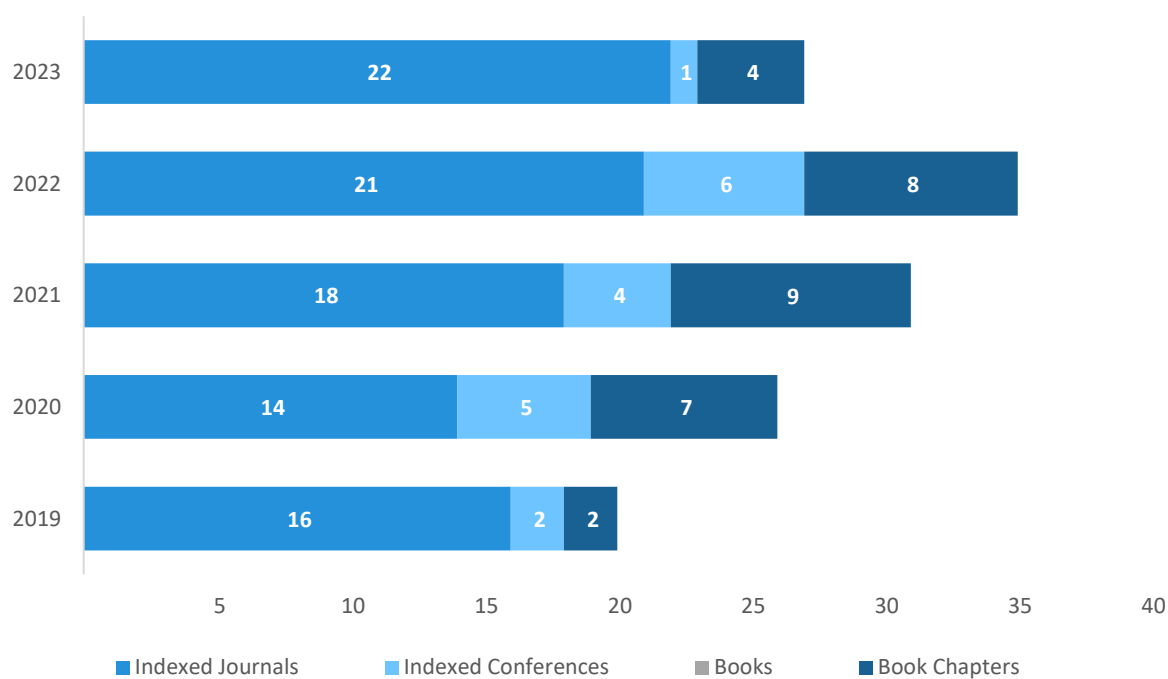


Figure 6.25 - CITE - Evolution of publications by members of the Centre

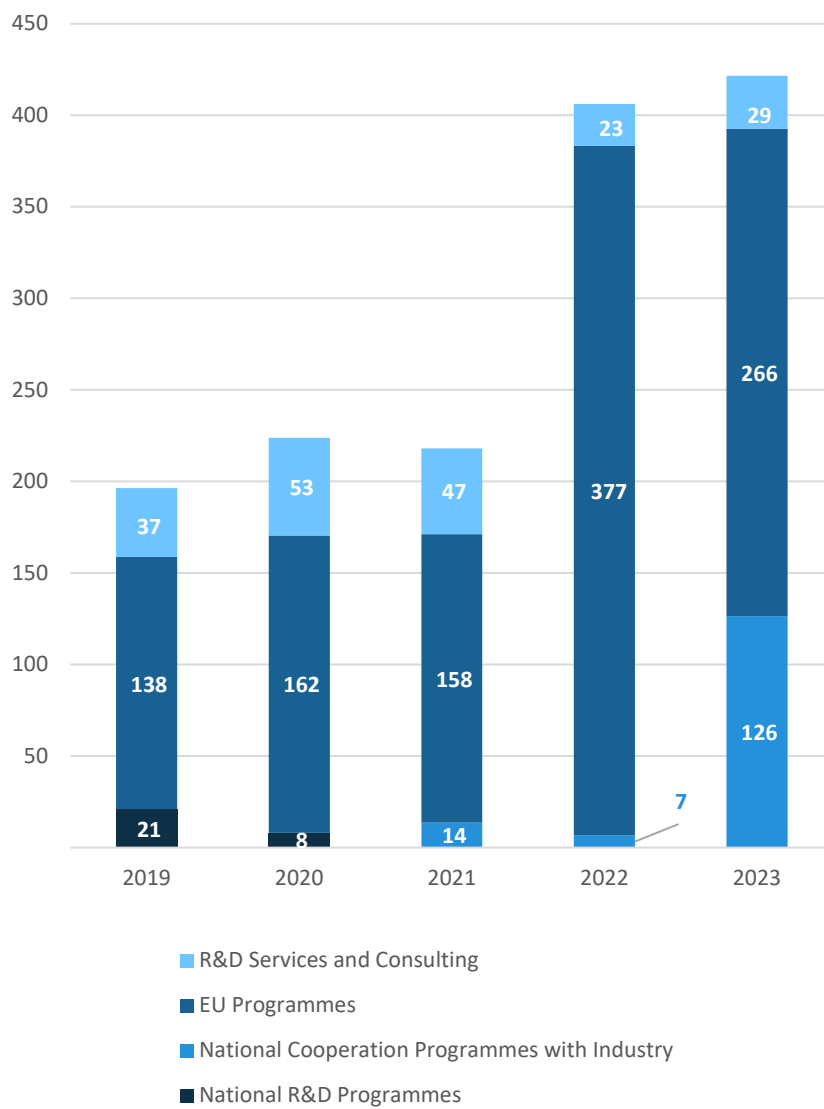


Figure 6.27 - CITE - Project funding evolution (k€)

6.10 HUMANISE – HUMAN-CENTRED COMPUTING AND INFORMATION SCIENCE

Coordinators: Ademar Aguiar and Artur Rocha

Presentation of the Centre

In 2023, the centre continued refocusing their activities at the forefront of human-centred computing (HCC), computer science (CS) and information science (IS), continuing to research and develop methods and tools for different kinds of software systems (e.g., applications, web platforms, information systems, digital games, embedded software, etc.) to leverage human abilities and practices within their communities and environments. In close cooperation with prestigious academic and industrial partners, we pursued high-quality research, innovation, consultancy, and technology transfer. We focus on six main research areas and four innovation areas.

During 2023, we perceived that the centre gained more traction and attracted new senior and young researchers. Furthermore, we continued our strong commitment to training young researchers and professionals, namely on 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).

Research outcomes in 2023

Information Management and Information Systems (IMIS). In 2023, our work expanded across various projects and collaborations within information systems, research data management, data infrastructures, and information visualisation and interaction. We have maintained active involvement in narrative extraction, visualisation, and exploration through participation in the concluded LIAAD Text2Story FCT project and the newly initiated LIAAD StorySense FCT project. Our focus on health information systems continued, demonstrated through the participation in the RECONNECTED EU project focusing on mental health literacy and social participation, as well as the Health from Portugal PRR project emphasizing data integration and AI-driven decision support. We continued as active participants in the EUGAIN COST project, tackling the topic of gender balance in informatics, and directly as a member of the management committee and a working group responsible for publishing the booklet "From Ph.D. to Professor". We maintained an active contribution to multiple H2020 projects related to the development of data infrastructures, data management, and supporting systems, notably EUCAN-CONNECT (cohort data), EPOSSP (plate observation), and ILIAD (ocean digital twin). Furthermore, our continued participation in organizing and serving on program committees for prominent conferences and workshops such as SIGIR, ECIR, TPD, and CHIIR (also in the steering committee) further underscores our commitment to advancing research in the field.

Computing for Embedded and Cyber-Physical Systems (C4E&CPS). The main activity in 2023 of the area was the gradual integration of research activities in INESC TEC. In particular, special focus was given to the Chips JU work plan addressing RISC-V processors in embedded systems and to the Portuguese strategy in the area of microelectronics and semiconductors. C4E&CPS researchers were also involved in several international initiatives, such as the HiPEAC CPS segment, or the CERCIRAS COST Action, as well as participation in the steering and program committees of conferences and workshops such as AEIC, ETFA, WFCSS, ISORC, DeCPS.

Human-Computer Interaction (HCI). Considered as an umbrella research area, in 2023, the main activities were focused on sharing knowledge on UX and User-centric design methodologies, techniques and principles. Specifically: in the A-MoVeR - mobilizing agenda, user-based interfaces are being planned. The H2020/PAFSE project has reached the last year of development; where 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. Moreover, HCI group worked on several research activities and projects, leading to multiple publications. These researchers were involved in the steering, organisation and scientific committees of HCI international conferences: HCI2023, ICITL 2023, ICEEL 2023.

Software Engineering (ES). Software engineering contributions are spread among several research topics and projects. In the Inno4Vac (IMI2/EU), the key contributions focused on the agile software development process, and the design and implementation of novel architectures using federated repositories, and privacy-preserving mechanisms to support federated machine learning. The researchers of the area were involved in the organisation of a few international conferences, namely the 28th European Conference on Pattern Languages of Programs (EuroPloP 2023), the 34th IEEE International Conference on Application-specific Systems,

Architectures and Processors (ASAP 2023), the Workshop on Challenges and New Approaches for Dependable and Cyber-Physical System Engineering (DeCPS 2023).

Special Purpose Computing Systems/Embedded Systems (LASPeCS). During 2023 we started work on two approved projects, which are now well under way. With them we were able to advance our knowledge regarding state-of-the-art technology related to compilation frameworks, in particular MLIR, and work towards a flow that maps trained machine learning models down to specialized hardware, including CGRAs and custom RISC-V instructions.

The team continued researching several topics, including implementing a Rust-like borrow checker for C, in order to provide similar memory-safety guarantees, studied techniques, using source-to-source compilation to study a mutation testing in Java using the schemata approach, which intends to reduce resources and time necessary for this testing technique, and explored the potential of using metadata in neural networks for UAV maritime surveillance.

Computer Graphics and Interactive Digital Media (CGDM). The group is focused on fundamental research in multisensory VR and 3D multimodal interaction for immersive environments, including shape-changing haptic devices, DeskVR interaction, and Immersive visualisation. As well as applied research, in training programs with industry for providing 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 has developed a set of games modules for digital literacy, based on the specifications developed in workshops of co-creation. The group has also continued the contract with EIT Manufacturing to conclude the recommendation platform for training in immersive environments.

Innovation outcomes in 2023

Geospatial Information Systems Engineering. Application of AI techniques, particularly Machine Learning, to identify and count automatically 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 anticipate quickly the occurrence of crop pests and diseases (INOLIVE P2020 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.

Earth, Ocean, and Space Science (EOSS). Some results of H2020 MELOA resulted in a Software ecosystem (Wavy Operations Bundle) that is protected by Invention Disclosures. In the EEA Grants WAVY-NOS this software ecosystem has been further tested and capacitated with new methods and tools for handling echosounder, hydrophone and camera data streams. H2020 ILIAD evolved the reference architecture to enable on-demand interoperable processing requests to the underlying models of the Digital Twin of the Ocean. It also defined new methods and tools to provide context and narrative to heterogeneous ocean data to facilitate the user's immersive exploration of data, behaviours and patterns. The FCT/MIT EESDataLab project evolved in the automatic representation and quantification of change on spatiotemporal phenomena through ML-based Point Set Registration techniques. Work with DITTO - Digital Twins of The Ocean, a program endorsed by the UN Decade of Ocean Science for Sustainable Development (2021-2030) and TURTLE, a project under the DITTO Programme, aims at establishing consensus on a meta-pattern for digital twins interoperability. The group is participating in a IEEE (PAR) Project Authorisation Request for the definition of a Working Group that covers the development processes for new Digital Twins (DTs) of the Earth. 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.

Personalised Health Research (PHR). EUCAN-Connect (federated FAIR platform enabling large-scale analysis of high-value cohort data connecting Europe and Canada in personalised health) was concluded in 2023. CORAL, a container-based distribution of its software ecosystem, was an outcome. RECONNECTED was started – a HEU project aiming to understand how global developments affect mental health and to develop digital tools to help vulnerable groups. It uses Moodbuster 2.0 (MB2), an online intervention framework, as the basis for its tools. Invention Disclosures have been registered for MB2. PHASE IV AI was also started, a HEU project that aims to improve data privacy and access for AI developers in Health. Inno4Vac/VAXPRED proceeded with the development of an in-silico platform to accelerate mRNA vaccine development, with the participation of

industrial partners (GSK, Sclavo, Sanofi). Finally, Health from Portugal, a project framed in the Recuperation and Resilience Plan, was also started.

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) 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.

Activity Overview

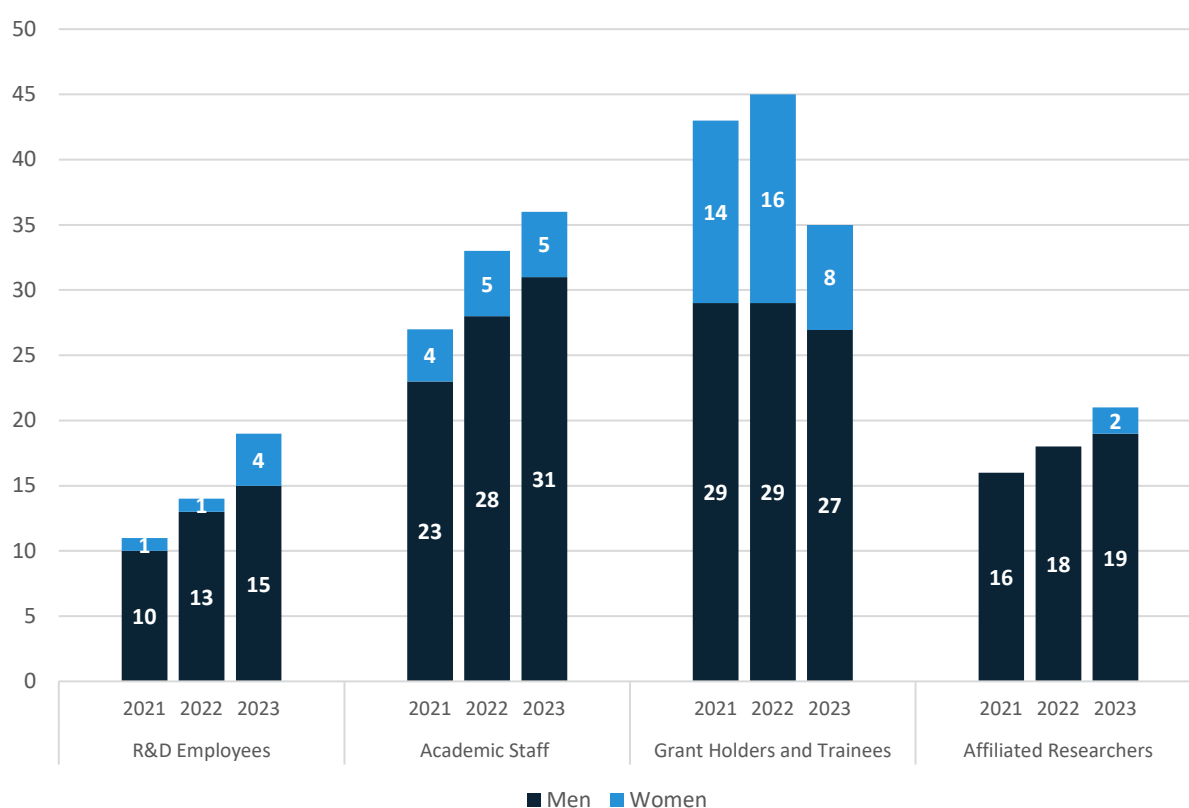


Figure 6.28 - HumanISE - Research team evolution

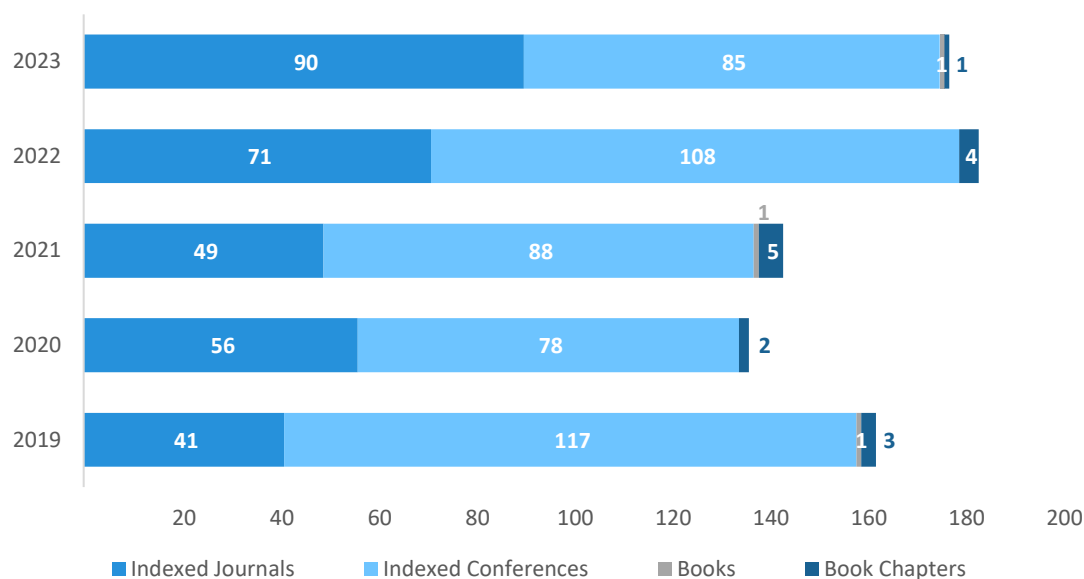


Figure 6.29 - HumanISE - Evolution of publications by members of the Centre

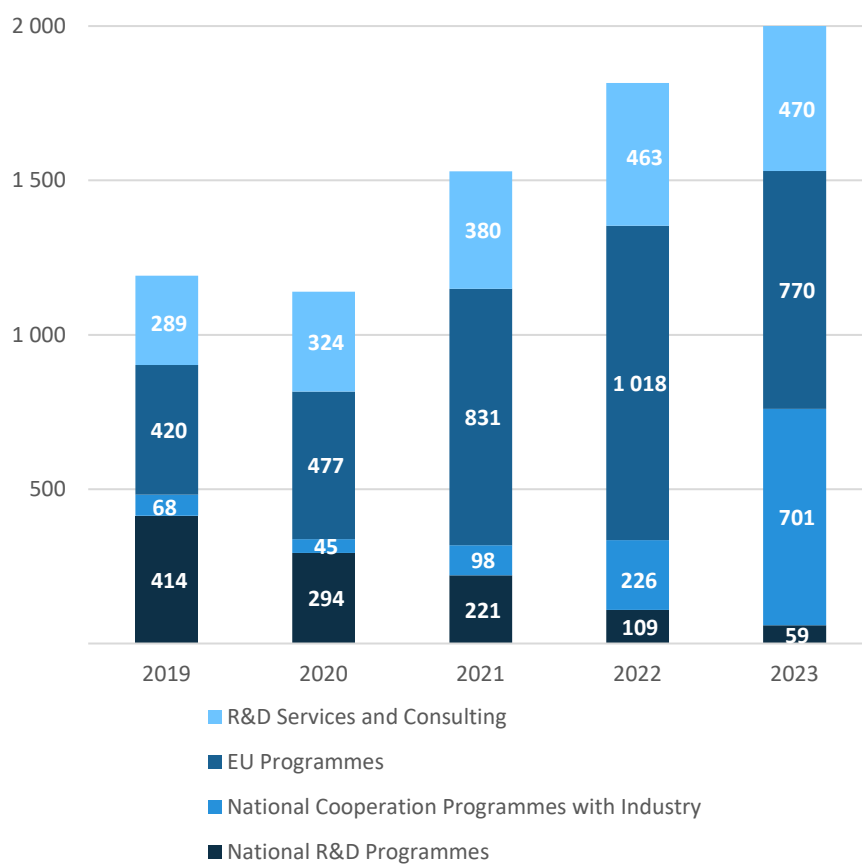


Figure 6.30 - HumanISE - Project funding evolution (k€)

6.11 LIAAD – ARTIFICIAL INTELLIGENCE AND DECISION SUPPORT LABORATORY

Coordinator: Alípio Jorge

Assistant to the Centre Coordination: Ricardo Sousa

Presentation of the Centre

LIAAD accomplishes its mission in Computer Science and Mathematics, focusing on Intelligent and Adaptive Systems and Mathematical Modelling in Decision Support.

LIAAD produces 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 Machine Learning and Data Science since 1991, later including Optimisation and Mathematical Modelling. The huge amounts of collected 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 modelling. Currently, the growing 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, data diversification and existing resources to invest in research lines that will help shorten the gap between collected data and useful data, offering diverse modelling 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 2023 LIAAD had a total of 126 members (including external students and collaborations), with 64 core researchers and 31 grant holders and trainees. 23 of the researchers were Academic staff mostly from the University of Porto, but also from P. Porto, U. B. Interior, I. P. Viana do Castelo and I. P. Leiria.

Research outcomes in 2023

The most active area of research is Machine Learning (ML), which includes the lines of **Large Scale ML**, **Auto ML** and **User Modelling and Natural Language Processing**. These lines accounted for 27 of the 47 journal papers published. **Modelling and Optimisation** counts with 7 papers.

In the European **Network of Excellence on Artificial Intelligence**, which started in 2020, LIAAD has continued its involvement in micro and macro projects. The HE project EMERITUS, where AI is used for fighting environmental crime, started. Gonçalo Duarte Nunes was awarded Best Master Dissertation by the Portuguese Pattern Recognition Association.

The research on Narrative Extraction brings together a team of researchers on **Natural Language Processing** with several publications and ongoing projects. We organized Text2Story2023, a workshop with 50 participants. In **User Modelling**, we lead the organisation of the ORSUM workshop at RecSys (Online Recommender Systems and User Modelling). Ricardo Campos was Best Demo Paper runner-up at CIKM 2023. Filipe Cunha won Best Student Paper at EPIA 2023.

In **Large Scale ML** LIAAD organized Discovery Science 2023, new editions of the Data Streams track at ACM SAC 2023, the IoT Stream for Predictive Maintenance workshop at ECMLPKDD 2023, the SoGood workshop (data mining for **social good**), also at ECML/PKDD, the KDBI - Knowledge Discovery and Business Intelligence stream at EPIA 2023.

Innovation outcomes in 2023

- We were involved with companies and public administration in a number of application and knowledge projects, namely XPM, SIGIPRO, OnlineAIOps, Transformers, *Promessa*, CityAnaliser, Produtech, ContinentalFoF, SadCopQ and AgWearCare, PAPVI2, PAFML and CareView.
- Yake! Keyword extractor software has been used by a considerable number of companies worldwide.
- 3rd place of the SWORDhealth competition on the use of LLMs in health.

Activity Overview

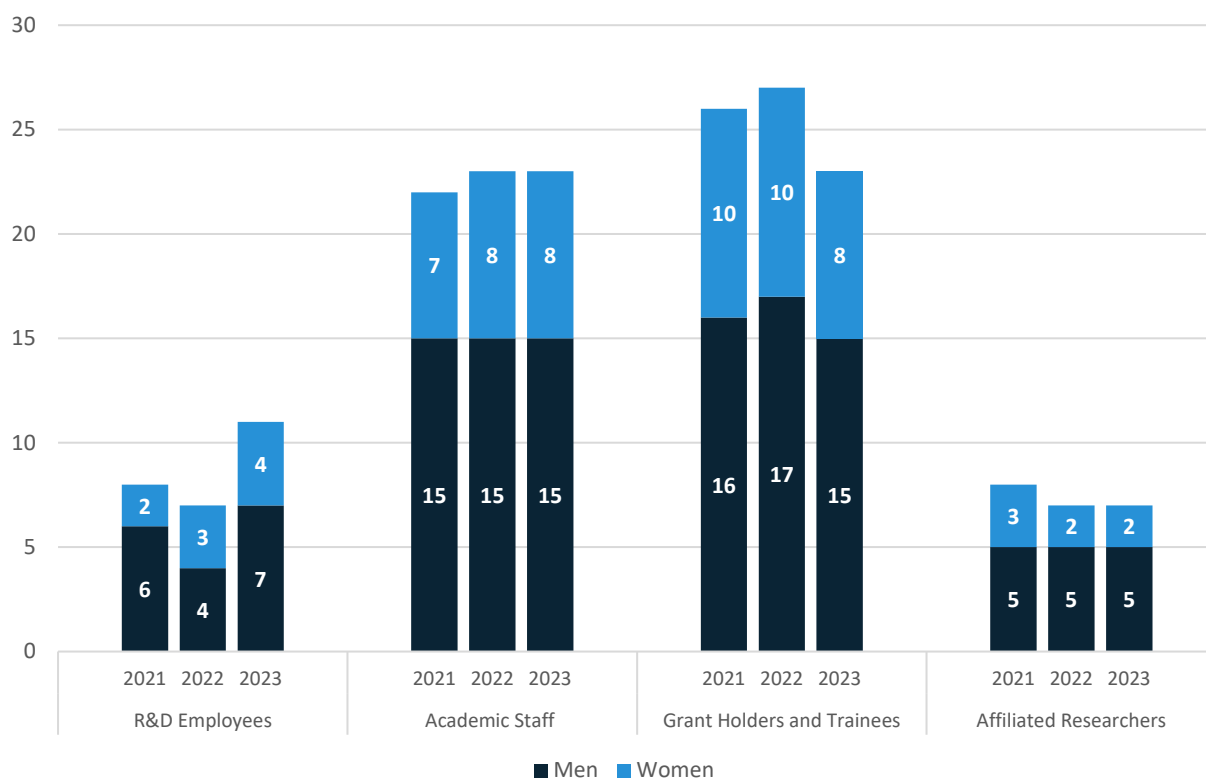


Figure 6.31 - LIAAD - Research team evolution

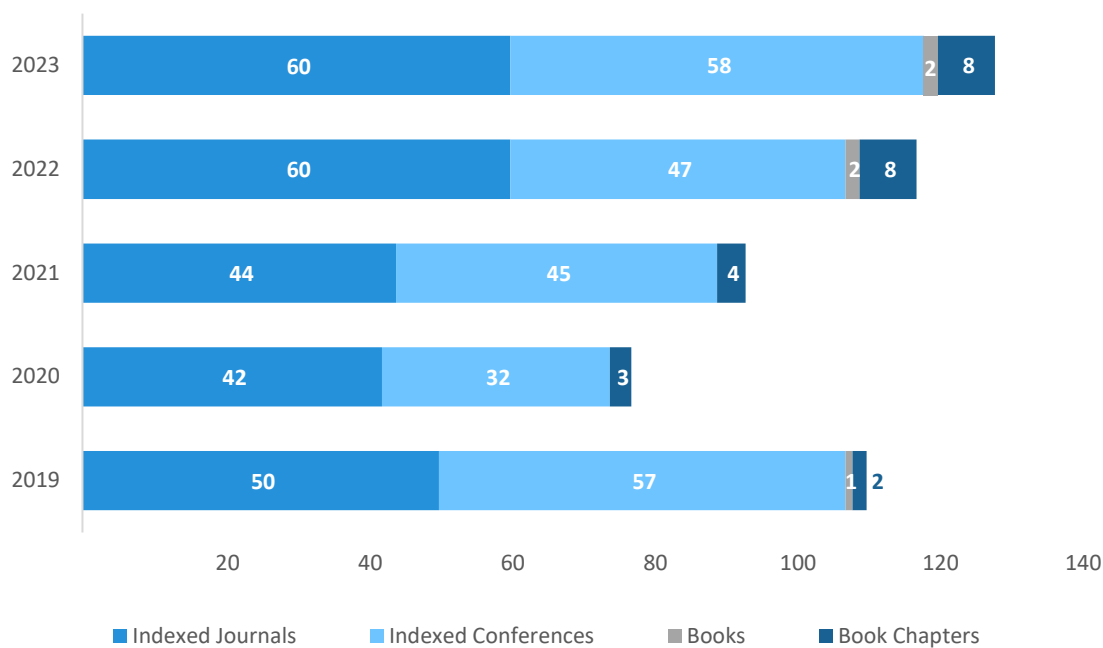


Figure 6.32 - LIAAD - Evolution of publications by members of the Centre

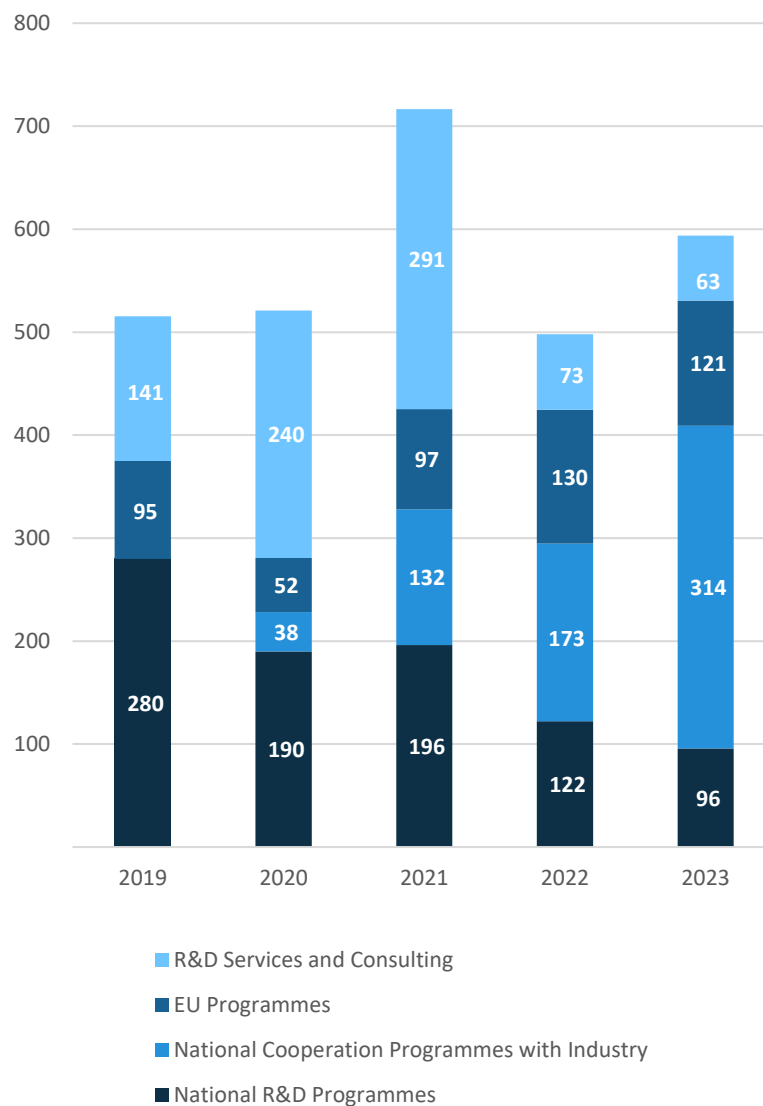


Figure 6.33 - LIAAD - Project funding evolution (k€)

6.12 CRACS – CENTRE FOR RESEARCH IN ADVANCED COMPUTING SYSTEMS

Coordinator: Ricardo Rocha

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 2023 (the same as in 2022). The research environment is enriched with talented junior researchers (grant holders, trainees and employees) for a total of 32 core researchers that together build the necessary critical mass and scientific competences to fulfil our mission.

Research outcomes in 2023

A key goal for 2023 was to maintain CRACS's international visibility, notoriety and publication output, after the improvement observed in the previous years. In fact, we achieved similar outputs for the number of participations as editor or associated editor in international journals, from 18 and 11 in 2021 and 2022, respectively, to 10 participations in 2023; for the number of international events organised by CRACS members, from 6 and 11 in 2021 and 2022, respectively, to 15 events in 2023; and for the number of participations in program committees of international events, from 41 and 42 in 2021 and 2022, respectively, to 34 events in 2023. Regarding the total number of publications in indexed journals, conferences and books, there was an expected decrease from the 68 and 58 publications reached in 2021 and 2022 to 42 publications in 2023 (this number may increase with later updates). In terms of project funding, we would like to emphasise the successful ending of project Theia, a P2020 project with Bosch Braga, and the start of project PRIVATEER, a Horizon Europe - Joint Undertaking project. In what follows, we enumerate in more detail CRACS's main research outcomes in 2023.

- Lock-freedom: (i) starting from a lock-free general purpose memory allocator, named LRMalloc, we extend it to support the Optimistic Access memory reclamation method in such a way that we can guarantee memory allocations to be readable and reused by other parts of the same process or the operating system, even after we free such allocations; (ii) replaced the original atom table implementation in the YAP Prolog system with a lock-free hash-based data structure, in order to provide efficient and scalable symbol management.
- Distributed systems: (i) development of a platform for fault injection in closed-loop distributed systems; (ii) development of a modular platform for Byzantine consensus algorithms.
- Quantitative type-systems for languages with effects: we show that recent approaches to static analysis based on quantitative typing systems for the functional paradigm, can be extended to deal with effects and explore these features in a calculus with global state. More precisely, we define a call-by-value language equipped with operations to access a global memory, together with a semantic model based on a (tight) multi-type system that captures exact measures of time and space related to evaluation of programs. We show that the type of system is quantitatively sound and complete with respect to the operational semantics of the language.
- Graph mining: (i) a novel time-aware node embedding approach and a general-purpose feature extraction framework for temporal graphs; (ii) applications of structural flow motifs in spatio-temporal datasets; (iii) consolidated the research on mapping methods for multivariate time series analysis using multilayer visibility graphs (or networks) and proposed a new set of topological features to better characterize multilayer networks.
- Time series analysis: the concept of multilayer horizontal visibility graphs based on a novel notion of cross-horizontal visibility between lagged timestamps of different time series components. This allows to describe of cross-dimension dependencies via inter-layer edges, leveraging the entire structure of multilayer networks. To this end, a novel parameter-free topological measure is proposed and common measures are extended for the multilayer setting. Our approach is general and applicable to any kind of multivariate time series data, in particular in mining tasks.

- Generative adversarial networks (GANs): (i) usage of GANs towards the generation of rich and realistic datasets with malicious activities; (ii) enhance the analysis of GANs for the generation of synthetic tabular samples aiming to balance the training datasets for our fake news detection classifiers and extended to include other renowned datasets, serving as a foundation for comparing outcomes and as a measure of robustness.
- Automated assessment: creation of a dataset of source-code submitted to introductory programming assessment.
- Semantic graphs: (i) an approach to extract narratives from large semantic graphs; (ii) summarisation of massive semantic graphs using identifiers; (iii) assessment of simple web applications.
- Learning environments: (i) integration of e-learning systems using international specifications ensuring seamless communication between different platforms and enhancing accessibility and user experience across disparate learning environments; (ii) collecting data via xAPI and store it in learning resource stores to generate visual insights for informed decision-making and enhanced learning experiences; (iii) leveraging OpenAI's API for exercise generation enabling the creation of different and tailored exercises to foster learning experiences with efficiency.
- Machine learning: continuation of the work on machine learning models in the following domains: (i) glycaemic detection; (ii) automatic species identification in Biology; (iii) automatic determination of stellar parameters from spectral datasets in astrophysics (collaboration with CAUP); (iv) indoor location using Bluetooth RSSI measurements and video data (datasets under preparation); (v) technique for efficient ML parameter selection using Visibility Graphs.
- Anomaly detection: research on the use of Benford's law applied to anomaly detection, in two distinct subjects: fake images and network packets flows.
- Trust, privacy and security: (i) methods for automated privacy protection of user location data, that can be tuned for general use, by using city or country-wide data, or for specific user profiles, thus warranting fine-grained tuning for users or environments; (ii) in the context of project PRIVATEER, we are starting to tackle the limitation of the reverse index, a known single point of failure of searchable encryption techniques. Current candidate solutions are under evaluation and range from cloning the index to using distributed hash tables of P2P networks. This task also has the goal of supporting more dynamic CTI sharing contexts.

Innovation outcomes in 2023

In what follows, we enumerate CRACS's main innovation outcomes in 2023.

- Edge-computing and edge-clouds: further development of the JAY framework for offloading tasks in hybrid topology clouds, publication of results (Software: Practice and Experience), and open-source release of the software (<https://github.com/jgmme/jay>).
- Automated assessment: an environment for authoring programming courses for the Agni JavaScript playground (<https://www.npmjs.com/package/webpal>).
- Semantic graphs: a system with a gamification-based approach for the generation of benchmarks for semantic measures (<https://stars.andrefs.com>).
- Learning tools interoperability for gamified programming education: evolution of the framework for application of gamification to programming education with the support for standard integration with learning management systems, enrichment of the user mobile experience and extension of the gamified exercise base. The expected impact is the improvement in efficiency of programming education and its student-perceived experience (<https://fgpeplus.usz.edu.pl>).
- Social media App: development of a social media reliability detection App incorporating the latest insights from our research and offering additional visual indicators and graphics to help users comprehend the basis of its reliability assessments.

Activity Overview

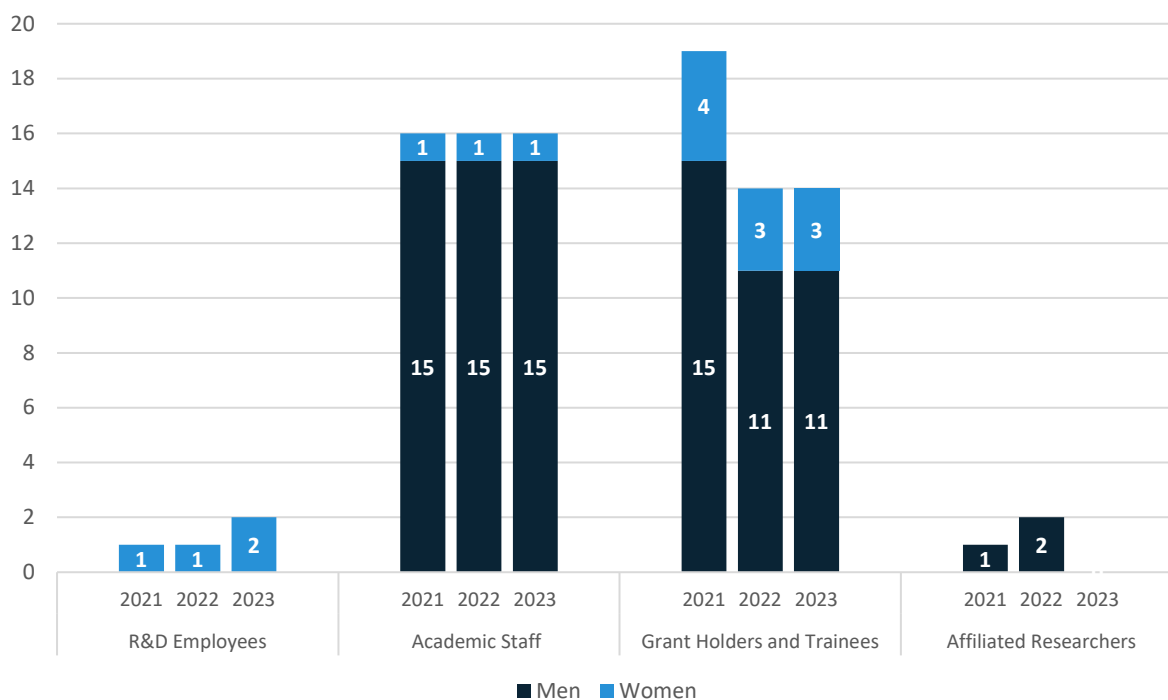


Figure 6.34 - CRACS - Research team evolution

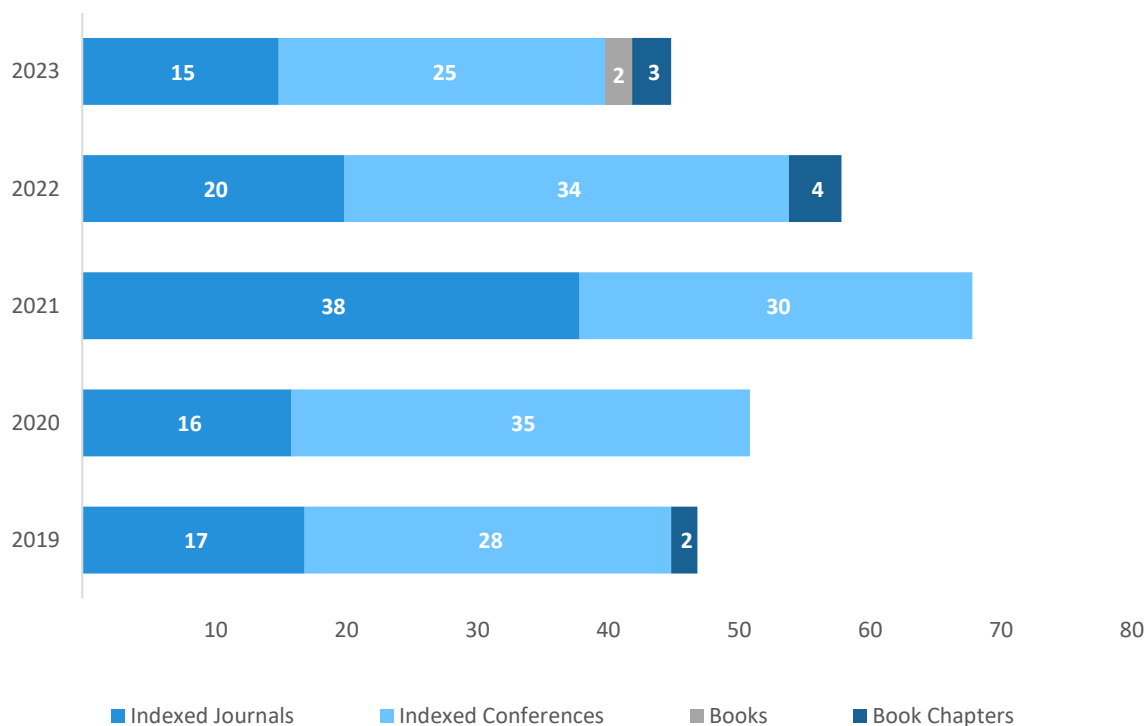


Figure 6.35 – CRACS - Evolution of publications by members of the Centre

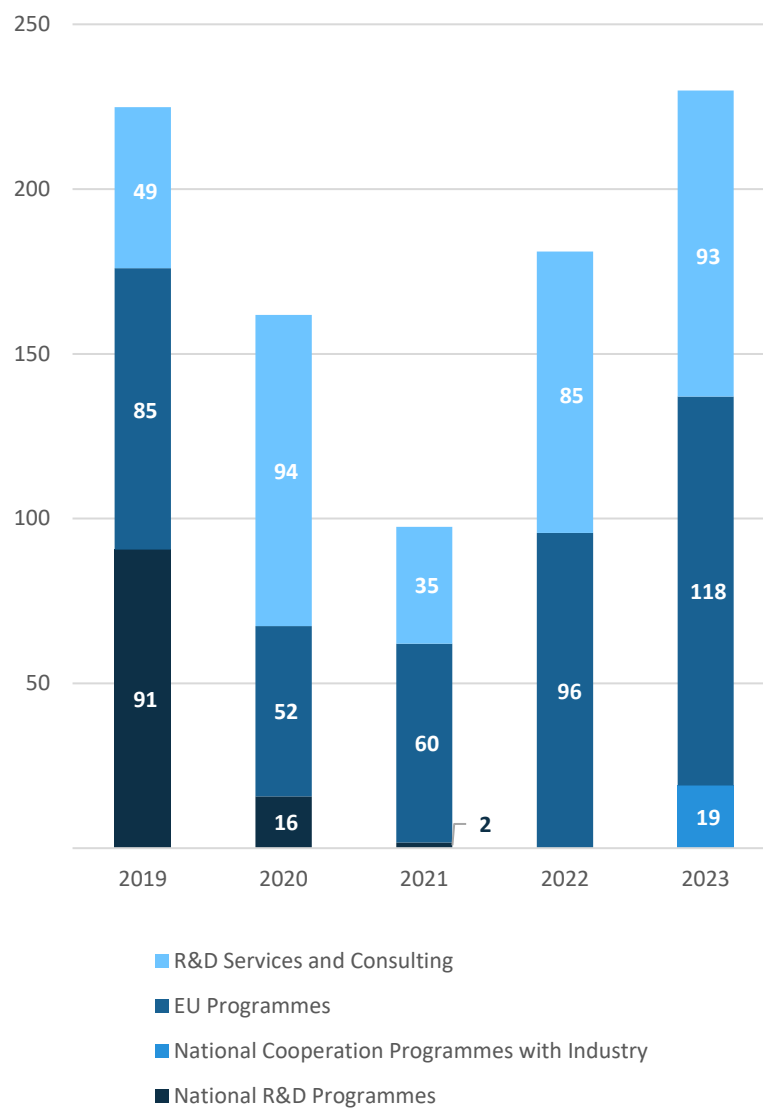


Figure 6.36 - CRACS - Project funding evolution (k€)

6.13 HASLAB – HIGH-ASSURANCE SOFTWARE LABORATORY

Coordinators: Alcino Cunha and António Luís Sousa

Assistant to the Centre Coordination: Catarina Leones Fernandes

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 — Software Engineering, Distributed Systems, and Information Security — complemented by other competences such as Human-Computer Interaction, Programming Languages, Quantum Computing or the Theory of Computation. In particular, HASLab's research focuses on three main competences:

- **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:** minimizing 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.

Research Outcomes in 2023

In 2023, HASLab continued to produce high-quality research together with renowned international partners, including academia and IT companies. In what concerns the research and scientific outputs, HASLab has increased the number of scientific publications, comparing with the last year. The team published 70 scientific publications, of which 47 were conference papers (including 3 CORE A* and 5 CORE A) and 23 journal articles (including 15 Q1 and 6 Q2). Among these publications, we highlight the following achievements:

- The software engineering group continued to achieve significant results in the field of quantum computing. In particular, in 2023, two articles were published in Q1 journals describing innovative results on the application of quantum computing in the implementation of a secure multi-party computation protocol and in reinforcement learning.
- The distributed systems group has achieved significant results in the area of transactional databases. In particular, they proposed an innovative technique to mitigate hot spots that may occur in operational environments with high throughput. In contrast to the state of the art, this technique can be applied in distributed and cloud systems and resulted in a publication at the ACM SIGMOD conference (and its respective journal). In collaboration with MonetDB B.V. and CWI, they also proposed an innovative technique for implementing transactions in an OLAP system, achieving transactional server performance improvements of up to 500x for the MonetDB database server. This work led to a publication at the VLDB conference (and its respective journal). It's worth noting that these are the top conferences in the database field.
- This group also continued its long-standing research on Bloom filters, a probabilistic data structure for representing sets of elements, widely used in the fields of communications and distributed systems. More specifically, they provided evidence that a variant of this data structure called Partitioned Bloom filters has significant advantages when compared to the classic variant. These results were published in the IEEE Transactions on Computers journal, one of the most prestigious Q1 journals in the field of Computer Science.
- The information security group continued to make progress towards its long-term goal of developing cryptographic structures and protocols with formal correctness guarantees. In particular, they were involved in the development of the first formally verified implementation of Kyber, the key encapsulation mechanism that won the NIST competition for post-quantum cryptographic mechanisms.

This is indeed the first verified implementation of any post-quantum cryptographic mechanism, and this work resulted in a publication in the IACR Transactions on Cryptographic Hardware and Embedded Systems journal, one of the most prestigious Q1 journals in the cryptography field.

Concerning research projects, two FCT funded national projects successfully came to an end in 2023: **FLEXCOMM**, that aimed to reduce the energy impact of communication networks, and **SpecRep**, that aimed to develop techniques to ease the learning of formal specification languages.

Innovation outcomes in 2023

In terms of innovation, a main highlight of 2023 is the **Wattchr Energy App**, developed in the scope of the InterConnect project (in cooperation with CPES), which aims to develop and demonstrate advanced solutions for connecting and converging digital homes and buildings with the electricity sector. This app leverages Interconnect's Semantic Interoperability Framework to interlink several data sources needed to generate and distribute energy recommendations to consumers to mitigate possible grid resilience problems. The HASLab team was responsible for developing the application and the necessary data interoperability component. It is worth noting that two technology disclosures were registered, related to this mobile app.

Still related to the energy sector, HASLab also kicked-off two new innovation focused projects: **GreenDat.Ai** is an European project that aims to contribute to the sustainability of machine learning models, namely in term of the energy footprint, and **ATE** is a national project, the Alliance for Energy Transition project, which aims to design a multi-tenant platform based on cloud technologies that will serve as an integrator for services with data from various domains. Concerning the former, in 2023 HASLab already contributed with the specification and roll-out of a tool to benchmark the performance of ML models in terms of the energy, time or data usage footprint.

In the area of High-Performance Computing, a major highlight in 2023 was the conclusion of the installation of the **Deucalion** supercomputer, that involved several HASLab researchers. Deucalion is hosted at the University of Minho, on the Azurém Campus in Guimarães, and is now the most powerful supercomputer in Portugal. Also related to the HPC area, HASLab had the kick-off of the **EuroCC2** European project, a project that aims to identify and address the skills gap in HPC in the European ecosystem and to promote cooperation in this area across Europe, and the conclusion of the **RISC2** European project, which for three years aimed to build bridges in the research and training of HPC. Among the main results achieved by the latter project, involving a consortium composed of 16 partners — 12 from Latin America and 4 from Europe — we have the HPC Observatory and the White Paper on HPC R&I Collaboration Opportunities.

In terms of cooperation with industry, we highlight the kick-off of **ATTRACT**, a European project that aims to help companies embrace digital transformation at lower costs, with emphasis on AI and HPC solutions. Two consultancy projects were also successfully concluded in 2023, namely **THEIA**, a partnership between the University of Porto and Bosch that aimed to make autonomous vehicles safer through a better perception of the outside environment, and in which HASLab was responsible for the development and implementation of secure protocols for decentralized data storage and processing, and **STDCNCS** a consultancy for the *Centro Nacional de Cibersegurança do Gabinete Nacional de Segurança*, where HASLab produced a study aimed at characterising the cybersecurity competence community in Portugal.

Activity Overview

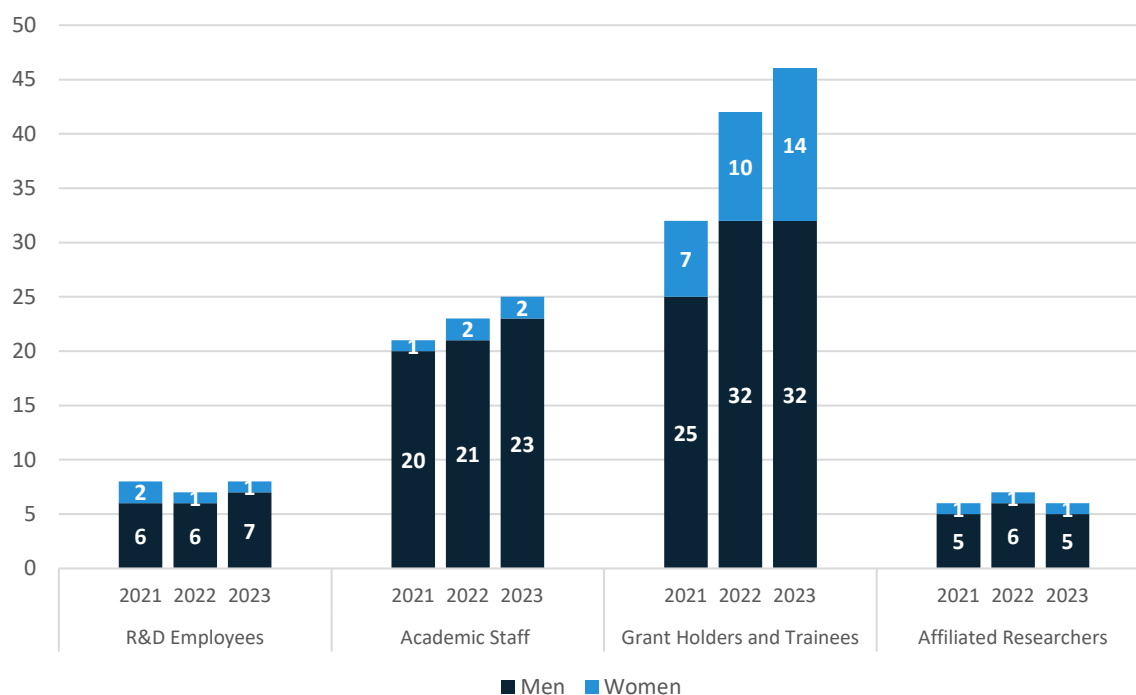


Figure 6.37 - HASLab - Research team evolution

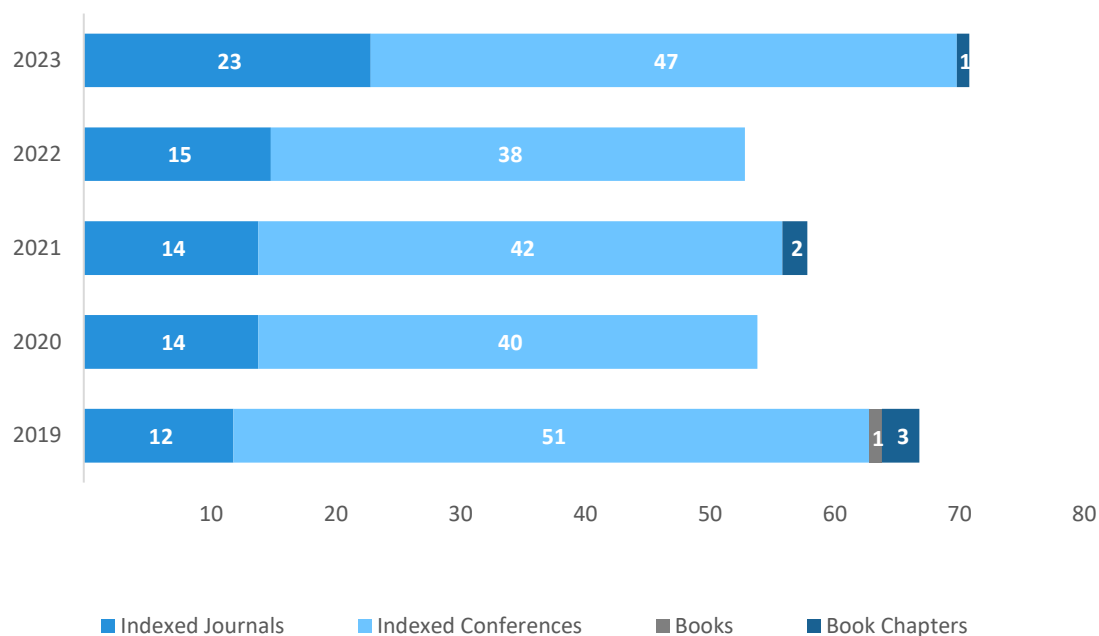


Figure 6.38 - HASLab - Evolution of publications by members of the Centre

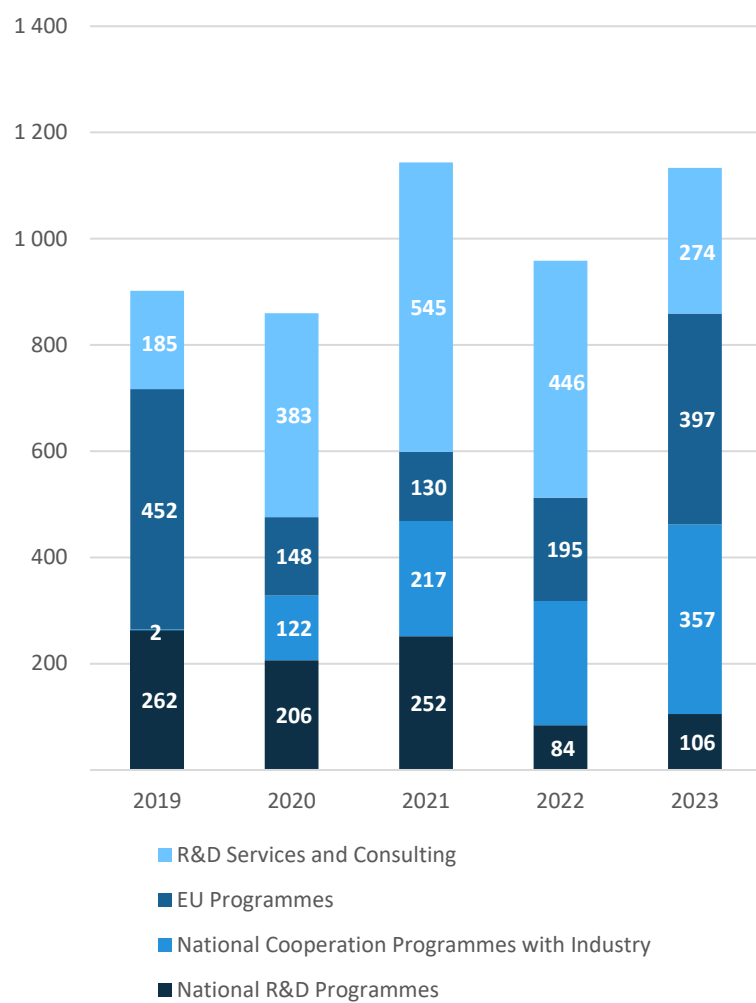


Figure 6.39 - HASLab - Project funding evolution (k€)

7 RESEARCH INFRASTRUCTURES

7.1 Technologies for the Sea (Tec4Sea)

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 had finished in the end of 2022 and was coordinated by Paulo Mónica as Principal Investigator. The implementation management team also had 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.

Main achievements in 2023

On March 17th, the Tec4Sea north facilities were inaugurated. The inauguration event included a formal presentation of the Tec4Sea infrastructure and visits to the Mar Profundo research vessel and the lab facilities at APDL.

In 2023, the research vessel Mar Profundo supported missions for several research projects (Atlantis, EU-SCORES, Nessie) and external entities, such as IPMA, to support the survey and data gathering of Vulnerable Marine Ecosystems required national reporting needs for the EU.

The research vessel Mar Profundo also supported the operation of robotic systems during the REP(MUS)23 naval exercise in September 2023. In that exercise, Mar Profundo was used to test and deploy several underwater systems (Turtle Lander and EVA AUVs) for 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.

It should also be mentioned that 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.

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

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 organized 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.

Main achievements in 2023

EMSO-PT finished its first implementation phase in 2023.

The main achievements of EMSO-PT during 2023 were:

- The operationalisation of the two new gliders.
- Improvements on the mobile EMSO-PT node. Several improvements to the Turtle 3 robotic lander have been made to increase the mobile EMSO-PT node's deployment times and add extra functionalities and robustness.

7.3 Robotics and Autonomous Systems Laboratory

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 operability and have been fundamental for the establishment of partnerships.

Main achievements in 2023

The main achievement of the Robotics and Autonomous Systems Laboratory in 2023 were the following:

- Reorganisation of the physical space at the FEUP campus, creating more space for PhD students
- Upgrade of robotic platforms taking advantage of ongoing projects:
 - Integration of a new horizontal propulsion system for the MARES AUV, with 4 thrusters, to increase efficiency and development of a variable buoyancy system to increase efficiency in vertical motion;
 - Integration of a new inspection camera and laser lines for scaling in the CRAB ROV;
 - Finalized and demonstrated a new ASV prototype for carrying a payload up to 200kg, mainly dedicated to pollution measurement and mitigation and another two ASV for harbour monitoring, mapping and characterisation of litter and waste in the harbour;
 - Upgrade of EVA AUV for 1000 m deep and high-resolution cameras and laser lines for sea bed mapping for Vulnerable Marine Ecosystems surveys;
 - Integration of an eDNA sampler in IRIS AUV adding new capabilities for environmental surveys.
- Development of a synchronised versatile underwater acoustic pinger, to transmit arbitrary coded signals for underwater positioning;
- Integration of a 2km long observatory in an underwater communications cable (SMART Cable), off the coast of Sesimbra;
- 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, help programming sensor drivers, and provide support to field operations.

7.4 Laboratory of Microfabrication

Mission and positioning

The Microfabrication laboratory explores non-traditional microfabrication techniques based on femtosecond laser direct writing processes. For example, microfluidics and optofluidics chips are produced to implement biosensors and micro and nanostructures. First order Bragg 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. Laser marking and surface treatment is also possible.

Main achievements in 2023

The Microfabrication laboratory explores non-traditional microfabrication techniques based on femtosecond laser direct writing processes. For example, microfluidics and optofluidics chips are produced to implement biosensors and micro and nanostructures. First order Bragg 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.

- Besides the fabrication of integrated optics or optofluidic devices, identify other areas of application where the installed micromachining capabilities can add value due to its unique characteristics;
- Micromachining and laser welding of glasses;
- Machining and waveguiding writing in Ultra Low Expansion (ULE) glasses;
- Exploration of glass poling techniques for the fabrication of active devices fabricated by femtosecond;
- 3D metallic electrode fabrication.
- Fabrication of microfluidic and optofluidic devices using FLICE techniques for sensing applications;
- Fabrication of Bragg and long period gratings (first and higher order structures).

The Bragg and long period gratings fabrication machine is currently undergoing a renovation in terms of positioning stages and beam conditioning. This major upgrade will permit to address fabrication in multicore fibres and use the cladding of standard fibres as a substrate.

The fabrication capabilities are complemented with equipment available at CEMUP – MNTEC. The cleanroom is a service providing laboratory managed by University of Porto that was supported since its creation by INESC TEC which made its micro/nanofabrication equipment available on this infrastructure for widespread use.

7.5 Smart Grids and Electric Vehicles Laboratory (SGEVL)

Mission and positioning

The Smart Grids and Electric Vehicle Laboratory (SGEVL) is a multifunctional and multipurpose electric and digital infrastructure that offers a distinctive integrated capacity to simulate, prototype and test solutions for the energy system of the future. 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, providing support and services to the scientific and industrial ecosystem.

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 encompassing: an efficient and transparent management of resources; a clear, well-defined and widely advertised policy defining the procedures to allow resident and visiting researchers to use the laboratory infrastructure; services to the scientific partners, educational entities, and business and industrial entities. The different projects, within INESC TEC activity, and services to business and industrial entities, guarantee the short and long-term financial support that ensures the operation of the laboratory its resources. The regular support to scientific and technical work (i.e., MSc. And PhD theses) guarantees the specialised and skilled human resources for ongoing and future research activities.

SGEVL has an advanced and fully configurable microgrid-based laboratorial framework, integrating commercial technologies and prototypes and systems developed by the researchers (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 led by Dr. Justino Rodrigues that is responsible for the management activities and the implementation of the research and innovation plan set by CPES.

Main achievements in 2023

The main achievements of the RI for the year 2023 were the following:

- Continued development of a laboratory scale validation facility including hydrogen producing electrolyzers (Horizon 2020 GREENH2ATLANTIC). A PEM electrolyser was commissioned, and its delivery is expected to 2024;
- Improvement of the hybrid AC+DC microgrid, previously initiated as part of an energy supply solution for a novel telescope infrastructure (Portugal 2020 SmartGlow). The hardware structure of the electronic power converter prototypes, as well as high power DC power sources, were already purchased. Two new 1000V DC cable emulators were purchased and should be delivered in 2024. The development of the hybrid AC+DC microgrid is expected to continue through 2024, aiming its completion by the end of that year;
- Expansion of the EV charging and V2G testbed with new EV chargers (prototypes and commercial) and new charging locations, to implement and validate new control strategies composed by EV chargers deployed in the field (H2020 POCITYF, H2020 GreenDataAI);
- Continued development of a grid automation and protections testbed, considering digital protection units, initiated under P2020 SCALE project, and to be continued in the Alliance for Energy Transition project in the scope of Recovery and Resiliency Plan (PRR). The existing HIL/PHIL platform will be updated by the replacement of the existing OP5600 real-time digital simulator will be updated with the newer OP5707XG model;
- Implementation of interoperable solutions for EV charging, smart appliance, and energy management, using the microgrid testbed (Horizon 2020 InterConnect);
- Reinforcement of the SGEVL microgrid, though the installation and successful testing of two additional hybrid PV inverters with storage.

7.6 Neuro-Engineering Lab – BRAIN Lab

Mission and positioning

The Neuro-Engineering laboratory, a.k.a. BRAIN (Biomedical Research And INnovation) has a strong focus on researching new biomedical engineering methods for neurosciences & neurological diseases (e.g., Parkinson's, Alzheimer's, Autism or Epilepsy) and we are divided in 5 main research lines: 1) Brain imaging (&signals); 2) Man-machine symbiosis with edge-AI (e.g. Brain-Computer Interfaces); 3)Multimodal Computer Vision Analysis for neurological diseases; 4) Neurosurgery Aiding Systems; and 5)Macro-to-nano bio-neuro-sensing.

BRAIN Lab also operates the Stim-BRAIN Lab which is an advanced Brain Imaging infrastructure (that offers scientific services to third-parties, apart for our own research project) with an f-MRI simulator (mock scanner) fully equipped with synchronised 64ch video-Electroencephalogram(EEG) medical systems from Micromed, wearable EEG devices, video cameras, MRI compatible pads and audio system to simulate f-MRI experiences and prepare stimulation protocols to be deployed in MRI scanners at the CHUSJ or any other clinical centre. This infrastructure is used for fMRI and Video-EEG-fMRI paradigms development and testing for neuroscience projects with our clinical partners.

Main achievements in 2023

Organiser of the main Bioengineering Portuguese Meeting 2023

Our lab was the main host and organiser of the 7th IEEE Portuguese Meeting in Bioengineering 2023 (ENBENG 23), held at the Serralves Foundation, Porto, on June 22 and 23, 2023. We also served as the Editors of the respective proceedings of this conference indexed on IEEE Xplore.

New video-EEG system

Our lab received and installed a new 64 channels video-EEG machine that is integrated with our BRAIN Stimulation room with the MRI simulator and the neurocognitive paradigm design tools for video-EEG-fMRI scenarios. This new system is a very important upgrade to the previous infrastructure and is also offered to the neuroscience community of the Porto region.

7.7 iiLAB - Industry and Innovation Lab

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 showroom.
- 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.

Main achievements in 2023

In 2023, in addition to concluding the new iiLab (PORTIC) facilities and equipping them (first half of the year), several actions have been carried out, in conjunction with various Centres, in order to:

- i) organise an efficient and attractive innovative laboratory for showroom and collaboration with private and public companies interested in testing, demonstrating, validating, and/or to implementing industry 4.0 enabling technologies (such as robotics, automation, digital twin, industrial internet-of-things, among other technologies);
- ii) Design and develop innovative and advanced training courses and educational programs, mainly oriented for companies and industrial clusters;
- iii) The implementation and deployment of a dedicated 5G infrastructure, coupled with Network Operating System (NOS), positions iiLab as a trailblazing laboratory for testing and validating 5G-ready digital solutions. This initiative, conducted in collaboration with national technology companies, particularly small and medium-sized enterprises (SMEs), not only solidifies iiLab's pioneering role but also facilitates the exploration and realization of the extensive benefits associated with 5G technology.

The internal inauguration of the new iiLab premises took place on 27 October and was targeted to INESC TEC staff and governing bodies.

On 28 November, a special inauguration session was provided to members of the CRIIS and CESE centres, the main users of iiLab.

iiLab's management bodies began to function, namely the Executive Committee, which now meets every fortnight, and the Advisory Board, which met for the first time on 28 November.

7.8 TRIBE LAB - Laboratory of Robotics and IoT for Smart Precision Agriculture and Forestry

Mission and positioning

The (TRIBE LAB) laboratory of Robotics and Internet-of-Things (IoT) for Smart Precision Agriculture and Forestry was conceptualised in 2013 with a clear mission: to pioneer robotics, automation, and IoT-based solutions. Our aim is to revolutionise smart precision agriculture and forestry, ensuring that operations are conducted at the "right time, right tool/product, right amount, right place" for optimal outcomes.

We focus on enhancing profitability, sustainability, and automation across three primary environments: Permanent Crops, Forest biomass harvesting, and Protected Cultivation (Greenhouses and Controlled Environment Agriculture). Our research, development, and technology deployment activities are guided by a comprehensive ten-year roadmap (2020-2030), meticulously aligned with European agendas, FAO's agricultural priorities, and the TEC4AGRO-FOOD Innovation Area agenda. By addressing societal challenges and leveraging cutting-edge innovation, we strive to be at the forefront of transforming the agricultural landscape for a sustainable future. TRIBE LAB has a multi-disciplinary team and operates with dynamic flexibility, focused on research and developing cutting-edge physical prototypes. We have the capability to quickly create prototypes on demand, ready to address emerging societal challenges.

Research Team: Filipe Neves Santos (PhD), Tatiana Pinho (PhD), António Paulo Moreira (Prof. PhD), Mário Cunha (Prof. PhD), José Boaventura (Prof. PhD), António Valente (Prof. PhD), Manuel Silva (Prof. PhD), Héber Sobreira (PhD), André Aguiar (PhD), Luís Santos (PhD), Pedro Moura (MSc), Sandro Magalhães (PhD candidate), Daniel Silva (PhD candidate), Vítor Tinoco (PhD candidate), Francisco Terra (MSc), Ricardo Neves (MSc), Humberto Rocha (MSc), Isabel Pinheiro (PhD candidate), Miguel Marques (PhD candidate), José Sarmiento (PhD candidate), Mafalda Pereira (PhD candidate), Renan Tosin (PhD candidate), André Baltazar (PhD candidate), Domingos Bento (MSc), Francisco Oliveira (PhD candidate), Germano Moreira (PhD candidate), Igor Portis (PhD candidate), Leandro Rodrigues (PhD candidate), Rui Coutinho (PhD candidate).

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

Main achievements in 2023

In 2023, INESC TEC got the recognition from The Mixing Bowl and Better Food Ventures as a key player in the "2022 Crop Robotics landscape," solidifying our position among the most influential players globally. TRIBE LAB successfully organised the first edition of the "Synergy Day: Robotics and IoT for Vineyards," by joining six European projects to showcase over 10 prototypes of IoT and robots developed in-house. The event drew a high number of registrations, surpassing the available capacity, underscoring the lab's impactful contributions and the relevance of its work. With TRIBE LAB, it was possible to consolidate and further research and develop 28 software and hardware prototypes, to achieve higher TRLs (average TRL 6). Among them are WETA and Modular-E, two robots built from scratch to simplify the process of technology transfer and meet end-users' needs. Making possible to reach successful public technology demonstrations and tangible results for H2020 and HE projects (such as SCORPION, NOVATERRA, DEMETER, AgRoboFood (DIH) and WATSON), P2020 (such as SPIN, SMARTCUT, SMARTDRYING, INCAFO, RePLANT, InOlive, Wine4cast) and PRR projects (Agenda transForm, Vine&Wine, InsectERA, Blockchain.PT). Our laboratory has also made notable contributions to the academic community with 22 scientific publications in international and indexed peer review journals, 5 master's theses, and 14 PhD works. We have garnered more than 40 references in mass media and technical magazines, and made oral presentations in conferences such as EPIA 2023 and ROBOT2023. It is worth highlighting the promotion of science from the earliest stages of education through participation in actions such as the Ciência Viva 2023 summer internships. We have also participated in several relevant national and international events for the area either with demonstration of prototypes developed in our laboratory, or with oral presentations or active participation (such as World FIRA 2023, European Robotics Forum 2023, embedded world, AgroIN, EU CAP Network workshop Innovative arable crop protection - using pesticides sustainably, Photonics Partnership Annual, myEUspace competition, Innovation and Technological Modernization in the Portuguese Army). Aligned with the projects, our prototypes were presented in 5 public demonstration sessions.

Overall, we are proud of our achievements in 2023 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

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 360° 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.

Main achievements in 2023

- 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
- Co-creation framework for game-design.
- And the following supervisions were concluded:
 - 2 doctoral theses
 - 20 master theses

7.10 CLOUDinha Laboratory

Mission and positioning

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

The cluster is composed of different generations of hardware namely, Haswell, Kaby Lake, Comet Lake, Coffee Lake and Raptor Lake. It is currently composed of 106 micro-ATX machines based on commodity hardware with Intel Core i3, i5, and i9 CPUs, 8GB, 16 GB, and 64GB of memory, and heterogeneous storage hardware including HDDs, SSDs, and NVMe devices. The machines are connected through either a 1 Gb or 10 Gb network.

In addition to these, the cluster has 4 rack servers based on Intel Xeon hardware, with 32, 64GB, 192GB of memory, and heterogeneous storage hardware including SSDs, NVMe, and persistent memory devices. They are connected through either a 1 Gb or 10 Gb network, while some of them also have programmable network capabilities (DPDK).

The heterogeneous 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).

Main achievements in 2023

In 2023, 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
- Bioinformatics

These software prototypes were developed under the scope of HASLab's research and innovation projects, as well as PhD and MSc theses. In particular, 7 ongoing PhD theses and 13 completed MSc theses used the CLOUDinha Laboratory as computational infrastructure for the research work. Moreover, 22 of these works exclusively used commodity hardware resources, 3 of them conducted their experiments on the enterprise-grade rack servers, and the remainder resorted to both resource types. All of these works resulted in thousands of hours of computation.

The main outcomes of these works resulted in 3 journal publications, 6 conference papers, 2 workshop papers, 5 communications, and 16 open-source software prototypes. The research quality and scientific rigor of the work assessed by the CLOUDinha Laboratory can be demonstrated with the following publications: "Privacy-Preserving Machine Learning on Apache Spark" and "Toward a Practical and Timely Diagnosis of Application's I/O Behaviour", published at IEEE ACCESS journal; "CRIBA: A Tool for Comprehensive Analysis of Cryptographic Ransomware's I/O Behavior", presented at the 42nd International Symposium on Reliable Distributed Systems (SRDS'23); and "Towards MRAM Byte-Addressable Persistent Memory in Edge Database Systems", presented at the Joint Workshops at 49th International Conference on Very Large Data Bases (VLDBW'23).

7.11 Communications Laboratory

Mission and positioning

The Communications Laboratory (ComLab) was established in 2006 at INESC TEC's main building, following a successful proposal to FCT under the National Program for Scientific Hardware Renewal. The ComLab, originally named "Optical Communications and Microwave Laboratory", has been constantly evolving over the years. In 2021, benefiting from funding from the National Roadmap for Scientific Infrastructures from FCT, the laboratory underwent a refurbishment, which significantly improved the comfort for researchers (in terms of illumination and air quality) as well as the conditions for carrying out experiments such as water supply, improved communications network infrastructure and uninterrupted power supply.

ComLab is composed of optical and electronic test equipment for R&D in electronics, optical and RF communications, including modulation/demodulation of RF signals using custom modulation formats up to 6 GHz bandwidth, as well as low frequency characterisation equipment and a 3D printing machine. Also, it includes an electrically large anechoic chamber (1.2 m x 0.6 m x 0.6 m) designed for evaluating antennas from 67 GHz to 115 GHz. The laboratory is also equipped with a Low Earth Orbit (LEO) Satellite communications gateway, Software Defined Radio (SDR) hardware, companion computing nodes, robotic platforms (e.g., drones, balloons, and a robot dog), and acoustic modems, supporting networking research activities related to radio and acoustic communications targeting mobile air, land and waterborne scenarios. A small sized water tank supports the characterisation and validation of optical, acoustic and RF underwater communications solutions.

The main objective of the ComLab is to support the experimental evaluation and testing of next generation communications and sensing solutions in a controlled environment, enabling the validation of simulation results and preparation for subsequent testing in real-world scenarios.

Main achievements in 2023

Aligned with the objectives of the ComLab, the main achievements in 2023 were the following:

- Implementation of the initial prototype modules of a vision-aided reconfigurable intelligent surface at 6.5 GHz suitable for human activity sensing, including the assembly of the experimental setup;
- Establishment of an initial waveguide-based experimental setup for the characterisation of antenna-array unit cell elements;
- Establishment and construction, within the laboratory, of a test assembly suitable for the characterisation of biological tissues using optical signals;
- Integration of a Low Earth Orbit (LEO) Satellite communications gateway in the laboratory giving support for new Wi-Fi and 5G-based backup communications solutions for emergency/disaster management scenarios;
- Kick-off of the extension of the laboratory facilities to a complementary room, enabling research on beyond 5G and 6G solutions in cooperation with a telecom operator;
- Implementation of the initial prototype of a mobile 5G cell, using the robotic dog to move the 5G Base Station aware of its users and obstacles, which has important applications not only for disaster management scenarios but also for general applications that may need on-demand communications in areas without enough network coverage and capacity;
- Contributions to training sessions and support of the ongoing works related to the CTM Summer Internships, B.Sc. curricular internships and MSc and PhD theses.

8 SPECIAL PROJECTS

8.1 UT AUSTIN PORTUGAL PROGRAMME

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.

Main Achievements in 2023

At the end of every year, the Program takes time to reflect on its activities and achievements between January and December. 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.

Nineteen research projects bearing the Program's seal and covering exploratory and industry-led research work were completed, showing promising results in health, nanomaterials, computing, climate change, and more. Many of these transatlantic teams, supported under the Program's Research component, have been looking for opportunities to work together to leverage results obtained through their previous collaborations or explore new research lines. The efforts of some Principal Investigators to raise additional funds have already paid off (e.g., QMETA, NxGNanoTher, 2DTherapy). The monitoring activities we conducted throughout 2023 helped us keep track of these projects' immediate outcomes and inform society at large of their potential impact through science storytelling in different formats, from podcasts to reels, long features and news items. As we neared the end of the year, FCT announced the preliminary results of the 2022 Call for Exploratory Research Projects, launched by the Program almost one year earlier, with eight new exploratory research projects in nanotechnology and medical physics being awarded seed funding. These projects are due to start in 2024. Throughout the year, the program provided online and hybrid workshops and courses in advanced computing, medical imaging, energy, and earth observation to hundreds of researchers and professionals from Portuguese organisations.

The Program's Space, Earth and Ocean (SOE) workshop, launched in 2022, in Porto, took off internationally, debuting in 2023 at the Global Exploration Summit. Also, by partnering for the first time with the Texas Engineering Executive Education (TxEEE), the Program explored a new area of advanced training in energy, engaging both academics and industry participants. UT Austin covered enrolment costs to lower the participation barrier for Portuguese researchers.

In 2023, thanks to a larger budget for mobility initiatives, the Program awarded 12 researchers – affiliated with Portuguese institutions – to spend between two to three months at the University of Texas at Austin and, for the first time ever, at the MD Anderson Cancer Center (MDACC), in Houston, and undertake research work under the guidance of seasoned faculty and researchers. Nevertheless, only ten ended up in Texas, and the duration of the internships was shorter (less than three months) because the review process was delayed after an FCT-mandated change to the review panel. Nanotechnology remained the Program area with the most significant number of funded internships. However, compared to last year, the number of applications received for Medical Physics – an area added to the Program only in Phase 3 – outpaced those for Advanced Computing and Space-Earth Interactions. Most work plans focused on the study and development of cancer therapies. energy, satellite data analysis and machine learning completed the list of research topics for this year's edition.

Mindful of the Program's impact on the country's advances in scientific excellence, technology transfer, and entrepreneurship, we worked with our sponsor, FCT, and several stakeholders on both sides to plan for the Partnership's future after December 31. The Ministerial delegation that travelled in mid-June to Austin, at the invitation of the UT Austin Portugal Program and the University of Texas at Austin (UT Austin), was an opportunity for the Portuguese Minister for Science, Technology and Higher Education and the President of FCT to take stock of FCT's long-running Partnership and discuss avenues of cooperation as the current funding cycle was close to end. During the visit, the Program Leadership articulated its future ideas in a vision document shared with FCT

and MCTES. The Program's participation in this year's edition of Ciência (Ciência 2023), together with the other two FCT's International Partnerships – CMU Portugal and MIT Portugal - demonstrated its commitment to communicating and discussing with the scientific community and society at large the value generated by FCT's International Partnerships with U.S Universities. The Annual Conference was the ultimate public activity in 2023, where the Program got to engage with researchers, policymakers, diplomats, companies, funding agencies and citizens to discuss how Portugal and Texas are and can go on helping model the future through bold, collaborative research in nanotechnology, advanced computing, and energy.

The Program's 2023 Activity Plan closed with the External Review Committee's Annual Meeting, an independent evaluation exercise conducted by a panel of world-class experts whose conclusions and recommendations help us align with the best international scientific standards. This was the second evaluation exercise led by the ERC in 2023. During September and October, the ERC members met specifically with seven of the eleven Strategic Research Projects to gain an in-depth understanding of the Program's innovation-driven research portfolio and the uniqueness of the collaboration with UT.

The year culminated with FCT's decision to extend Phase III to 2024. This additional year will give the Program time to further discuss the terms for a potential Phase IV of the Partnership with its sponsor and the new government taking office after March.

9 SUPPORT SERVICES

9.1 LEGAL SUPPORT SERVICE

Manager: Rita Barros



Employees
2 Women

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.

Highlights in 2023

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 taking account the evolution of International and 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, considering the diversity of contractual relationships existing in the Institution and the inherent idiosyncrasies.
- 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.
- Deal with the increase of contractual activity, both within the scope of funded projects and in direct contracting with national and foreign companies and institutions.
- Increase of drafting/review 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.
- Legal support to the negotiation and drafting of licensing agreements, in close collaboration with SAL; participation in the Task Force formed by the two services, to make the follow up of the most critical projects in IP matters.
- Preparation and negotiation of the Consortium Agreements for European projects AI4REALNET and AI4LUNGS, being INESC TEC the coordinator. Similarly, INESC TEC was also a partner in several European projects, which implied intense contractual negotiations.
- Support to the international relations service, both in the negotiation and drafting of Memorandums of Understanding and with legal reports on applications for residence permits and visas.

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: 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).
- Launch of a public tender for the construction of the Hub Azul de Leixões Ocean Basin - Polo 1,
- Intense activity in public procurement, both as contracting authority, especially in the implementation of large infrastructure projects, and as tenderer.

9.2 ACCOUNTING AND FINANCE SERVICE

Manager: Paula Faria

Assistant Manager: Libânia Caetano



Employees
2 Men
7 Women

Presentation of the Service

The Accounting and Finance service is responsible for coordinating and executing the accounting activities, fulfilling all fiscal obligations, for managing INESC TEC's cash flow, and ensuring the availability of enough funds to meet the payments due. In this context, the service acts as a mediator between the institute and external parties, according to the guidelines provided by the Board. From an administrative perspective, it is also responsible for the purchasing and travel processes and for managing the institute's insurance and fixed assets.

Highlights in 2023

The 25% increase in activity in 2023, following several years of intense growth, had a direct impact on the volume of service operations. This implied a strong commitment of the CF team and the need to improve its processes.

According to the main actions planned for 2023 and the goals of the Accounting and Finance service, the main highlights for this year are:

- Improvement of the digital archive process by enhancing the digitised expenses procedure from the credit card circuit.
- Reinforce continuous improvement activities and practices through internal training sessions on different topics.
- Improvement of the invoice entry process to make it easier to consult invoices that have already been issued.
- Implementation of a new process to allow internal invoicing.
- Participation in a cross-functional team to identify requirements for a new ERP system.
- Analysis and identification of improvement opportunities in the fixed assets process and the disposal of unused fixed assets at INESC TEC.
- Negotiation of special conditions with financial institutions, to provide better benefits for INESC TEC and its employees.

9.3 MANAGEMENT CONTROL SERVICE

Manager: Vanda Ferreira

Assistant Manager: Bárbara Maia



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.

Highlights in 2023

During 2023 the service supported the financial management of 220 funded projects, having submitted 232 financial reports to the respective funding entities, including more than 20 million euros of expenses. The service was involved in the financial closure of 45 projects funded by Portugal 2020 and at the same time supported the starting of 29 PRR's projects (22 mobilising agendas, 3 bioeconomy agendas, 3 agriculture agendas and 1 infrastructure).

In addition to funded projects, the service monitored 141 projects providing direct services to companies, which in 2023 represented 3 million euros.

Among funded projects, 96 projects were funded by Horizon 2020 and Horizon Europe European Union framework programmes, 12 of which were coordinated by INESC TEC. The service also reported 19 projects funded by other European programs, such as INTERREG. The expenses reported throughout the year accounted to 7 million euros.

Regarding national projects and related with the end of Portugal 2020 framework the biggest amount of expenses submitted was in the 43 projects in cooperation with companies, funded by *Agência Nacional de Inovação* (ANI), reporting 5.9 million euros of expenses.

In 2023 the service started the submission of the financial reports for PRR projects, reporting 1M euros of expenses.

There were also a set of large-scale strategic projects such as FCT's Multiannual funding, regional funding for highly qualified human resources (CCDRN), large infrastructures and funding for Technology and Innovation Centres funded by ANI. All these large strategic projects required a huge effort from the service (37 financial reports), representing more than 4.2 million euros of reported expense.

With regard to internal control, the service committed itself to documenting internal procedures, publishing the rules for new funding programmes, and improving the budget control process. The work of searching and writing requirements for the new ERP was continued.

9.4 HUMAN RESOURCES SERVICE

Manager: Luís Seca

Assistant Manager: Margarida Gonçalves



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).

Highlights in 2023

In 2023, the main highlights of the service were:

Strategy and Development

- **Job descriptions and competences policy:**
 - Definition of the job description matrix of INESC TEC;
 - Preparation and presentation of competencies framework workshop;
 - Identification and analysis of the current job descriptions and alignment/mapping with the current model.
- **Career policy:**
 - Consolidation of the Executive Board's (EB) inputs to the document "Guidelines for INESC TEC's new Career Policy";
 - Analysis of relevant national and international documentation regarding the researcher's careers and its alignment with INESC TEC 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:**
 - Presentation and provision of novel documentation (e.g: Onboarding manual and other relevant documents) and welcome kits;
 - Welcoming of new employees through the organisation of monthly welcome sessions.
- **Training policy:**
 - Public presentation to INESC TEC managers of the new INESC TEC training policy;
 - Implementation of the training needs assessment;
 - Preparation of the training plan for 2024 based on the data collected from the relevant stakeholders;
 - Meetings with the main stakeholders involved in the process (scientific council; potential internal trainers...);
 - Registration and management of training activities taking place in the organisation.
- **Recruitment and selection policy:**
 - Gathering and analysis of relevant information in recruitment process; employee branding benchmark; KPIs regarding the current recruitment process;
 - Execution of the expert working group (GTE);

- **Develop wellbeing and occupational health actions:** organisation and promotion of a talk session “How to Embrace Well Being & Performance” targeted to INESC TEC managers.

Operational

- **Process internal reorganisation:** Updating all internship templates in RH DRIVE and on the intranet;
- **Improvement of the intranet HR processes to reduce workload, processing time and error rates:**
 - Workflow review of automatic emails notifying employees of their appointment or contract renewal;
 - Implementation of an automatic email informing grant holders to sign their grant contract whenever it is placed in the NC (new collaborator) or ML (connection change);
- **Revision and creation of new HR documents:**
 - Revision of the internal document on the payment of tuition fees to research grants, with important notes on the delay and incorrect filling of the Tuition Fee Module by grant holders and the updating of tuition fee amounts;
 - Revision of grant contracts, inclusion of new clause on tuition fees’ payment;
 - Revision of employment PHD contracts in the scientific employment: inclusion of new clause on the possibility of changing the position in the pay scale under the terms of DL 57/2016 and Regulatory Decree no. 11-A/2017, dated 29 December;
 - New labour code - Decent work: review of our template employment contracts and supplementary information for employees;
- **New Programmes:**
 - 2nd Edition IVRP – International Visiting Researcher; with the accession and registration many researcher files at INESC TEC;
 - Reception and allocation of internships to 85 students under the summer internship;
- **New Platform:** Updating and registering all our current employment contracts on the Social Security website (326 cases were recorded).
- **New Projects:**
 - 4 Days Week: participation in the pilot project launched by the Portuguese Government;
- **New Models:** New model Grant Complement (CB).
- **New protocols and partnerships**
- **Salaries and benefits:** Wage increases occurred twice during the year 2023, which meant extra work for the HR Service in terms of salary processing, updating individual employee files (MLs), updating INESC TEC's salary scales and in our calls;
- **Recruitment and selection:** In order to cope with the high number of adverts we have each week and to improve the recruitment, additional 10-licence slots of LinkedIn Jobs were acquired;
- **Resumption of Safety and health at work:** Medical consultations have resumed with the novelty of being held on our premises;
- **INESC TEC Merchandising** is now provided by the Resources Service.

9.5 MANAGEMENT SUPPORT SERVICE

Manager: Isabel Macedo



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.

Highlights in 2023

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;
- Support to the formulation of INESC TEC Strategic Plan 2023/2030 and its associated public consultation process;
- Groundwork with the Scientific Domains' Steering Committees in preparation for the FCT Units Evaluation process 2023/2024;
- Support and mediation to INESC TEC's accession to the associations ADRA, CCLIF and CRESYM.

Information Management:

- Continuous document management support as part of the reorganisation of the institutional archives;
- Implementation of a new Funding Opportunities Area in the Intranet in collaboration with SAAF;
- Fostering the Open Science policy of INESC TEC by stimulating the researchers to publish in Open Access venues, and by maintaining the INESC TEC Institutional and Data repositories;
- Talk at the Faculty of Medicine, University of Porto, at the invitation of the Knowledge Management Unit, promoting INESC TEC's data management practices and services;
- Organisation of a workshop dedicated to DMP development aimed at the leaders of European projects coordinated by INESC TEC – "Opportunities and challenges in the development of DMPs", as well as a presentation at the Centres' Council (CCI) – "Raising awareness to the DMP";
- Writing of the Data Management Plan deliverable for the TRIDENT project and key contributions and ongoing support to several DMPs, whether led by INESC TEC or by external partners;
- Publication of the sixth issue of the INESC TEC Science & Society magazine in digital format;
- Curation of theses and dissertations data from 2017/2022, available on the IRIS platform. Expansion and curation of the Projects database.

Continuous improvement:

- Development of a Power BI dashboard consolidating the key performance indicators from all R&D Centres (to be released in the 1st Quarter 2024).

9.6 SECRETARIAL COORDINATION

Managers: Ana Isabel Oliveira and Grasiela Almeida



Employees
18 Women

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 2023, the team was composed by 18 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.

Highlights in 2023

Apart from the regular operational activities mentioned above, the main highlights in 2023 were:

- Implementation and monitorisation of the new Travel Agency contract with a consortium of three companies;
- Instruction of the public procurement procedures for acquiring catering services, as well as printing services for use by the secretarial team;
- Maintaining the use of CRM as an institutional contact database;
- Recruitment and training of a new Assistant for the Centre for Power and Energy Systems, and recruitment of a new Executive Assistant for the Board of Directors;
- Definition of entry levels for the positions of Assistants;
- Market enquiry for training solutions regarding MS Office updating and Event Management;
- Acquisition and consolidation of the coordination team's transversal knowledge through the participation in training sessions in the areas of "Recruitment and Selection Interviews", "General Regime for the Protection of Whistleblowers and the General Regulation for the Prevention of Corruption" and "How to Embrace Well-Being & Performance", targeted to leaders' training.

9.7 FUNDING OPPORTUNITIES OFFICE

Manager: Marta Barbas



Employees

1 Men

1 Women

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.

Highlights in 2023

From all the activities developed we shall highlight, for its relevance, the creation of Funding Opportunities pages on the Intranet available for everyone to access information regarding the different Funding Programmes (funding rates, rules of participation, call calendars, etc.), the Workshop “Lump Sum Funding on Horizon Europe: How it works and budget preparation?”, 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:

- Internal Seed Projects: 13 proposals
- PRIMA – Section 2 (FCT) Call: 1 proposal
- FCT call *Prémio Belmiro de Azevedo*: 1 proposal
- ERANET Calls: 2 proposals
- *Turismo de Portugal* Support to Meetings: 2 proposals
- PROdex for Science in Space Exploration (2023): 1 proposal
- Human Frontier Science Program (2024): 1 proposal
- BIP Proof Call: 2 proposals
- European Tenders: 2 proposals
- HORIZON Europe: 93 proposals were submitted;
- Digital Europe Programme: 2 proposals EUROHPC;
- European Defence Fund: 4 proposals;
- Interregional Innovation Investments Instrument (I3): 1 proposal;
- EU4Health Programme (EU4H): 1 proposal;
- European Space Agency (ESA): 1 proposal;
- EIT RAW Materials: 1 proposal;
- EIT Manufacturing: 1 proposal;
- COST Actions: 2 proposals;
- Cascade Funding: 1 proposal.

9.8 TECHNOLOGY LICENSING OFFICE

Manager: Daniel Marques de Vasconcelos



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**.

Highlights in 2023

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 2023, the achievements and highlights are briefly presented:

In 2023, the TLO made significant progress in the transformation into a Knowledge Transfer Office, highlighting the following achievements:

- **Fine-tune the systematic follow-up of strategic INESC TEC projects:**
 - In-depth analysis of P2020 projects, which finished in 2023. Expansion of the follow-up to include more intelligence about projects by diagnosing success factors and lessons learned to be tackled in new trainings;
 - The systematic strategic scouting approach developed by INESC TEC is visible in the Repository of Best Practices in Knowledge Valorisation promoted by the European Commission.
- **Continue the implementation of the new market-driven IP portfolio management, including a Tech Review Day with external advisors and look for synergies with TEC4s:**
 - Increase of the number of new patent applications, active patent families, granted patents, and licensing contracts. License agreement with the spin-off iLoF and Volkswagen AG;
 - The first pilot of a tech review day for the health portfolio was tested in 2023 with very positive feedback;
 - Joint effort with TECPartnerships in several leads and participation in the French fair – Rendez-vous Carnot 2023 (Lyon) unlocking opportunities with top global players.
- **Co-develop a Spin-off Committee:**
 - Definition of the workflow and practices to support new entrepreneurial projects and to monitor the 7 (seven) active INESC TEC spin-offs.
- **INESC TEC reinforces its key role at the European level:**
 - Leader of the Open Source Software thematic group of the TTO Circle;
 - Member of the Spin-offs and Benchmarking thematic group of the TTO Circle;
 - Lead the application to the EARTO Innovation Award – Impact Expected MyNPK, granted with the 3rd prize.
- **Training of new tech transfer executives:**
 - In 2023, four TLO members left INESC TEC and two new members with no previous experience in tech transfer were integrated in the team. However, this stress factor had no impact in the TLO performance, which improved in all KPIs.

9.9 INTERNATIONAL RELATIONS OFFICE

Manager: *Andreia Passos*



Presentation of the Service

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

Highlights in 2023

As a young service, the SRI must work to consolidate its role in the organisational chart. Such consolidation requires streamlining its operations and processes while looking for innovative ways to help INESC TEC improve its international standing. One of the main barriers to this endeavour has been staff turnover, with efforts to create a permanent core team failing to meet expectations. Nevertheless, the service's objectives remained consistent throughout 2023, and the team, though small-sized, worked to accomplish them all. The following table highlights our main achievements last year.

What goals did the Service set itself in 2023	Highlights – How well did the Service live up to its goals?
Support the Board of Directors in articulating the institution's vision for internationalisation.	At the beginning of the year, the SRI put forward a blueprint for a framework to help INESC TEC articulate its internationalisation engagement based on a crossover between top-down goals and bottom-up internationalisation initiatives. Although this blueprint has yet to be approved by the BoD to be adopted by the institution, it helped the SRI contribute with sound input to the institution's 2023-2030 Strategic Plan, a document which explicitly recognises internationalisation as a key enabler of INESC TEC's longer-term strategy and lays out the institution's priorities in the international arena.
Carry on assisting in bilateral and multilateral cooperation.	The SRI continued advising the institution on international cooperation, backing the BoD and researchers in MoU negotiation, monitoring and renewal (eg.. NII, Japan); participating in exploratory discussions with potential partners/customers; planning and hosting visiting delegations, including high-ranking visitors; and nurturing relationships with external stakeholders for internationalisation such as AICEP or Embassies in Portugal. The service was particularly involved in negotiations leading up to new agreements that should come into force in 2024 (e.g., the National Laboratory of Scientific Computing (Brazil), the Instituto ElDorado (Brazil) and the establishment of a collaborative agreement for joint R&D projects that will deepen collaboration with an MoU partner, NARLabs (Taiwan). The Service organised training activities for the first time to equip INESC TEC's researchers with the tools to engage in international cooperation successfully and become more literate in interculturality. Last but not least, the Service continued managing, at an executive level, the UT Austin Portugal Program, which has been continuously credited for its outstanding performance by the Program's External Review Committee. In 2023, the SRI was deeply committed to high-level discussions to strategise on the Partnership's renewal for a new five-year period.
Carry on supporting inbound and outbound research mobility processes.	In 2023, the SRI eventually established itself as the service that manages inbound and outbound research mobility. It worked closely with HR and the research centres to help foreign staff and visiting researchers in relocation and mobility processes (over 70 in total) while keeping pace with the profound changes in Portugal's immigration-related legislation and organisational landscape. The service continuously encouraged and supported researchers from our community interested in participating in secondments or internships abroad (e.g.,

	OpenInnoTrain and NII's internships). In 2023, the service managed two editions of the INESC TEC International Visiting Researcher Program (IIVRP), producing reports to keep track of the initiative's investment return and improve subsequent editions.
Contribute to enhancing the institution's standing as an institution of choice for talented researchers worldwide.	<p>The SRI worked with SCOM to improve how we communicate the institution's global engagement. In 2023, this work was evident with the IIVRP initiative, with social media content containing testimonials from visiting researchers being crafted and posted on the institution's social media channels.</p> <p>The team also worked closely with the Diversity and Inclusion Committee and the Intercultural Ambassadors' Network towards a more inclusive work environment, which is fundamental to attracting and retaining international talent. One significant achievement of this work was the launch of the first <i>Portuguese as a Foreign Language</i> Course – Beginner Level, directed to INESC TEC's non-Portuguese-speaking researchers. Two classes running twice a week at our headquarters were formed.</p> <p>Enhancing the institution's standing as an institution of choice for talented researchers from all over the world also entailed reviewing and updating the Quick Mobility Guide for Foreign Newcomers. The revised version should be made available in the first quarter of 2024 after undergoing a redesign by SCOM.</p>

9.10 COMMUNICATION SERVICE

Manager: Joana Coelho



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 focuses on five main components - contents, design and multimedia, events, projects leadership in communication and dissemination working groups and translation -, in a mission entirely dedicated to highlight the role of science communication. The activities of the Communication Service follow an integrated marketing communication (IMC) approach.

Highlights in 2023

EXTERNAL COMMUNICATION

- SCIENCE COMMUNICATION
 - **“INESC TEC Ciência e Sociedade” Podcast and Videocast** - Following the concept of the “INESC TEC Science and Society” magazine, first published in November 2020, the first season of the “INESC TEC Ciência e Sociedade” Podcast and Videocast was launched in 2023. The first season, with four episodes, focused on Artificial Intelligence and Health. The episodes were broadcast on YouTube (videocast) and distributed through a podcast distribution company (Blubrry) that disseminates the episodes among platforms like Spotify or Google Podcast. The first season reached around 1700 views on YouTube. A total of 279 people listened to the podcast, with 48% of impactful plays, meaning that if the average duration of the episodes is 49 minutes, almost half of the listeners stay tuned for 24 minutes.
 - **“INESC TEC Ciência e Sociedade” Magazine** – only one edition was published in 2023. The edition about Blue Economy was only disseminated in English. Despite this fact (1 version in 2023 VS 4 versions in 2022), the number of visits increased from 1919 to 1920 and the total number of page visualisations decreased in a non-significant way – 4.725 page views (5.404 in 2022).
 - **Spotlight** - In 2023, this section of the Newsletter BIP had 2050 total page visualisations. Spotlight featured 5 editions in 2023, with the "Immersive learning: it's not fiction, it's the future" piece achieving the highest number of readers: more than 270 visualisations (both in Portuguese and English).
 - **Science Bits Podcast** – The “INESC TEC Science Bits” was among the five nominees in the “Science, Technology and Education” category of the PODES awards – a national award that aims to acknowledge podcasts in different areas. In 2023, 11 new episodes were published, resulting in more than 4000 streams/downloads. The episode "A conversation about renewable energy sources, engineering, math, and influencers" achieved the highest number of streams – more than 640.
 - **BOLD Campaign** – 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 and was named BOLD. It was composed of four conversations with eight women, about four topics: education, work-life balance, leadership, and future. 1,043 visualizations on YouTube.
- PUBLIC RELATIONS
 - **National Press Relations** - In 2023, 1178 news pieces were published in the national media, with an Automatic Advertising Value of more than €17M. The Communication Service released 30 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 2023, the international press office activities continued to follow the same pattern as in the previous year, with a clear focus on press releases via the Alpha Galileo (AG) platform. In total, 12 press releases were sent out between January and December - on average, one per month - which totalled more than 5200 views. In other words, compared to 2022, there was an

increase of 73%. It is also clear that the press releases sent via the platform are reaching more email inboxes: the average number of alerts generated is around 4.200, compared to 3.800 in 2022 (a positive variation of around 10%).

- **Events** - in 2023, the Communication Service was involved in 48 events, even though the level of involvement was different. 13 of said events were organised with the objective of disseminating the science and technology activities of the institution, such as *Encontro Ciência or Mostra U. Porto*. Seven of these events were co-organised 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, SOE'23, or ERCIM Forum, etc. SCOM supported the organisation of 28 events, such as QSP Summit. 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 2023, the event welcomed 225 people in person and 327 online.
- **DIGITAL MARKETING**
 - **Website** – the number of visits increased almost 2% when compared to 2022, with a total number of 55.287. The number of page views also increased almost 22%, achieving 240.774.
 - **BIP** – the number of subscriptions of INESC TEC BIP Magazine increased to 1.484, and the number of visits increased more than 10%, achieving a total of 22.146 visits. The pages visualisations also increased, when compared to 2022, to almost 9%, achieving 43.505.
 - **Social media channels** - the number of followers increased in all the accounts. 2023 ended with 7.856 followers on Facebook (+139), 2.920 on Instagram (+366), 21.450 on LinkedIn (+4215), 9.488 on X (former Twitter) (+126) and 1.385 on YouTube (+135).
- **ADVERTISING**
 - **Design and Multimedia** – a work that is mainly divided into three main aspects: institutional communication (namely supporting design works like INESC TEC Science & Society Magazine, the illustrations developed for each of the Spotlight's editions, multimedia works like the Intercultural Corner section on BIP, or other types of activities 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. EMS LIBS 2023, SOE'23, 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, like flyers, videos, stands, etc.

INTERNAL COMMUNICATION

- Organisation of six internal events – INESC TEC on foot, INESC TEC on the move, INESC TEC having (fun)mily, 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. In 2023, the INESC TEC Season Party took on a completely revamped format, integrating new segments into the agenda.
- 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



Presentation of the Service

The Networks and Communications Service is responsible for the operation and maintenance of INESC TEC's voice and data infrastructures, the implementation of network-based services, and for providing users the respective support.

Besides daily operation and support in the utilisation of resources (e.g., network access, telephony, hybrid events, printing, etc.), permanent activities of the service include the continuous monitoring of the infrastructure, namely to allow for corrective and preventive measures. Strategic modernisation and improvements (concerning e.g. performance, scale, security) is also conducted, for example in the provisioning of datacentre resources, network equipment, videoconferencing solutions, etc.

Highlights in 2023

- Full upgrade of INESC TEC's Wi-Fi infrastructure to an IEEE 802.11ax ("Wi-Fi 6") capable solution, now spanning coverage to remote labs (e.g. FEUP, IPP) while keeping a centralised management approach;
- Several small upgrades in the passive infrastructure of the headquarters' building, namely to improve connectivity capabilities to IOT devices like EV chargers, heat pumps, etc.
- Review and continuous improvement of the various lab and IoT (sub-)networks under a performance and cybersecurity point of view;
- Expansion of INESC TEC's headquarters' main datacentre, particularly increasing the offer of high-speed network ports, physical space and uninterrupted power supply capacity;
- Improvements on INESC TEC's headquarters' secondary datacentre, namely upgrading both uninterrupted power supply and HVAC subsystems;
- Leveraging of the off-site disaster recovery infrastructure located at U. Minho, in cooperation with SAS, now enabling high availability of the email service.

9.12 MANAGEMENT INFORMATION SYSTEMS SERVICE

Manager: José Carlos Sousa



Employees
7 Men
1 Women

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

The team size in 2023 has been 7.69 FTE, totalising eight technicians.

Highlights in 2023

The main new functionalities added to the website were:

- Revamping of the innovation section of the website;
- New INESC TEC secure whistleblower channel.

The IRIS kept growing through the addition of more functionalities:

- Refactoring of the publications module to automate the data extraction from the bibliographic data aggregator Authenticus;
- Management of researchers' participation in scientific domains;
- Streamlining remuneration information for funded projects;
- Social networks registration on personal profile;
- Detailed export of project control;
- Development of the beta version for the new timecard's module.

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

- Generation of the TEC4 activity report;
- Possibility to register Event, Consortium and Partnership;
- Expanding relationships between items to support many-to-many relationships.

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 2023:

- New calendar module displaying next project events;
- New Gantt chart showing project plan with work packages, tasks, milestones and deliverables;
- IRIS database integration providing project overheads data.

9.13 SYSTEM ADMINISTRATION SERVICE

Manager: Jaime Dias



Presentation of the Service

The System Administration Service is responsible for managing storage and computing infrastructures, collaborative applications, and for providing support to end-users – administrative staff and 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.

Highlights in 2023

Beyond the usual tasks of maintenance and continuous improvements of the infrastructures and services, security and resiliency tasks have taken up a significant portion of the SAS effort on system administration.

In 2023, procedures for supporting end users and their computers were enhanced to uphold the quality of service provided, notwithstanding the heightened volume of support requests.

Next are listed the highlights in 2023:

- **Storage and computing infrastructures.**
 - Five new servers with GPGPUs were acquired and integrated into the CCloud computing cluster, increasing the cluster computing capacity by 75%, from 768 CPU cores and 6 Tbytes of RAM to 1300 CPU cores and 10 TB of RAM, as well as 23 new high-performance GPGPUs. These new servers are intended for HPC-related tasks for machine learning/deep learning/AI R&D.
 - Storage capacity was extended with 150 TB of HDD capacity to meet the growing demand for research data storage.
- **Disaster recovery.** SAS extended the mail service (Exchange servers) to the hot site at the University of Minho, together with SRC (MTA servers), to enable high availability of the mail service in the event of a main site failure or disaster.
- **Legacy SAP server hosting.** A hosting solution was deployed to guarantee the availability of the legacy SAP server in the medium term.
- **Knowledge Base.** SAS deployed a collaborative Wiki (<https://kb.inesctec.pt>) for collaborators within centres and services to actively contribute, edit, and collectively maintain internal documentation.

9.14 INFRASTRUCTURE MANAGEMENT SERVICE

Manager: Jorge Couto



Presentation of the Service

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

Highlights in 2023

- **Increase energy efficiency of buildings:**
 - Installation of led lighting in the open spaces secretarial area on the 1st, 2nd, 3rd floors, and offices on the 4th floor;
 - Conclusion of an electrical alternative (heat pump with inertia reservoir) to reduce the use of natural gas, by pre-heating the water circuit;
 - Reformulation of HVAC control systems, to increase visibility on consumption and foster the adoption of corrective set points according to weather conditions;
 - Overall cleaning of all solar panels on the rooftop;
 - Preventive and corrective maintenance of the various security, electrical and mechanical equipment installed in the buildings.
- **Security of people**
 - Plan and design a hydraulic network for the installation of two reels and two water curtains in the building's courtyards in order to better deal with a possible fire in the electric vehicles parked;
 - Updating and reformulating of self-protection measures against fire in buildings;
 - Preventive and corrective maintenance of the various fire control devices installed in all the buildings.
- **Workspace improvement**
 - Updating and reformulating of self-protection measures against fire in buildings;
 - Conclusion of changing spaces in the lunchroom of building A;
 - Conclusion of the building renovation works at Portic (new iiLab facilities);
 - Installation of Video Wall in auditorium located at building A;
 - Adaptation of a space at UTAD for the HCI Lab.
- **Other activities**
 - Installation of five double chargers for electric vehicles outside the building;
 - Replacement of the identification panel installed on the façade of building A.

10 ANNEX I

10.1 CTM – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CTM research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	9	9	13	4
		Academic Staff	13	14	15	1
		Grant Holders and Trainees	45	49	65	16
		Total Core Researchers	67	72	93	21
		Total Core PhD	21	22	24	2
	Affiliated Researchers		8	10	10	0
	Administrative and Technical Employees		1	1	1	0
	Total Integrated HR		76	83	104	21
	Total Integrated PhD		29	32	34	2

Table 10.2 - CTM – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes - FCT	396	113	103	-10
PN-PICT	National R&D Programmes - S&T Integrated Projects	4	77	32	-45
PN-COOP	National Cooperation Programmes with Industry	150	277	671	394
PUE-FP	EU Framework Programmes	205	244	983	739
PUE-DIV	EU Cooperation Programmes - Other	0	11	9	-2
SERV-NAC	R&D Services and Consulting - National	708	625	235	-390
SERV-INT	R&D Services and Consulting - International	37	21	0	-21
OP	Other Funding Programmes	59	74	5	-70
Total Funding		1 559	1 443	2 037	595

Table 10.3 - CTM - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	45	45	51
Indexed Conferences	48	39	44
Books			
Book Chapters	3	1	
Concluded PhD Theses - Members	4	5	2
Concluded PhD Theses – Supervised	7	6	3

Table 10.4 - CTM - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre-Disclosures (PDF)	2	4	7
Technology Disclosures (TDF)		1	2
First Priority Patent Applications (New Inventions)	1	1	2
First Patents Internationalisation			
First Patents Granted	2	1	1
Commercial Contracts (Licences, Options, Assignments)	1		
Spin-offs established			
Spin-offs in development			

Table 10.5 - CTM - Summary of dissemination activities

Type of Activity	2023
Participation as principal editor, editor or associated editor in journals	8
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	5
International events in which INESC TEC members participate in the program committees	35
Participation in events such as fairs, exhibitions or similar	20
Conferences, workshops and scientific sessions organised by the Centre	7
Participants in the conferences, workshops and scientific sessions organised by the Centre	900
Advanced training courses organised by the Centre	2

Table 10.6 - CTM - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	MATinMOL	Maria Inês Carvalho	01/03/2021	28/02/2025
PN-FCT	CIRCUMSTANCE	Hélder Filipe Oliveira	01/01/2022	31/12/2024
PN-FCT	UNIFY	Nuno Miguel Paulino	10/03/2023	09/03/2026
PN-FCT	TORIS	Luís Manuel Pessoa	01/03/2023	31/08/2024
PN-FCT	CAGING	Luís Filipe Teixeira	01/02/2023	31/07/2024
PN-FCT	LUCCA	Tânia Pereira	01/03/2023	31/08/2024
PN-FCT	CELLO	Hélder Filipe Oliveira	06/03/2023	05/03/2026
PN-PICT	DECARBONIZE-1	Hélder Martins Fontes	01/01/2021	30/06/2023
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	HfPT-3	Hélder Filipe Oliveira	01/10/2021	31/12/2025
PN-COOP	NewSpacePortugal-3	Filipe André Ribeiro	01/10/2022	31/12/2025
PN-COOP	NEXUS-2	Filipe André Ribeiro	01/10/2022	31/12/2025
PN-COOP	SUSTAINABLE PLASTICS	Pedro Miguel Carvalho	01/09/2022	30/08/2025
PN-COOP	A-MoVeR	Luís Manuel Pessoa	01/12/2022	01/12/2025
PUE-DIV	OpenMinds	Gilberto Bernardes Almeida	30/12/2021	29/12/2023
PUE-FP	EuConNeCts4	Rui Lopes Campos	01/06/2019	30/11/2022
PUE-FP	InterConnect-1	Filipe André Ribeiro	01/10/2019	31/03/2024
PUE-FP	OpenInnoTrain-2	Filipe André Ribeiro	01/01/2019	30/06/2024
PUE-FP	CINDERELLA	Jaime Cardoso	01/06/2022	31/05/2026
PUE-FP	WATSON	Pedro Miguel Carvalho	01/03/2023	28/02/2026
PUE-FP	EADIGIFOLK	Gilberto Bernardes Almeida	01/01/2023	31/12/2026
PUE-FP	OVERWATCH-1	Hélder Martins Fontes	01/11/2022	31/10/2025
PUE-FP	CONVERGE	Luís Manuel Pessoa	01/02/2023	31/01/2026
PUE-FP	A-IQ Ready	João Canas Ferreira	01/01/2023	31/12/2025
PUE-FP	SuperIoT	Hélder Martins Fontes	01/01/2023	31/12/2025
PUE-FP	TERRAMETA	Luís Manuel Pessoa	01/01/2023	31/12/2025
SERV-NAC	WaveCorkCal	Filipe André Ribeiro	25/06/2021	30/11/2023
SERV-NAC	THEIA	Luís Manuel Pessoa	03/01/2022	30/09/2023
SERV-NAC	Vision2Control-1	Pedro Miguel Carvalho	01/10/2022	31/07/2023
SERV-NAC	AURORA	Pedro Miguel Carvalho	01/10/2022	31/05/2023
SERV-NAC	Shielding	Filipe André Ribeiro	01/03/2023	31/03/2023
OP	Inphinit	Paula Viana	01/12/2019	01/12/2022

Type of Project:

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

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Books

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Chapter/Paper in Books

Blank

Publications (Editor)

Blank

Dissertations (PhD)

1. Coelho, A., "Traffic-aware Management of Communications Resources in Flying Networks"

2. Sá Pinto, A., "Towards Human-in-the-Loop Computational Rhythm Analysis in Challenging Musical Conditions"

10.2 CAP – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CAP research team composition and evolution and the main indicators of its activity carried out in 2023 participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 - CAP – Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-2023
Integrated HR	Core Research Team	Employees	11	15	15	0
		Academic Staff	8	8	7	-1
		Grant Holders and Trainees	11	19	16	-3
		Total Core Researchers	30	42	38	-4
		Total Core PhD	16	19	19	0
	Affiliated Researchers		5	3	2	-1
	Administrative and Technical Employees		1	1	1	0
	Total Integrated HR		36	46	41	-5
	Total Integrated PhD		20	22	21	-1

Table 10.8 - CAP - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT	191	120	113	-7
PN-PICT	National R&D Programmes - S&T Integrated Projects	1	0	0	0
PN-COOP	National Cooperation Programmes with Industry	46	201	287	86
PUE-FP	EU Framework Programmes	260	206	169	-37
PUE-DIV	EU Cooperation Programmes - Other	47	5	4	-1
SERV-NAC	R&D Services and Consulting - National	-3	43	5	-38
SERV-INT	R&D Services and Consulting - International	17	64	14	-50
OP	Other Funding Programmes	9	21	89	67
Total Funding		567	659	680	20

Table 10.9 - CAP - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	42	27	26
Indexed Conferences	8	14	15
Books			
Book Chapters			
Concluded PhD Theses - Members	2	1	2
Concluded PhD Theses – Supervised	4	1	2

Table 10.10 - CAP - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre Disclosures (PDF)	2	1	1
Technology Disclosures (TDF)	1	2	3
First Priority Patent Applications (New inventions)	3	1	2
First Patents Internationalisation	1	2	2
First Patents Granted	1		4
Commercial Contracts (Licences, Options, Assignments)		1	1
Spin-offs established			
Spin-offs in development	1	1	1

Table 10.11 - CAP - Summary of dissemination activities

Type of Activity	2023
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)	3
International events in which INESC TEC members participate in the program committees	8
Participation in events such as fairs, exhibitions or similar	2
Conferences, workshops and scientific sessions organised by the Centre	2
Participants in the conferences, workshops and scientific sessions organised by the Centre	200
Advanced training courses organised by the Centre	1

Table 10.12 - CAP - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	MYTAG	Pedro Jorge	01/01/2022	01/01/2025
PN-FCT	MODAS	Orlando Frazão	01/03/2023	28/02/2026
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
PN-COOP	AgendaTransform-1	Diana Filipa Guimarães	01/10/2022	31/12/2025
PN-COOP	ATE-1	Pedro Jorge	01/01/2023	31/12/2025
PN-COOP	HfPT-4	Pedro Jorge	01/10/2021	31/12/2025
PUE-DIV	CostActions	José Luís Santos	01/01/2008	
PUE-FP	WiPTherm	Orlando Frazão	01/11/2019	30/06/2023
PUE-FP	EUSCOTES-1	Luís Carlos Coelho	01/09/2021	31/08/2025
PUE-FP	SUBMERSE	Orlando Frazão	01/05/2023	30/04/2026
PUE-FP	INNOAQUA-1	Luís Carlos Coelho	01/06/2023	31/05/2027
SERV-NAC	LIBS_1_2023	Ireneu Dias	23/06/2023	30/06/2023
SERV-INT	LIRA	Orlando Frazão	01/11/2021	31/12/2023
OP	HotQFL	Nuno Azevedo Silva	01/01/2020	31/10/2023
OP	SMARTCAP	Orlando Frazão	01/02/2022	01/02/2025
OP	OFS29	Paulo Vicente Marques	01/02/2023	31/01/2026
OP	EMSLIBS2023	Ireneu Dias	10/02/2023	09/01/2024

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

List of Publications

International Journals with Scientific Referees

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2. Monteiro, C., "Study and development of optical fiber structures based on graphene"

10.3 CRAS – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CRAS research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 - CRAS - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	20	24	28	4
		Academic Staff	12	12	11	-1
		Grant Holders and Trainees	38	35	40	5
		Total Core Researchers	70	71	79	8
		Total Core PhD	16	17	17	0
	Affiliated Researchers		0	1	0	-1
	Administrative and Technical Employees		4	3	5	2
	Total Integrated HR		74	75	84	9
	Total Integrated PhD		16	17	17	0

Table 10.14 - CRAS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT	355	543	566	23
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	328	469	843	374
PUE-FP	EU Framework Programmes	950	1 791	1 769	-22
PUE-DIV	EU Cooperation Programmes – Other	262	149	276	127
SERV-NAC	R&D Services and Consulting – National	30	89	68	-22
SERV-INT	R&D Services and Consulting - International	312	128	124	-3
OP	Other Funding Programmes	1	0	0	0
Total Funding		2 239	3 169	3 646	477

Table 10.15 - CRAS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	16	22	25
Indexed Conferences	21	29	25
Books	1	1	
Book Chapters	1	4	2
Concluded PhD Theses - Members			1
Concluded PhD Theses – Supervised			1

Table 10.16 - CRAS - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre Disclosures (PDF)	3	1	2
Technology Disclosures (TDF)		1	1
First Priority Patent Applications (New Inventions)		1	1
First Patents Internationalisation			1
First Patents Granted		1	1
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established	1		
Spin-offs in development			

Table 10.17 - CRAS - Summary of dissemination activities

Type of Activity	2023
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)	2
International events in which INESC TEC members participate in the program committees	4
Participation in events such as fairs, exhibitions or similar	25
Conferences, workshops and scientific sessions organised by the Centre	12
Participants in the conferences, workshops and scientific sessions organised by the Centre	400
Advanced training courses organised by the Centre	3

Table 10.18 - 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	Connect2Oceans	Alfredo Martins	20/03/2021	19/03/2024
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	ATE-3	José Miguel Almeida	01/01/2023	31/12/2025
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
PN-COOP	StoneByPortugal	Ana Cristina Pires	01/07/2022	30/06/2025
PUE-DIV	PROTOATLANTIC	Eduardo Silva	01/11/2017	30/06/2023
PUE-DIV	Prince	Hugo Miguel Silva	01/01/2019	31/12/2022
PUE-DIV	SHIELD	Hugo Miguel Silva	01/09/2020	31/08/2023
PUE-DIV	FLYPASS	Bruno Miguel Ferreira	06/06/2022	30/04/2024
PUE-FP	SPRING	Aníbal Matos	01/08/2019	31/07/2024
PUE-FP	DEEPFIELD	Hugo Miguel Silva	01/10/2019	30/09/2023
PUE-FP	ATLANTIS	Andry Maykol Pinto	01/01/2020	31/12/2023
PUE-FP	EUSCOTES-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
PUE-FP	TRIDENT	José Miguel Almeida	01/01/2023	31/12/2027
PUE-FP	MineIO	José Miguel Almeida	01/01/2023	30/06/2026
PUE-FP	AIRSHIP	José Miguel Almeida	01/01/2023	31/12/2026
PUE-FP	TALOS	Andry Maykol Pinto	01/10/2023	30/09/2026
PUE-FP	NETTAGPlus	Diana Viegas	01/05/2023	30/04/2026
PUE-DIV	SEAWINGS	José Miguel Almeida	01/12/2022	31/05/2026
SERV-NAC	EDIDPMiracle	José Miguel Almeida	01/09/2022	30/06/2023
SERV-NAC	ASM_research2022	Alfredo Martins	01/12/2022	30/11/2023
SERV-INT	SantoAntonio	Aníbal Matos	01/03/2019	31/12/2021
SERV-INT	AECUD_2	José Miguel Almeida	01/12/2022	28/02/2023
SERV-INT	ILVO_1	José Miguel Almeida	29/04/2023	28/07/2023
SERV-INT	ILVO2_eBAR	José Miguel Almeida	01/10/2023	01/05/2024
INT	SUMO_Mar_Profundo	Nuno Cruz	01/01/2022	

Type of Project:

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

List of Publications

International Journals with Scientific Referees

1. Abreu, N, Pinto, A, Matos, A, Pires, M, "Procedural Point Cloud Modelling in Scan-to-BIM and Scan-vs-BIM Applications: A Review", ISPRS International Journal of Geo-Information, vol.12, no.7, pp.260, JUL, 2023
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10.4 C-BER – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present C-BER research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.19 – C-BER - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	4	4	4	0
		Academic Staff	5	6	6	0
		Grant Holders and Trainees	14	15	25	10
		Total Core Researchers	23	25	35	10
		Total Core PhD	8	8	8	0
	Affiliated Researchers		1	1	1	0
	Administrative and Technical Employees		1	1	1	0
	Total Integrated HR		25	27	37	10
	Total Integrated PhD		9	9	9	0

Table 10.20 – C-BER - Project funding

Funding Source		Total Income (k€)			Δ (k€) 2022-23
		2021	2022	2023	
PN-FCT	National R&D Programmes - FCT	95	76	99	23
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	98	80	83	4
PUE-FP	EU Framework Programmes		38	98	60
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	24	23	10	-14
SERV-INT	R&D Services and Consulting - International		21	163	142
OP	Other Funding Programmes	2	6	7	1
Total Funding		218	244	460	216

Table 10.21 – C-BER - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	23	31	23
Indexed Conferences	34	25	36
Books			1
Book Chapters		1	
Concluded PhD Theses - Members	2	1	
Concluded PhD Theses – Supervised	2	1	2

Table 10.22 – C-BER - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre-Disclosures (PDF)	3	3	1
Technology Disclosures (TDF)	3	5	1
First Priority Patent Applications (New inventions)	1	2	1
First Patents Internationalisation	1		2
First Patents Granted	2		1
Commercial Contracts (Licences, Options, Assignments)	3		1
Spin-offs established			1
Spin-offs in development	2	2	1

Table 10.23 – C-BER - Summary of dissemination activities

Type of Activity	2023
Participation as principal editor, editor or associated editor in journals	6
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	7
International events in which INESC TEC members participate in the program committees	25
Participation in events such as fairs, exhibitions or similar	5
Conferences, workshops and scientific sessions organised by the Centre	3
Participants in the conferences, workshops and scientific sessions organised by the Centre	160
Advanced training courses organised by the Centre	

Table 10.24 – 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	30/06/2023
PN-COOP	AgWearCare	Duarte Filipe Dias	01/08/2021	30/06/2023
PN-COOP	TEXPACT-1	Miguel Velhote Correia	01/07/2022	31/12/2025
PN-COOP	HfPT	Duarte Filipe Dias	01/10/2021	31/12/2025
PN-COOP	Vine&Wine_PT-2	Duarte Filipe Dias	11/10/2022	10/10/2025
PUE-FP	FIRE_RES-1	Duarte Filipe Dias	01/12/2021	01/12/2025
PUE-FP	CARE-IN-HEALTH	João Paulo Cunha	01/01/2023	31/12/2027
SERV-NAC	BenchWearables	Duarte Filipe Dias	27/01/2023	26/02/2023
SERV-NAC	PD_MultiCentre	João Paulo Cunha	01/04/2023	31/12/2023
SERV-NAC	GSSICconsulting	Rute Ferreira	01/04/2023	31/05/2023
SERV-INT	iProcureSecurity	Duarte Filipe Dias	01/10/2022	01/05/2024
SERV-INT	RAISE	Duarte Filipe Dias	01/10/2022	31/08/2024
OP	smartDBS	João Paulo Cunha	01/12/2022	30/11/2025

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

List of Publications

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Chapter/Paper in Books

Blank

Publications (Editor)

Blank

Dissertations (PhD)

Blank

10.5 CPES – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CPES research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.25 - CPES – Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	39	50	63	13
		Academic Staff	10	10	9	-1
		Grant Holders and Trainees	33	39	47	8
		Total Core Researchers	82	99	119	20
		Total Core PhD	25	29	31	2
	Affiliated Researchers		4	5	2	-3
	Administrative and Technical Employees		2	3	2	-1
	Total Integrated HR		88	107	123	16
	Total Integrated PhD		29	34	33	-1

Table 10.26 - CPES – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT	179	117	84	-34
PN-PICT	National R&D Programmes - S&T Integrated Projects	44	77	70	-6
PN-COOP	National Cooperation Programmes with Industry	367	527	1 083	556
PUE-FP	EU Framework Programmes	1 648	2 034	2 831	797
PUE-DIV	EU Cooperation Programmes – Other	8	60	2	-58
SERV-NAC	R&D Services and Consulting – National	850	956	1 044	88
SERV-INT	R&D Services and Consulting - International	123	27	168	141
OP	Other Funding Programmes	11	180	11	-168
Total Funding		3 230	3 978	5 293	1 315

Table 10.27 - CPES – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	97	128	52
Indexed Conferences	85	40	54
Books			
Book Chapters	3	3	3
Concluded PhD Theses - Members	4	3	4
Concluded PhD Theses – Supervised	6	4	4

Table 10.28 - CPES – Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre Disclosures (PDF)	5	2	9
Technology Disclosures (TDF)			8
First Priority Patent Applications (New inventions)			1
First Patents Internationalisation	1		
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			1

Table 10.29 - CPES – Summary of participation in dissemination activities

Type of Activity	2023
Participation as principal editor, editor or associated editor in journals	8
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	3
Participation in events such as fairs, exhibitions or similar	3
Conferences, workshops and scientific sessions organised by the Centre	13
Participants in the conferences, workshops and scientific sessions organised by the Centre	745
Advanced training courses organised by the Centre	3

Table 10.30 - CPES - List of projects

List of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-PICT	DECARBONIZE	David Emanuel Rua	01/01/2021	30/06/2023
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
PN-COOP	BioShoes4All-1	Ricardo Jorge Bessa	01/07/2022	31/12/2025
PN-COOP	H2DRIVEN	Rui Esteves Araujo	01/10/2022	01/10/2025
PN-COOP	ATE	Ricardo Jorge Bessa	01/01/2023	31/12/2025
PN-COOP	Vine&Wine_PT-1	Conceição Nunes Rocha	11/10/2022	10/10/2025
PN-COOP	NEXUS	David Emanuel Rua	01/10/2022	31/12/2025
PN-COOP	NGS	Clara Sofia Gouveia	01/01/2023	31/12/2025
PN-COOP	Tools4AgriEnergy-LA11.1	José Villar	01/04/2023	30/09/2025
PN-COOP	Tools4AgriEnergy-LA11.2	José Villar	01/04/2023	30/09/2025
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	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	29/02/2024
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	13/10/2023
PUE-FP	EUniversal	Clara Sofia Gouveia	01/02/2020	15/12/2023
PUE-FP	OneNet	Alexandre Lucas	01/10/2020	31/03/2024
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	19/06/2023
PUE-FP	ENERSHARE	Ricardo Jorge Bessa	01/07/2022	30/06/2025
PUE-FP	BeFlexible	Ricardo Jorge Bessa	01/09/2022	31/08/2026
PUE-FP	iSTENTORE	Filipe Joel Soares	01/01/2023	31/12/2025
PUE-FP	Green_Dat_AI	Gil Silva Sampaio	01/01/2023	31/12/2025
PUE-FP	SINNOGENES	Clara Sofia Gouveia	01/01/2023	31/12/2026
PUE-FP	Every1	Alexandre Lucas	01/11/2022	30/04/2026
PUE-FP	InterStore	Alexandre Lucas	01/01/2023	31/12/2025
PUE-FP	AI4REALNET	Ricardo Jorge Bessa	01/10/2023	31/03/2027
PUE-FP	ENFIELD	Ricardo Jorge Bessa	01/09/2023	31/08/2026
PUE-FP	TALOS-1	Tatiana Guedes	01/10/2023	30/09/2026
PUE-FP	ENPOWER	José Villar	01/09/2023	31/08/2026
PUE-FP	CRETE_VALLEY	Leonel Magalhães Carvalho	01/12/2023	30/11/2028
SERV-NAC	IoT4Distribuicao	Clara Sofia Gouveia	04/01/2021	31/12/2023
SERV-NAC	MORADIST	Leonel Magalhães Carvalho	01/02/2021	31/12/2025
SERV-NAC	Redes_GasRenov	João Peças Lopes	02/01/2021	31/12/2023

List of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	PE_Sernancelhe	Bernardo Silva	28/01/2021	31/03/2023
SERV-NAC	Pontas_Modelo	José Nuno Fidalgo	01/09/2021	28/02/2023
SERV-NAC	Fin_Losses	Filipe Joel Soares	01/10/2021	31/12/2023
SERV-NAC	PV_Lagoa2	Bernardo Silva	01/03/2022	28/02/2023
SERV-NAC	PV_LAJES_PICO	Bernardo Silva	01/02/2022	28/02/2023
SERV-NAC	PV_VELAS_SJorge	Bernardo Silva	15/02/2022	28/02/2023
SERV-NAC	PV_Horta_Faial	Bernardo Silva	15/02/2022	28/02/2023
SERV-NAC	TechMeter	David Emanuel Rua	18/04/2022	31/12/2023
SERV-NAC	SCAMI	Carlos Moreira	15/04/2022	30/06/2023
SERV-NAC	MARROHID	Bernardo Silva	01/07/2022	31/12/2023
SERV-NAC	H2IND	Zenaida Mourão	01/07/2022	31/03/2023
SERV-NAC	Perfis_Perdas_2023	José Nuno Fidalgo	23/05/2022	31/01/2023
SERV-NAC	PERSA_4ed	Ricardo Jorge Bessa	01/03/2023	30/06/2023
SERV-NAC	ELFOS_maintenance	José Ricardo Andrade	01/10/2022	01/10/2023
SERV-NAC	PROTEnerN	João Peças Lopes	02/07/2022	31/12/2023
SERV-NAC	ECOVALE	Zenaida Mourão	01/09/2022	30/06/2024
SERV-NAC	BioWaste2Energy	Zenaida Mourão	01/01/2023	31/12/2023
SERV-NAC	LossesVila	Filipe Joel Soares	01/01/2023	31/03/2023
SERV-NAC	MVLineDown	Clara Sofia Gouveia	01/01/2023	30/05/2023
SERV-NAC	PV_Acores23	Carlos Moreira	10/01/2023	07/09/2023
SERV-NAC	greenH2ammonia	Filipe Joel Soares	01/02/2023	30/04/2023
SERV-NAC	AquaTerra	João Peças Lopes	15/01/2023	30/09/2023
SERV-NAC	Parecer-PDIR-G	João Peças Lopes	15/01/2023	14/02/2023
SERV-NAC	CampusREN2023	João Peças Lopes	01/06/2023	30/09/2023
SERV-NAC	Wind-Pico1	Carlos Moreira	01/01/2023	15/05/2023
SERV-NAC	PV_Baterias_Azores2	João Peças Lopes	25/03/2023	01/08/2023
SERV-NAC	ConsultGrid4WaterII	Eric Zanghi	03/04/2023	29/05/2023
SERV-NAC	Wind_Curtail_Soft_4	Leonel Magalhães Carvalho	15/02/2023	20/06/2023
SERV-NAC	Eolica_offshorePT	Leonel Magalhães Carvalho	01/06/2023	31/03/2024
SERV-NAC	ELFOS_evolved	José Ricardo Andrade	01/06/2023	30/06/2024
SERV-NAC	PV_PICO_PEDRA	Bernardo Silva	15/06/2023	03/08/2023
SERV-NAC	ENS_Pico	Carlos Moreira	01/07/2023	31/10/2023
SERV-NAC	SmartAmmonia	Filipe Joel Soares	01/07/2023	30/06/2024
SERV-NAC	PerfisPerdasFA	José Nuno Fidalgo	03/04/2023	31/12/2023
SERV-NAC	UPAC_GridCode_RAM	Justino Miguel Rodrigues	01/05/2023	31/07/2023
SERV-NAC	WF_Sernancelhe_V2	Bernardo Silva	01/06/2023	31/07/2023
SERV-NAC	ConnectH2	Zenaida Mourão	03/07/2023	02/10/2023
SERV-NAC	BES_Cegonha	Clara Sofia Gouveia	15/05/2023	31/12/2023
SERV-NAC	SolarPVSaoMiguel-Poente	João Peças Lopes	15/07/2023	14/08/2023
SERV-NAC	SolarPVSaoMiguel_Nas	João Peças Lopes	15/07/2023	14/08/2023
SERV-NAC	SolarPV_SaoJorge	João Peças Lopes	15/07/2023	14/08/2023
SERV-NAC	SolarPV_SantaMaria	João Peças Lopes	15/07/2023	14/08/2023
SERV-NAC	SolarPV_Pico	João Peças Lopes	15/07/2023	14/08/2023
SERV-NAC	SolarPV_Faial	João Peças Lopes	15/07/2023	14/08/2023
SERV-NAC	SolarPV_Terc	João Peças Lopes	15/07/2023	14/08/2023
SERV-NAC	PV_Ferreira3	Bernardo Silva	01/09/2023	31/12/2023
SERV-NAC	RAM_PLAN_GREEN_PORT	Leonel Magalhães Carvalho	01/10/2023	31/08/2024
SERV-NAC	PV_Alcacer	João Peças Lopes	15/09/2023	14/12/2023
SERV-NAC	BIOMASS	Bernardo Silva	01/10/2023	31/01/2024

List of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	SolarPVSMiguel_EstC	João Peças Lopes	15/10/2023	14/02/2024
SERV-NAC	PVTerceira_EstComp	João Peças Lopes	22/11/2023	21/12/2023
SERV-NAC	PV_Pico_EstComp	João Peças Lopes	22/11/2023	21/12/2023
SERV-NAC	SolarPV_Faial_EstCom	João Peças Lopes	22/11/2023	21/01/2024
SERV-NAC	R3EA	José Villar	01/01/2022	31/12/2024
SERV-INT	PV_POMBAL_REQUIP	Bernardo Silva	15/07/2022	28/02/2023
SERV-INT	Grid_In_CM	Bernardo Silva	15/11/2022	30/09/2023
SERV-INT	CleanEnergy4EUIslands2	João Peças Lopes	15/04/2023	14/04/2027
SERV-INT	Helas_ExtremeRES	Ricardo Jorge Bessa	06/10/2022	31/03/2023
SERV-INT	PV_STORAGE_PT	Bernardo Silva	17/04/2023	31/12/2023
SERV-INT	PV_POMBAL3	Bernardo Silva	01/03/2023	30/04/2023
SERV-INT	GridNode	Clara Sofia Gouveia	01/07/2023	29/02/2024
SERV-INT	Promove_Energia	Vladimiro Miranda	01/11/2022	30/09/2023
OP	Sustainable HPC	Ricardo Jorge Bessa	01/07/2021	30/06/2025

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

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Dissertations (PhD)

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10.6 CESE – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CESE research team composition and evolution and the main indicators of its activity carried out in Click or tap to enter a date.2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.31 - CESE - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	22	27	30	3
		Academic Staff	4	6	6	0
		Grant Holders and Trainees	14	11	16	5
		Total Core Researchers	40	44	52	8
		Total Core PhD	14	16	16	0
	Affiliated Researchers		8	9	9	0
	Administrative and Technical Employees		2	2	2	0
	Total Integrated HR		50	55	63	8
	Total Integrated PhD		22	24	25	1

Table 10.32 - CESE - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT	126	130	21	-110
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	521	918	1 367	449
PUE-FP	EU Framework Programmes	440	533	550	17
PUE-DIV	EU Cooperation Programmes – Other		1	-1	-2
SERV-NAC	R&D Services and Consulting – National	272	347	225	-122
SERV-INT	R&D Services and Consulting - International	40	37	64	26
OP	Other Funding Programmes	1		2	2
Total Funding		1 400	1 967	2 227	260

Table 10.33 - CESE - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	15	24	33
Indexed Conferences	39	37	33
Books	1		1
Book Chapters	6	2	2
Concluded PhD Theses - Members			2
Concluded PhD Theses – Supervised	1		2

Table 10.34 - CESE - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre-Disclosures (PDF)	4	1	2
Technology Disclosures (TDF)	1	8	3
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 10.35 - CESE - Summary of dissemination activities

Type of Activity	2023
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	8
Participation in events such as fairs, exhibitions or similar	5
Conferences, workshops and scientific sessions organised by the Centre	8
Participants in the conferences, workshops and scientific sessions organised by the Centre	190
Advanced training courses organised by the Centre	1

Table 10.36 - CESE - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	FuturePharma	Jorge Pinho de Sousa	29/03/2021	28/03/2024
PN-FCT	eLOG	Tânia Daniela Fontes	01/01/2022	31/12/2023
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
PN-COOP	AgendaTransform	Reinaldo Silva Gomes	01/10/2022	31/12/2025
PN-COOP	Hi_reV-1	Rui Diogo Rebelo	01/01/2022	31/12/2025
PN-COOP	TEXPACT-2	César Toscano	01/07/2022	31/12/2025
PN-COOP	GIATEX	Rui Diogo Rebelo	01/10/2022	01/09/2025
PN-COOP	Drivolution-1	Filipa Rente Ramalho	01/09/2022	01/09/2025
PN-COOP	Blue_Bioeconomy	Rui Correia Dias	01/01/2023	31/12/2025
PN-COOP	Produtech_R3	Luís Guardão	01/09/2022	31/12/2025
PN-COOP	NEXUS-3	Jorge Pinho de Sousa	01/10/2022	31/12/2025
PN-COOP	BLOCKCHAINPT	Luís Guardão	01/09/2022	31/08/2025
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	MAGPIE-1	António Henrique Almeida	01/10/2021	01/10/2026
PUE-FP	SoTecInFactory	Gustavo Dalmarco	01/06/2022	31/05/2025
PUE-FP	ReSchape	Ricardo Augusto Zimmermann	01/10/2022	30/09/2025
PUE-FP	tExtended	César Toscano	01/12/2022	30/11/2026
PUE-FP	Confacts2	Ana Cristina Simões	01/01/2023	31/12/2024
PUE-FP	EITM_RIS_Hub_2023	Vasco Bernardo Teles	01/01/2023	31/12/2023
PUE-FP	INNOAQUA	Filipe David Ferreira	01/06/2023	31/05/2027
SERV-NAC	SIACEDV_A_OAZEMEIS	Rui Diogo Rebelo	29/09/2021	31/05/2023
SERV-NAC	SIACEDV_A_FEIRA	Rui Diogo Rebelo	29/09/2021	31/03/2023
SERV-NAC	ECOSSISTEMA	Rui Diogo Rebelo	28/02/2022	31/03/2024
SERV-NAC	DTNARR3PROC	Rui Diogo Rebelo	01/07/2022	31/03/2023

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	OptiLog7Fluxos	Romão Filipe Santos	18/07/2022	31/12/2023
SERV-NAC	VOXPOP	Jorge Pinho de Sousa	10/05/2022	28/02/2023
SERV-NAC	DIGI4PLAST	António Correia Alves	01/10/2022	31/03/2023
SERV-NAC	TransDigiFundicao	Filipe David Ferreira	31/01/2023	29/09/2023
SERV-NAC	TIIM_TS	Jorge Pinho de Sousa	15/05/2023	31/12/2023
SERV-NAC	PFAI4_4eD	Américo Azevedo	03/05/2023	02/07/2023
SERV-NAC	DTNARR3AUTO	Rui Diogo Rebelo	25/09/2023	30/04/2024
SERV-INT	FIT4NMP	José Carlos Caldeira	26/01/2023	13/02/2023
SERV-INT	C2T_CODI	Filipe David Ferreira	06/03/2023	30/05/2023
SERV-INT	BOWI_EyeSense	Gustavo Dalmarco	13/03/2023	12/04/2023
SERV-INT	BOWI_DmPlan	Gustavo Dalmarco	06/02/2023	30/06/2023
SERV-INT	BOWI_ViaNN	Gustavo Dalmarco	10/02/2023	30/06/2023
SERV-INT	BOWI_ARRobot	Gustavo Dalmarco	10/02/2023	31/12/2023
SERV-INT	C2T_GLASS	Rui Diogo Rebelo	01/02/2023	30/06/2023
SERV-INT	BeamAutoLogSim	Romão Filipe Santos	01/11/2023	31/01/2024
OP	IAMOT 2024	Ana Cristina Simões	15/05/2023	14/09/2024

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

List of publications

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6. Fagundes, PB, de Macedo, DDJ, Soares, AL, "FIRMa: A Framework to Support the Requirements Management Process Based on Information Management Tools", Mobile Networks & Applications, 2023
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Books

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10.7 CRIIS – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CRIIS research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.37 - CRIIS - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	15	19	25	6
		Academic Staff	16	13	13	0
		Grant Holders and Trainees	24	33	41	8
		Total Core Researchers	55	65	79	14
		Total Core PhD	22	20	22	2
	Affiliated Researchers		2	3	1	-2
	Administrative and Technical Employees		2	2	3	1
	Total Integrated HR		59	70	83	13
	Total Integrated PhD		24	22	23	1

Table 10.38 - CRIIS – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT	-14	5	19	14
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	182	510	1 416	906
PUE-FP	EU Framework Programmes	604	780	875	94
PUE-DIV	EU Cooperation Programmes - Other	9	19	-1	-21
SERV-NAC	R&D Services and Consulting - National	365	236	177	-58
SERV-INT	R&D Services and Consulting - International			9	9
OP	Other Funding Programmes	4	4	6	3
Total Funding		1 149	1 554	2 500	946

Table 10.39 - CRIIS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	50	52	46
Indexed Conferences	58	63	46
Books		1	
Book Chapters	2	5	4
Concluded PhD Theses - Members	2		2
Concluded PhD Theses – Supervised	3	3	2

Table 10.40 - CRIIS – Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre Disclosures (PDF)	7	1	4
Technology Disclosures (TDF)	3		2
First Priority Patent Applications (New inventions)	1		1
First Patents Internationalisation		1	
First Patents Granted			1
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			1

Table 10.41 - CRIIS – Summary of dissemination activities

Type of Activity	2023
Participation as principal editor, editor or associated editor in journals	2
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	11
Participation in events such as fairs, exhibitions or similar	10
Conferences, workshops and scientific sessions organised by the Centre	2
Participants in the conferences, workshops and scientific sessions organised by the Centre	250
Advanced training courses organised by the Centre	

Table 10.42 - CRIIS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
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	InsectERA	Tatiana Martins Pinho	01/01/2023	31/12/2025
PN-COOP	AgendaTransform-4	Filipe Neves Santos	01/10/2022	31/12/2025
PN-COOP	Hi_reV	Luís Freitas Rocha	01/01/2022	31/12/2025
PN-COOP	TEXPACT	Germano Veiga	01/07/2022	31/12/2025
PN-COOP	GIATEX-1	Germano Veiga	01/10/2022	01/09/2025
PN-COOP	Produtech_R3-2	Manuel Santos Silva	01/09/2022	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
PN-COOP	HfPT-1	Héber Miguel Sobreira	01/10/2021	31/12/2025
PN-COOP	NGS-1	Germano Veiga	01/01/2023	31/12/2025
PN-COOP	PhenoBot-LA8.1-1	Filipe Neves Santos	01/10/2022	30/09/2025
PN-COOP	PhenoBot-LA8.3-1	Filipe Neves Santos	01/10/2022	30/09/2025
PN-COOP	PhenoBot-LA8.4-1	Filipe Neves Santos	01/10/2022	30/09/2025
PN-COOP	PhenoBot-LA8.5-1	Filipe Neves Santos	01/10/2022	30/09/2025
PN-COOP	Wine4Cast-LA8.1	Filipe Neves Santos	01/10/2022	30/09/2025
PN-COOP	Wine4Cast-LA8.3	Filipe Neves Santos	01/10/2022	30/09/2025
PN-COOP	Wine4Cast-LA8.4	Filipe Neves Santos	01/10/2022	30/09/2025
PN-COOP	Wine4Cast-LA8.5	Filipe Neves Santos	01/10/2022	30/09/2025
PUE-FP	AgRoBoFood	Filipe Neves Santos	01/06/2019	29/02/2024
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	AI4RWeld	Luís Freitas Rocha	17/01/2022	30/06/2023
PUE-FP	DIH4TAKING2	Rafael Lirio Arrais	01/05/2023	31/12/2023
PUE-FP	Waste2BioComp	Germano Veiga	01/06/2022	31/05/2025
PUE-FP	WATSON-1	Tatiana Martins Pinho	01/03/2023	28/02/2026
PUE-FP	MomaFlex	Luís Freitas Rocha	01/01/2023	31/12/2024
PUE-FP	PEER-1	Luís Freitas Rocha	01/10/2023	30/09/2027

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PUE-FP	AI4ENGINE	Rafael Lírio Arrais	01/01/2023	31/12/2023
SERV-NAC	Smart-Fertilizers	Filipe Neves Santos	01/01/2019	30/09/2023
SERV-NAC	ROBOCARE	Filipe Neves Santos	01/03/2020	31/12/2023
SERV-NAC	VINCI7D	Manuel Santos Silva	01/09/2020	31/12/2023
SERV-NAC	BRAINY	Luís Freitas Rocha	01/09/2021	31/01/2023
SERV-NAC	Vision2Control	Luís Freitas Rocha	01/10/2022	31/07/2023
SERV-NAC	OptiLog7Fluxos-1	António Paulo Moreira	18/07/2022	31/12/2023
SERV-NAC	FARO	António Paulo Moreira	01/10/2022	31/12/2023
SERV-NAC	Lever_AdDP	Joaquim João Sousa	07/12/2022	30/09/2023
SERV-NAC	Works_TechAgrob	Filipe Neves Santos	16/10/2023	15/11/2023
SERV-NAC	Estaleiro40-1	Reinaldo Silva Gomes	01/05/2023	31/01/2024
SERV-NAC	PFAI4_4eD-2	Luís Freitas Rocha	03/05/2023	02/07/2023
SERV-NAC	ARTURO	Marcelo Petry	01/09/2023	31/12/2023
SERV-NAC	AdvisoryAR	Germano Veiga	01/12/2023	31/12/2023
SERV-INT	BeamAutoLogSim-1	Germano Veiga	01/11/2023	31/01/2024
SERV-INT	BOWI_ARRobot-2	Germano Veiga	10/02/2023	31/12/2023
OP	Orioos	André Silva Aguiar	01/01/2023	31/12/2023

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

List of publications

International Journals with Scientific Referees

1. Aguiar, A, dos Santos, FN, Santos, L, Sousa, AJ, Cunha, JB, "Topological map-based approach for localization and mapping memory optimization", J. Field Robotics, vol.40, no.3, pp.447-466, May, 2023
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Blank

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1. Cascalho, JM, Tokhi, MO, Silva, MF, Mendes, AB, Goher, KM, Funk, M, "Robotics in Natural Settings - CLAWAR 2022, Ponta Delgada, Portugal, 12-14 September, 2022", CLAWAR, vol.530, 2023

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1. Aguiar de Souza, J. P., "Adaptive Grasping Planning: A Novel Unified and Modular Grasping Pipeline Architecture"
2. Silva Pinto de Aguiar, A., "Localization and Mapping Based on Semantic and Multi-layer Maps Concepts"

10.8 CEGI – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CEGI research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.43 - CEGI – Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	6	7	13	6
		Academic Staff	18	19	18	-1
		Grant Holders and Trainees	24	24	29	5
		Total Core Researchers	48	50	60	10
		Total Core PhD	26	26	29	3
	Affiliated Researchers		6	5	5	0
	Administrative and Technical Employees		1	1	1	0
	Total Integrated HR		55	56	66	10
	Total Integrated PhD		32	31	34	3

Table 10.44 - CEGI – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes - FCT	297	107	165	58
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	39	98	239	141
PUE-FP	EU Framework Programmes	267	478	512	34
PUE-DIV	EU Cooperation Programmes - Other	3	11		-11
SERV-NAC	R&D Services and Consulting - National	119	137	35	-103
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	2		-2	-2
Total Funding		725	832	949	117

Table 10.45 - CEGI – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	37	63	61
Indexed Conferences	8	14	15
Books	1		
Book Chapters	2	5	5
Concluded PhD Theses - Members	4	7	1
Concluded PhD Theses – Supervised	5	10	2

Table 10.46 - CEGI – Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
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)			
Spin-offs established			
Spin-offs in development			2

Table 10.47 - CEGI – Summary of participation in dissemination activities

Type of Activity	2023
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)	5
International events in which INESC TEC members participate in the program committees	12
Participation in events such as fairs, exhibitions or similar	1
Conferences, workshops and scientific sessions organised by the Centre	
Participants in the conferences, workshops and scientific sessions organised by the Centre	
Advanced training courses organised by the Centre	

Table 10.48 - CEGI – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	BeFresh	Pedro Amorim	01/01/2022	31/12/2024
PN-FCT	CIBELE	José Fernando Oliveira	01/03/2023	31/08/2024
PN-FCT	MOSH	Beatriz Brito Oliveira	01/01/2023	30/06/2024
PN-FCT	TacitRouting	António Galvão Ramos	01/03/2023	31/08/2024
PN-FCT	eduBEST	Ana Camanho	01/02/2023	31/01/2026
PN-COOP	TRF4p0-1	Luís Guimarães	01/07/2020	01/07/2023
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	InsectERA-2	Pedro Amorim	01/01/2023	31/12/2025
PN-COOP	Produtech_R3-1	António Galvão Ramos	01/09/2022	31/12/2025
PN-COOP	SMARTgNOSTICS	Luís Guimarães	01/01/2023	31/12/2025
PUE-FP	XFLEX_HIDRO-1	Armando Leitão	01/09/2019	29/02/2024
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	FIRE_RES-2	Jorge Daniel Teixeira	01/12/2021	01/12/2025
PUE-FP	OpenInnoTrain-1	Lia Patrício	01/01/2019	30/06/2024
PUE-FP	PEER	Fábio Silva Moreira	01/10/2023	30/09/2027
SERV-NAC	BestOrder3	Mário Amorim Lopes	01/03/2022	30/10/2023
SERV-NAC	CAREVIEW	Mário Amorim Lopes	01/06/2023	31/05/2024
SERV-NAC	TIIM_TS-1	Marta Campos Ferreira	15/05/2023	31/12/2023

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

List of publications

International Journals with Scientific Referees

1. Abrantes, D, Ferreira, MC, Costa, PD, Hora, J, Felício, S, Dias, TG, Coimbra, M, "A New Perspective on Supporting Vulnerable Road Users' Safety, Security and Comfort through Personalized Route Planning", International journal of environmental research and public health, vol.20, no.4, pp.3027, 2023
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3. Barbosa, M, Pedroso, JP, Viana, A, "A data-driven compensation scheme for last-mile delivery with crowdsourcing", Computers & Operations Research, vol.150, pp.106059, 2023
4. Barros, D, Ferreira, MC, Silva, AR, "A review on urban traffic cameras: Video image processing techniques and applications", Advances in Transportation Studies, vol.59, pp.179-192, 2023

5. Biró, P, Klijn, F, Klimentova, X, Viana, A, "Shapley-Scarf Housing Markets: Respecting Improvement, Integer Programming, and Kidney Exchange", *Mathematics of Operations Research*, 2023
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2. Camanho, A; Stumbriene, D; Barbosa, F; Jakaitiene, A, Are The Trends of Education and Training Systems In European Countries Improving and Converging?, EDULEARN, 2023
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4. Gonçalves, JM, Ferreira, MC, Dias, TG, Gonçalves, MJA, "Methodological Approach for the Definition of Urban Tourist Patterns Through Data Mining", Smart Innovation, Systems and Technologies, vol.345, pp.557-573, 2023
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7. Oliveira, JPF, Fontes, T, Galvao, T, "The Impact of CNG on Buses Fleet Decarbonization: A Case Study", Smart Energy for Smart Transport, CSUM2022, vol.Part F1378, pp.606-620, 2023
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9. Sena, I; Mendes, J; Fernandes, FP; Pacheco, MF; Vaz, C; Pires, AAC; Maia, JP; Pereira, AI, Cluster ING analysis – A case study, ICNAAM, 2023
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11. Sousa, H, Pasquali, A, Jorge, A, Santos, CS, Lopes, MA, "A Biomedical Entity Extraction Pipeline for Oncology Health Records in Portuguese", Proceedings of the 38th ACM/SIGAPP Symposium on Applied Computing, SAC 2023, Tallinn, Estonia, March 27-31, 2023, pp.950-956, 2023
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15. Yamada, L, Rampazzo, P, Yamada, F, Guimarães, L, Leitão, A, Barbosa, F, "Multiobjective Evolutionary Clustering to Enhance Fault Detection in a PV System", Springer Proceedings in Mathematics and Statistics, vol.437, pp.227-242, 2023

Books

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Chapter/Paper in Books

1. Camanho, S, D'Inverno, G, "Data Envelopment Analysis: A Review and Synthesis", Lecture Notes in Economics and Mathematical Systems, vol.692, pp.33-54, 2023
2. Camanho, S, Zanella, A, Moutinho, V, "Benefit-of-the-Doubt Composite Indicators and Use of Weight Restrictions", Lecture Notes in Economics and Mathematical Systems, vol.692, pp.93-112, 2023
3. Do Espírito Santo Faria, RM, Torres, AI, Beirão, G, "Trustworthy artificial intelligence and machine learning: Implications on users' security and privacy perceptions", Confronting Security and Privacy Challenges in Digital Marketing, pp.73-94, 2023
4. Gonçalves, JM, Ferreira, MC, Dias, TG, Gonçalves, MJA, "Methodological Approach for the Definition of Urban Tourist Patterns Through Data Mining", Smart Innovation, Systems and Technologies, 2023
5. Piran, FS, Camanho, S, Silva, MC, Lacerda, DP, "Internal Benchmarking for Efficiency Evaluations Using Data Envelopment Analysis: A Review of Applications and Directions for Future Research", Lecture Notes in Economics and Mathematical Systems, vol.692, pp.143-162, 2023

Publications (Editor)

Blank

Dissertations (PhD)

1. Fernandes, H., "Decision Support Tools for Water Utility Management: Using Optimisation and Frontier Methods for Continuous Improvement"

10.9 CITE – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CITE research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.49 - CITE – Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	5	5	7	2
		Academic Staff	2	2	2	0
		Grant Holders and Trainees	1	1	3	2
		Total Core Researchers	8	8	12	4
		Total Core PhD	4	5	6	1
	Affiliated Researchers		2	2	2	0
	Administrative and Technical Employees		0	0	0	0
	Total Integrated HR		10	10	14	4
	Total Integrated PhD		6	7	8	1

Table 10.50 - CITE – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT				
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	14	7	126	120
PUE-FP	EU Framework Programmes	158	331	212	-119
PUE-DIV	EU Cooperation Programmes - Other		45	54	9
SERV-NAC	R&D Services and Consulting - National	17	23	2	-21
SERV-INT	R&D Services and Consulting - International	30		28	28
OP	Other Funding Programmes				
Total Funding		218	406	422	15

Table 10.51 - CITE – Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	18	21	22
Indexed Conferences	4	6	1
Books			
Book Chapters	9	8	4
Concluded PhD Theses - Members	1		
Concluded PhD Theses – Supervised	1		

Table 10.52 - CITE – Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
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 10.53 - CITE - Summary of participation in dissemination activities

Type of Activity	2023
Participation as principal editor, editor or associated editor in journals	1
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	2
Participation in events such as fairs, exhibitions or similar	4
Conferences, workshops and scientific sessions organised by the Centre	12
Participants in the conferences, workshops and scientific sessions organised by the Centre	120
Advanced training courses organised by the Centre	

Table 10.54 - CITE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-COOP	InsectERA-1	Sara Correia Neves	01/01/2023	31/12/2025
PN-COOP	AgendaTransform-3	Sara Correia Neves	01/10/2022	31/12/2025
PN-COOP	ATE-2	Alexandra Xavier	01/01/2023	31/12/2025
PN-COOP	HfPT-6	Cristina Machado Guimarães	01/10/2021	31/12/2025
PN-COOP	NEXUS-4	Alexandra Xavier	01/10/2022	31/12/2025
PUE-DIV	EEN2022	Alexandra Xavier	15/01/2022	15/07/2025
PUE-FP	FIRE_RES	Alexandra Xavier	01/12/2021	01/12/2025
PUE-FP	VR2Care-1	Cristina Machado Guimarães	01/01/2022	30/06/2024
PUE-FP	OpenInnoTrain-3	Alexandra Xavier	01/01/2019	30/06/2024
PUE-FP	SoTecInFactory-1	Cristina Machado Guimarães	01/06/2022	31/05/2025
PUE-FP	TECH2MARKET	Alexandra Xavier	01/01/2022	31/12/2022
PUE-FP	Every1-1	José Coelho Rodrigues	01/11/2022	30/04/2026
PUE-FP	TURING2	Alexandra Xavier	01/01/2023	31/12/2023
PUE-FP	TransPathCO2	Cristina Maria Barbosa	01/01/2023	31/05/2023
PUE-FP	AI4REALNET-3	Alexandra Xavier	01/10/2023	31/03/2027
PUE-FP	EITJumpstarter23	Alexandra Xavier	17/05/2023	16/11/2023
PUE-FP	EITJumpUkraine23	Cristina Maria Barbosa	01/01/2023	15/10/2023
SERV-NAC	AuditAgro	Alexandra Xavier	02/03/2023	29/04/2023
SERV-INT	BOWI_EyeSense-1	Alexandra Xavier	13/03/2023	12/04/2023
SERV-INT	BOWI_DmPlan-1	Alexandra Xavier	06/02/2023	30/06/2023
SERV-INT	BOWI_ViaNN-1	Alexandra Xavier	10/02/2023	30/06/2023
SERV-INT	BOWI_ARRobot-1	Alexandra Xavier	10/02/2023	31/12/2023

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

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10.10 HUMANISE – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present HUMANISE research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.55 - HumanISE - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	11	14	19	5
		Academic Staff	27	33	36	3
		Grant Holders and Trainees	43	45	35	-10
		Total Core Researchers	81	92	90	-2
		Total Core PhD	31	38	41	3
	Affiliated Researchers		16	18	21	3
	Administrative and Technical Employees		1	1	1	0
	Total Integrated HR		98	111	112	1
	Total Integrated PhD		47	56	62	6

Table 10.56 - HumanISE – Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes - FCT	221	109	59	-50
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	98	226	701	475
PUE-FP	EU Framework Programmes	786	943	623	-320
PUE-DIV	EU Cooperation Programmes - Other	45	76	147	72
SERV-NAC	R&D Services and Consulting - National	354	450	470	20
SERV-INT	R&D Services and Consulting - International	26	12		-12
OP	Other Funding Programmes	6	1		
Total Funding		1 535	1 816	2 001	185

Table 10.57 - HumanISE - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	49	71	90
Indexed Conferences	88	108	85
Books	1		1
Book Chapters	5	4	1
Concluded PhD Theses - Members	2	7	4
Concluded PhD Theses - Supervised	18	11	8

Table 10.58 - HumanISE - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre-Disclosures (PDF)	1	5	4
Technology Disclosures (TDF)	1	1	
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted			1
Commercial Contracts (Licences, Options, Assignments)			1
Spin-offs established			
Spin-offs in development			

Table 10.59 - HumanISE - Summary of dissemination activities

Type of Activity	2023
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)	12
International events in which INESC TEC members participate in the program committees	37
Participation in events such as fairs, exhibitions or similar	7
Conferences, workshops and scientific sessions organised by the Centre	
Participants in the conferences, workshops and scientific sessions organised by the Centre	
Advanced training courses organised by the Centre	

Table 10.60 - HumanISE - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	EPISA	Carla Lopes	01/01/2019	31/12/2022
PN-FCT	FronTowns	Leonel Morgado	20/03/2021	19/03/2025
PN-FCT	SpecRep-1	Ana Cristina Paiva	01/01/2022	31/12/2023
PN-FCT	DBoidS	João Barroso	01/01/2022	31/12/2024
PN-FCT	EESDataLab	Alexandre Carvalho	22/03/2022	21/06/2023
PN-FCT	Osler	Nuno Feixa Rodrigues	01/03/2023	31/08/2024
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	30/06/2023
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
PN-COOP	AgendaTransform-5	José Correia	01/10/2022	31/12/2025
PN-COOP	TEXPACT-3	Lino Oliveira	01/07/2022	31/12/2025
PN-COOP	HfPT-5	Artur Rocha	01/10/2021	31/12/2025
PN-COOP	NewSpacePortugal-2	Marco Amaro Oliveira	01/10/2022	31/12/2025
PN-COOP	FAIST-1	Lino Oliveira	01/06/2022	31/05/2025
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	Maria van Zeller	28/02/2022	27/05/2024
PUE-DIV	WavyNOS	Artur Rocha	06/06/2022	30/04/2024
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	PAFSE	Paulo Martins	01/09/2021	31/08/2024
PUE-FP	VR2Care	Hugo Paredes	01/01/2022	30/06/2024
PUE-FP	ILIAD	Artur Rocha	01/02/2022	01/02/2025
PUE-FP	EUGLOHRIA	Gabriel David	01/01/2021	31/12/2023
PUE-FP	EPOSSP	Artur Rocha	10/02/2020	30/04/2023
PUE-FP	A-IQ Ready-1	João Bispo	01/01/2023	31/12/2025
PUE-FP	RECONNECTED	Gonçalo Campos Gonçalves	01/06/2023	30/11/2027
PUE-FP	PHASE IV AI-1	Artur Rocha	01/10/2023	30/09/2026
SERV-NAC	ARQNET3	José Correia	10/07/2021	30/09/2023
SERV-NAC	BPrepared	Fernando Cassola Marques	08/11/2021	31/12/2023
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	31/03/2023
SERV-NAC	MAP3	José Correia	15/09/2022	14/01/2024
SERV-NAC	SIGMAIA3	Ricardo Henriques	01/09/2022	30/11/2024
SERV-NAC	BankRoad2DataCtlg	José Correia	02/01/2023	30/04/2024

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	IT4IT	José Correia	01/04/2023	30/10/2023
SERV-NAC	eVote23	José Correia	29/05/2023	28/10/2023
SERV-NAC	ARSensor	Lino Oliveira	27/03/2023	30/09/2023
SERV-NAC	BankDigitalTransf	José Correia	01/09/2023	30/06/2024

Type of Project:

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

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3. Karimova, Y., "Research data description in multiple domains: supporting researchers with data management plans"
4. Sousa, S., "Trust in Computing: Trust as a facilitator on the uptake (or appropriation) of technology"

10.11 LIAAD – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present LIAAD research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.61 - LIAAD - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	8	7	11	4
		Academic Staff	22	23	23	0
		Grant Holders and Trainees	26	27	23	-4
		Total Core Researchers	56	57	57	0
		Total Core PhD	29	28	31	3
	Affiliated Researchers		8	7	7	0
	Administrative and Technical Employees		1	1	1	0
	Total Integrated HR		65	65	65	0
	Total Integrated PhD		37	35	68	3

Table 10.62 - LIAAD - Project funding

Funding Source		Total Income (k€)			Δ (k€) 2022-23
		2021	2022	2023	
PN-FCT	National R&D Programmes – FCT	196	122	96	-26
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	132	173	314	141
PUE-FP	EU Framework Programmes	83	69	106	36
PUE-DIV	EU Cooperation Programmes – Other	15	61	16	-45
SERV-NAC	R&D Services and Consulting – National	283	73	63	-10
SERV-INT	R&D Services and Consulting – International	8			
OP	Other Funding Programmes	22		14	14
Total Funding		739	498	608	110

Table 10.63 - LIAAD - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	44	60	60
Indexed Conferences	45	47	58
Books		2	2
Book Chapters	4	8	8
Concluded PhD Theses - Members	2	2	2
Concluded PhD Theses - Supervised	4	2	7

Table 10.64 - LIAAD - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre Disclosures (PDF)	1	1	1
Technology Disclosures (TDF)		1	1
First Priority Patent Applications (New inventions)			1
First Patents Internationalisation			
First Patents Granted			
Commercial Contracts (Licences, Options, Assignments)			1
Spin-offs established			
Spin-offs in development			

Table 10.65 - LIAAD - Summary of dissemination activities

Type of Activity	2023
Participation as principal editor, editor or associated editor in journals	20
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	8
International events in which INESC TEC members participate in the program committees	45
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	300
Advanced training courses organised by the Centre	

Table 10.66 - LIAAD - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Text2Story	Alípio Jorge	14/11/2019	30/06/2023
PN-FCT	DAnon	João Vinagre	01/02/2022	31/01/2023
PN-FCT	StorySense	Alípio Jorge	01/03/2023	28/02/2026
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	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	HfPT-2	Alípio Jorge	01/10/2021	31/12/2025
PN-COOP	FAIST	Ricardo Teixeira Sousa	01/06/2022	31/05/2025
PN-COOP	Produtech_R3-4	Ricardo Teixeira Sousa	01/09/2022	31/12/2025
PUE-DIV	XPM	João Gama	01/03/2021	29/02/2024
PUE-DIV	ATTRACT_DIH	Ricardo Teixeira Sousa	01/10/2022	30/09/2025
PUE-FP	HumanE-AI-Net	João Gama	01/09/2020	31/08/2024
PUE-FP	EMERITUS	João Gama	01/09/2022	31/08/2025
PUE-FP	AI4REALNET-4	Pedro Gabriel Ferreira	01/10/2023	31/03/2027
PUE-FP	AIBOOST	João Gama	01/09/2023	28/02/2027
SERV-NAC	PAFML	Alípio Jorge	30/06/2020	30/06/2023
SERV-NAC	THEIA-3	Alípio Jorge	03/01/2022	30/09/2023
SERV-NAC	PAPVI	Ricardo Teixeira Sousa	15/10/2022	31/03/2023
SERV-NAC	CAREVIEW-1	Alípio Jorge	01/06/2023	31/05/2024
SERV-NAC	PAPVI2	Ricardo Teixeira Sousa	01/06/2023	31/05/2024
OP	DS2023	João Gama	01/01/2023	31/12/2024

Type of Project:

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

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2. Martins, I, Resende, JS, Gama, J, "Online Influence Forest for Streaming Anomaly Detection", Advances in Intelligent Data Analysis XXI - Lecture Notes in Computer Science, pp.274-286, 2023

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1. Loureiro, D., “Learning Word Sense Representations from Neural Language Models”
2. Muhammad, S., “Domain-specific and Context-aware Approaches to Sentiment Analysis”

10.12 CRACS – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present CRACS research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.67 - CRACS - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	1	1	2	1
		Academic Staff	16	16	16	0
		Grant Holders and Trainees	19	14	14	0
		Total Core Researchers	36	31	32	1
		Total Core PhD	17	16	17	1
	Affiliated Researchers		1	2	0	-2
	Administrative and Technical Employees		0	0	0	0
	Total Integrated HR		37	33	32	-1
	Total Integrated PhD		18	18	17	-1

Table 10.68 - CRACS - Project funding

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT	2			
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry			19	19
PUE-FP	EU Framework Programmes			84	84
PUE-DIV	EU Cooperation Programmes – Other	60	96	34	-61
SERV-NAC	R&D Services and Consulting – National	35	85	93	7
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	8	5		-5
Total Funding		106	186	230	44

Table 10.69 - CRACS - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	38	20	15
Indexed Conferences	30	34	25
Books			2
Book Chapters		4	3
Concluded PhD Theses - Members	5	2	3
Concluded PhD Theses – Supervised	6	2	4

Table 10.70 - CRACS - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre-Disclosures (PDF)			
Technology Disclosures (TDF)			
First Priority Patent Applications (New inventions)			
First Patents Internationalisation			
First Patents Granted	1		1
Commercial Contracts (Licences, Options, Assignments)			
Spin-offs established			
Spin-offs in development			

Table 10.71 - CRACS - Summary of dissemination activities

Type of Activity	2023
Participation as principal editor, editor or associated editor in journals	10
Conferences organised by INESC TEC members (in the organising committee or chairing technical committees)	15
International events in which INESC TEC members participate in the program committees	34
Participation in events such as fairs, exhibitions or similar	2
Conferences, workshops and scientific sessions organised by the Centre	
Participants in the conferences, workshops and scientific sessions organised by the Centre	
Advanced training courses organised by the Centre	

Table 10.72 - CRACS - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-COOP	BLOCKCHAINPT-1	António Pinto	01/09/2022	31/08/2025
PUE-DIV	FGPEPlus	Ricardo Queirós	01/06/2021	31/05/2023
PUE-DIV	FGPEPlusPlus	Ricardo Queirós	01/10/2023	30/09/2025
PUE-FP	PRIVATEER	António Pinto	01/01/2023	31/12/2025
PUE-DIV	JuezLTI	Ricardo Queirós	01/05/2021	30/04/2023
SERV-NAC	THEIA-1	Rolando Martins	03/01/2022	30/09/2023

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

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10.13 HASLAB – ACTIVITY RESULTS IN 2023

Activity indicators

The following tables present HASLab research team composition and evolution and the main indicators of its activity carried out in 2023 - participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2023 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 10.73 - HASLab - Research team composition

Type of Human Resources			2021	2022	2023	Δ 2022-23
Integrated HR	Core Research Team	Employees	8	7	8	1
		Academic Staff	21	23	25	2
		Grant Holders and Trainees	32	42	46	4
		Total Core Researchers	61	72	79	7
		Total Core PhD	26	28	29	1
	Affiliated Researchers		6	7	6	-1
	Administrative and Technical Employees		2	3	5	2
	Total Integrated HR		69	82	90	8
	Total Integrated PhD		32	34	35	1

Table 10.74 - HASLab - Project funding Table

Funding Source		Total Income (k€)			Δ (k€)
		2021	2022	2023	2022-23
PN-FCT	National R&D Programmes – FCT	252	84	106	21
PN-PICT	National R&D Programmes - S&T Integrated Projects				
PN-COOP	National Cooperation Programmes with Industry	217	234	357	123
PUE-FP	EU Framework Programmes	130	195	370	175
PUE-DIV	EU Cooperation Programmes – Other			27	27
SERV-NAC	R&D Services and Consulting – National	459	431	269	-162
SERV-INT	R&D Services and Consulting - International	85	15	5	-10
OP	Other Funding Programmes	29	25	193	168
Total Funding		1 173	984	1 326	343

Table 10.75 - HASLab - Summary of publications by members of the Centre

Publication Type	Total Publications		
	2021	2022	2023
Indexed Journals	14	15	23
Indexed Conferences	42	38	47
Books			
Book Chapters	2		1
Concluded PhD Theses - Members	2	3	2
Concluded PhD Theses – Supervised	2	3	2

Table 10.76 - HASLab - Summary of IP protection, exploitation and technology transfer

Type of Result	2021	2022	2023
Pre Disclosures (PDF)	3	3	
Technology Disclosures (TDF)		2	2
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 10.77 - HASLab - Summary of participation in dissemination activities

Type of Activity	2023
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)	8
International events in which INESC TEC members participate in the program committees	34
Participation in events such as fairs, exhibitions or similar	4
Conferences, workshops and scientific sessions organised by the Centre	1
Participants in the conferences, workshops and scientific sessions organised by the Centre	82
Advanced training courses organised by the Centre	1

Table 10.78 - HASLab - List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	SAFER	Alcino Cunha	01/07/2018	15/10/2021
PN-FCT	IBEX	Renato Jorge Neves	01/01/2022	31/12/2024
PN-FCT	SpecRep	Nuno Moreira Macedo	01/01/2022	31/12/2023
PN-FCT	FLEXCOMM	João Marco	01/01/2022	30/12/2023
PN-COOP	BigHPC	João Tiago Paulo	31/03/2020	30/06/2023
PN-COOP	AIDA	Ricardo Pereira Vilaça	12/05/2020	30/06/2023
PN-COOP	ATE-4	Fábio André Coelho	01/01/2023	31/12/2025
PN-COOP	NewSpacePortugal-1	Ana Nunes Alonso	01/10/2022	31/12/2025
PUE-DIV	ATTRACT_DIH-3	João Carlos Barbosa	01/10/2022	30/09/2025
PUE-DIV	EuroCC2	Rui Carlos Oliveira	01/01/2023	31/12/2025
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	30/09/2023
PUE-FP	ENERSHARE-1	Fábio André Coelho	01/07/2022	30/06/2025
PUE-FP	BeFlexible -1	Fábio André Coelho	01/09/2022	31/08/2026
PUE-FP	Green_Dat_AI-1	Fábio André Coelho	01/01/2023	31/12/2025
SERV-NAC	IoT4Distribuicao-1	Fábio André Coelho	04/01/2021	31/12/2023
SERV-NAC	DigiLightRail	Alcino Cunha	26/10/2020	31/03/2023
SERV-NAC	SIS	Ana Nunes Alonso	12/02/2021	31/12/2023
SERV-NAC	IDINA	João Marco	20/10/2021	01/09/2024
SERV-NAC	STDCNCS	João Marco	10/12/2021	30/09/2023
SERV-NAC	THEIA-2	Manuel Barbosa	03/01/2022	30/09/2023
SERV-NAC	AURORA-1	António Luís Sousa	01/10/2022	31/05/2023
SERV-NAC	ENSCOMP2	José Nuno Oliveira	01/07/2023	30/09/2023
SERV-NAC	ENSCOMP3	José Nuno Oliveira	15/11/2023	14/02/2025
SERV-INT	AlloyAibex	Alcino Cunha	05/03/2023	09/05/2023
OP	Sustainable HPC-1	António Luís Sousa	01/07/2021	30/06/2025
OP	Deucalion	António Luís Sousa	01/01/2023	31/12/2024

Type of Project:

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

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