INSTITUTO DE ENGENHARIA
DE SISTEMAS E COMPUTADORES,
TECNOLOGIA E CIÊNCIA

INESCTEC

INESC TEC
ACTIVITY PLAN
2018

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1 INTRODUCTION

This document presents INESC TEC Plan of Scientific and Technological Activities for the year 2018.

Section 2 offers a summarized presentation of INESC TEC institution, its scope, mission, vision, strategy and organisational model. Section 3 presents the main activity indicators planned for 2018, including Human Resources, Activity in Projects and Publications.

The research at INESC TEC is developed in 13 Research Centres, under four stable structures denoted as Clusters: Computer Science (CS), Industry and Innovation (II), Networked Intelligent Systems (NIS), and Power and Energy (PE). Section 4 presents these four Clusters and their objectives for the short and medium term.

Section 5 presents the Scientific and Technological Activities planned by the 13 Research Centres for 2018, including their objectives, activity plan and activity indicators for 2018, following the same order of the Clusters in Section 4.

Section 6 focus on the TEC4 initiatives articulating INESC TEC's activity towards the market and details the vision and high-level objectives for the ongoing initiatives in the following domains: SEA, AGRO, ENERGY, INDUSTRY, HEALTH AND MEDIA.

Section 7 introduces two "special" projects that run at INESC TEC: UT Austin Portugal Program and the Digital Competences National Initiative (k.2030).

Finally, Section 8 presents INESC TEC Support Services, including the Business Development Services, the Management and Organisation Services and the Technical Support Services.

2 INESC TEC PRESENTATION

2.1 Scope and Mission

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

INESC TEC's associates are the University of Porto, INESC and the Polytechnic Institute of Porto, and the University of Minho and the University of Trás-os-Montes e Alto Douro are privileged partners. Presently, the main sites are located in the cities of Porto, Braga and Vila Real.

The 13 R&D Centres of INESC TEC are structured in four thematic domains, leading to four Clusters - Computer Science, Industry and Innovation, Networked Intelligent Systems, and Power and Energy – hosting, at the end of 2017, 687 integrated researchers (301 PhDs), including staff researchers, researchers from Higher Education Institutions, grant holders and affiliated researchers. INESC TEC's team also includes trainees and technical and administrative support staff.

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

The mission of INESC TEC is to achieve advancement in science and technology and to enable science-based innovation through the transfer of new knowledge and technologies to industry, services and public administration.

2.2 Vision

INESC TEC vision is to be a leading Science and Technology Institution at international level, perceived as an important world player, in the domains of Computer Science, Industry and Innovation, Networked Intelligent Systems and Power and Energy.

The scientific objectives for 2018-2022 are in line with the response to the CHALLENGE OF PERVASIVE INTELLIGENCE that INESC TEC continues to face head on. This response is made possible by the processes put in place at INESC TEC that promote and facilitate multi-disciplinary cooperation and can therefore link sensors to communications, systems, data, knowledge, models, decision and action.

In a very brief summary, INESC TEC goals per Cluster include (more details can be found in the Clusters and Centres sections below):

- POWER AND ENERGY - Service-oriented energy management systems for a cyber-secure and dynamic energy system; hybridization of artificial intelligence techniques with distributed and parallel architectures and processes for operation and forecasting; advanced dynamic behaviour modelling and analysis including synthetic inertia to assure systems robustness and survival for large scale intermittent renewables scenarios.
- NETWORKED INTELLIGENT SYSTEMS - Prediction, detection and diagnosis in cancer by combining computer vision and artificial intelligence; new photonic sensors in fibre and planar platforms, wearable devices, hyperspectral imaging; deep sea challenges overcome with new vehicles developed, sensors and new subsystems for navigation integrated, broadband wireless communications and wireless energy transfer underwater.
- COMPUTER SCIENCE - Management, analytics and novel visualisation techniques for stationary and streamed big data; usable and scalable techniques of computation over encrypted data, multi-party and verifiable outsourced computation; intelligent immersive virtual environments and inclusive HCI with multi-sensorial immersion in augmented and virtual reality.

- INDUSTRY AND INNOVATION - Customer-centric production optimisation 'on the fly' in real time, decentralization of decisions, mass customization and use of collaborative robots; novel vertical IoT-based information architectures; collaborative mobile manipulators and human-robot collaboration, integrated in the IoT paradigm; conditions and enablers for the adoption of new business concepts and models of Cyber-Physical Production Systems.

These scientific targets are complemented by knowledge valorisation and technology transfer targets, structured by INESC TEC in the form of the TEC4 initiatives. These are presented and materialise the effect of the market pull driver into R&D, as opposed (or complementary) to the science push drivers referred to above. Six TEC4 initiatives are organized to address challenges in different markets/domains (SEA, AGRO, ENERGY, INDUSTRY, HEALTH AND MEDIA), all cross-cutting the R&D organization in Centres and Clusters. They are not seen as science challenges, but drivers for a social/economic relevance of the science developed. Their success is measured not only by the number of direct contracts with industry transferring technology, but also by the number of multi-disciplinary/multi-Centre projects promoted.

2.3 Strategy

INESC TEC's strategy is driven by the following main axes:

- Excellence in: science, talent development, technology transfer and collaboration with industry;
- Full coverage of the knowledge-to-value chain;
- Multi-disciplinarity;
- Scale, density, critical mass and integration;
- International visibility and presence.

2.3.1 Excellence in science

Without excellence, all aspiration to world recognition and relevant impact in leading companies is void of hope. Therefore, the resolve in making robust a culture of demanding responsibility, quality, accountability, productivity of advanced science must be sustained at all cost. Most of all, incentives and recognition to high level science and researchers must be present. At INESC TEC, the classical indicator of quality (papers in international journals) has witnessed a steady growth that has moved the ratio papers/researcher to a reference value at international level for the areas of activity covered. A continued effort in pursuing excellence and valuing excellence as the trade mark of INESC TEC is one of the foundations of the institution.

2.3.2 Excellence in talent development

The deep involvement in Doctoral Programmes is an underlying condition to have access to human resources for conducting excellent research and publishing its results. INESC TEC must be able to add value to Doctoral Programmes in the several institutions that are in one way or another associated to the Institution. In particular, the MAP (Minho-Aveiro-Porto) programmes in computer science and in telecommunications, as they join the strongest schools in the north of Portugal, should be examined as possible models to be extended to other areas. A requirement to take this step forward is the strengthening of the natural strategic alliance between INESC TEC and the Department/Schools /Universities to reinforce these programmes.

2.3.3 Excellence in technology transfer and collaboration with industry

The other side of the coin representing INESC TEC - as an interface organization - must be the capacity to produce socially relevant results and to transfer them to bring impact to the economic fabric. The relations with companies are crucial and INESC TEC must be perceived as a partner of excellence, able to provide unique knowledge and relevant technology for product, process, service and business model innovation in organisations. The requirement here is that all Research Centres of INESC TEC may contribute to this objective – either autonomously or by integrating a process of knowledge transfer with other Centres.

2.3.4 Managed Science Model

INESC TEC's management and operational model implements the concept of the knowledge-to-value production chain, driving the knowledge generation research activities to their valorisation through a mix of processes of technology transfer, from technology licensing to collaborative development, advanced consulting, training and spin-off launching.

This concept is illustrated in a very simplified manner in the figure below, which depicts the division into four stages: basic knowledge production; applied research; development; and technology transfer and valorisation.

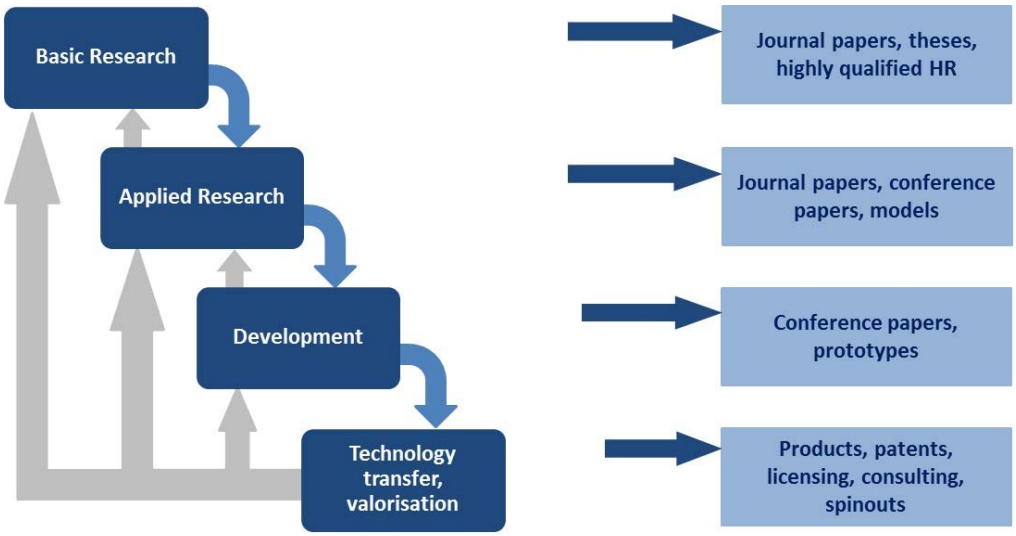

Figure 1 - Knowledge production and valorisation chain concept

The figure also shows some relevant outputs produced at each stage and the feedback links from downstream to upstream activities. The outputs at each stage also serve as performance indicators for the corresponding activity. As with any model depicting a complex reality, the divisions between the stages are fluid and not rigid.

The valorisation of research results through technology transfer and advanced consulting activities is essential to the economic sustainability of the institute and the interaction and collaboration with industry is essential for the identification of new research lines.

Each of the 13 INESC TEC Centres presents a distinct coverage of this chain. Some Centres are more research oriented and are therefore better positioned at the early stages, while others are more market oriented and thus their activity has a higher share in the later stages. The aim is not that each Centre encompasses the whole value chain, but their organisation must allow for knowledge to flow, not only within each Centre but also between Centres, so that INESC TEC as a whole and its four Clusters can perform socially relevant research and is able to transfer its results to relevant established companies, start-ups or other organisations. This means that INESC TEC focus on both science and technology transfer.

The success of this model relies on the ability to enable easy flows from top to bottom and feedbacks in the reverse direction. In order to achieve this, one does not require that each researcher should act on every stage of the chain but should instead focus where he/she feels comfortable to excell. There is thus a definite incentive for the Centres to have a large enough dimension so that they can accommodate a broad spectrum of activities with critical mass.

2.3.5 Multi-disciplinarity

In alignment with its focus on practical applications, INESC TEC seeks to facilitate the multi-disciplinary work that those applications typically require.

A special emphasis is placed on generating and supporting interaction among the several Centres. While the Clusters and the TEC4 initiatives, described in the Managed Science Model section, play a key infrastructural role towards this purpose, other measures have been implemented, which include, among others: incentive for research projects bringing together more than one Centre; encouragement of cooperation in co-authorship of papers with authors from different Centres; special actions, called Internal Seed Projects, put in place to allow inter-Center research and junior researcher development ; support to contract research with industry by teams constituted by members from several Centres; management and accounting procedures allowing a Centre to use resources (including researchers) from other Centres.

2.3.6 Scale, density, critical mass

INESC TEC's ambitious vision and mission require a level of scale and density that can only be made possible through its multi-institutional base model.

The resource endowment collaboratively brought to INESC TEC by its associates and privileged partners is continuously leveraged by the institution to sustain a level of growth and densification in the areas of knowledge that are critical for its activity, which is not only unique in the country, but also increasingly relevant in the international arena.

The challenge for the future will be a consistent effort to focus the activities and attract leading researchers to further reinforce INESC TEC's critical mass.

2.3.7 Integration

INESC TEC cannot run the risk of becoming a loose federation of almost independent Centres or its potential will be put in jeopardy. Some Centres at present have more than 100 researchers and therefore the risk of self-containment in each private universe is real.

The Clusters and the TEC4 initiatives are key instruments to support INESC TEC's policy for achieving institutional cohesion and maximising synergies, differentiation and impact. Overall, this policy seeks to strengthen the ties among Centres, by deepening cross-border fertilization, originating new science by fusion of knowledge and skills, and conducting multi-disciplinary research by truly multi-disciplinary teams.

2.3.8 International visibility and presence

One only exists when one is seen. Moreover, one is only valued when one is measured. The importance of international projects and activities is crucial to attain the status of international player. The long-term objective is to guarantee that the international activity of INESC TEC may be accounted as a significant part of the total activity, measured through scientific output as well as financial indicators. To reach excellence in science and technology, it is essential to collaborate and develop strong partnerships with leading international research institutions.

The first and most important undertaking is the consolidation of the massive presence in European research.

A second step is the constitution of a base of operations outside Portugal, to gain access to projects, funding, human resources and ultimately to conquer the status of multi-national organization. The operation in Brazil, with the constitution of INESC P&D Brasil and its recognition by the Brazilian S&T agencies as a Brazilian ICT (Institution of Science and Technology) must be understood under this perspective. The India Office aims to develop relevant bridges with important companies and public actors and support the attraction of students and post-docs.

2.4 Managed Science Model

2.4.1 Management

The management of INESC TEC is undertaken by a Board of Directors, composed of nine individuals. The Board acts in coordination with the Council of the Coordinators of R&D Centres, Clusters and Support Services, meeting

every other week. This ensures cross-centre coherency in vision and policy and joint responsibility and commitment, both in strategic and operational management decisions.

The external Scientific Advisory Board is another important body, whose composition reflects the diversity of areas and interests within INESC TEC. It has always had a relevant role in permanently auditing the institute scientific activity and counselling the Board. Its highly valued recommendations have been appreciated and implemented. The Business Advisory Board supports the Board in business development and industrial relations issues.

A group of advisors on specific scientific areas and business development, completes the management team. Performance is assessed at the end of each quarter, considering both economic and scientific perspectives. The deployment of the annual Plan of Activities is equally monitored. Each researcher is subject to an evaluation process every year and all the grant holders every three months. In order to provide the appropriate incentives, INESC TEC has in place a set of rewards from supplementary payments to publication prizes.

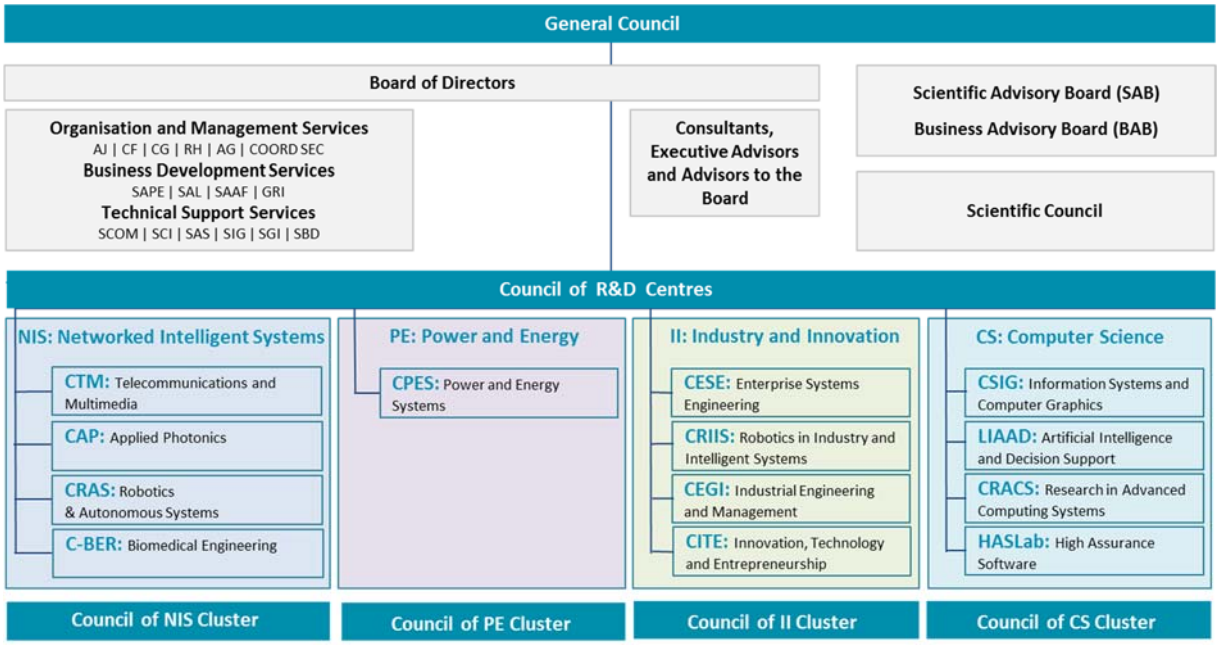

Figure 2 - INESC TEC Organisational Structure

2.4.2 Clusters

The research at INESC TEC is undertaken by the 13 Research Centres, organised in four stable structures denoted as Clusters (see the organisational chart above): Networked Intelligent Systems (NIS), Power and Energy (PE)), Industry and Innovation (II) and Computer Science (CS).

The Clusters are responsible for the research and development strategy and long term planning of each thematic domain. They gather together their “core” Centres in their specific domain and articulate and interface with other relevant Centres, denoted “associated” Centres. The strategy in a Cluster is formulated in collaboration between the Core and associated Centres. Each Cluster is coordinated by a Cluster leader and a Cluster Council. Performance indicators are consolidated at Cluster level to enable the proper planning for the next periods. Each Centre is nevertheless responsible for its own planning, strategy and resources and answers directly to the Board regarding its budget and performance indicators. Each Cluster is followed closely by two Members of the Board.

2.4.3 The TEC4 initiatives

The TEC4 initiatives articulate INESC TEC’s activity towards the market, defining the market strategy and planning INESC TEC’s interaction with its main markets or application areas. A TEC4 must not be confused with a Cluster: it is a process implementing a market pull vision and does not have a rigid core of Research Centres. Instead, a

TEC4 initiative structures and provides coherency to INESC TEC activity towards specific markets, integrating and articulating the competencies of the relevant Centres and Clusters.

A TEC4 is not driven by science but by a market of application domain perspective, where multidisciplinary interventions are usually necessary. A TEC4 initiative establishes a network of external contacts and dialogue with industrial partners and brings back to the several INESC TEC Centres major challenges and the identification of opportunities.

The TEC4s are not rigid or permanent structures. They are flexible, evolving and adaptive to external conditions and internal response. Presently six TEC4 initiatives are operating with different levels of maturity: TEC4Sea, TEC4Health, TEC4Agro-food, TEC4Media, TEC4Energy and TEC4Industry.

2.4.4 Support services

A streamlined and dynamic team of highly qualified technical and administrative personnel provides support to INESC TEC activities, aiming to alleviate researchers from desirably all administrative and bureaucratic burden.

A set of services are organized to support the researchers over the following domains: legal, project management, accounting, information management, human resources, computing and communications, communication and media. Furthermore, each research Centre has its autonomous administrative support, also with qualified staff at the same high level.

Area	Service Name
Business Development Services	Industrial Partnerships Technology Licencing Office Funding Opportunities Office International Relations Office
Management and Organisation Services	Finance and Accounting Management Control Human Resources Legal Support Management Support Secretarial Coordination
Technical Support Services	Communication Information Management Systems Networks and Informatics Systems Administration Infrastructures Management

3 MAIN INDICATORS FOR 2018

This section presents the main global indicators for INESC TEC, regarding human resources, activity in projects and scientific publications planned for 2018. The presentation of each Cluster and R&D Centre and detailed discussion of its objectives, activities and results is carried out in Sections 4 and 5, respectively for Clusters and Centres.

3.1 Human Resources

3.1.1 Global Indicators

Table 3.1 and Figure 3.1 show the breakdown of INESC TEC Human Resources by type of contractual link with INESC TEC and the expected evolution for 2018. The number of PhDs is also shown (354 planned at the end of 2018). In Figure 3.2 it can be seen that grant holders and trainees is the largest group of human resources (48%).

Table 3.1 – Evolution of INESC TEC Human Resources

Type of Human Resources			2016	2017	2018	Δ 2017-2018	
Integrated HR	Core Research Team	Employees	56	75	82	7	9%
		Academic Staff	200	192	194	2	1%
		Grant Holders and Trainees	400	452	366	-86	-19%
		Total Core Researchers	**656**	**719**	**642**	**-77**	**-11%**
		Total Core PhD	**283**	**306**	**301**	**-5**	**-2%**
	Affiliated Researchers		59	38	45	7	18%
	Management, Administrative and Technical	Employees	59	64	78	14	22%
		Academic Staff	8	8	8		0%
		Grant Holders and Trainees	25	19	7	-12	-63%
		Total Manag, Admin and Tech	**92**	**91**	**93**	**2**	**2%**
	Total Integrated HR		**807**	**848**	**780**	**-68**	**-8%**
	Total Integrated PhD		**347**	**353**	**354**	**1**	**0%**

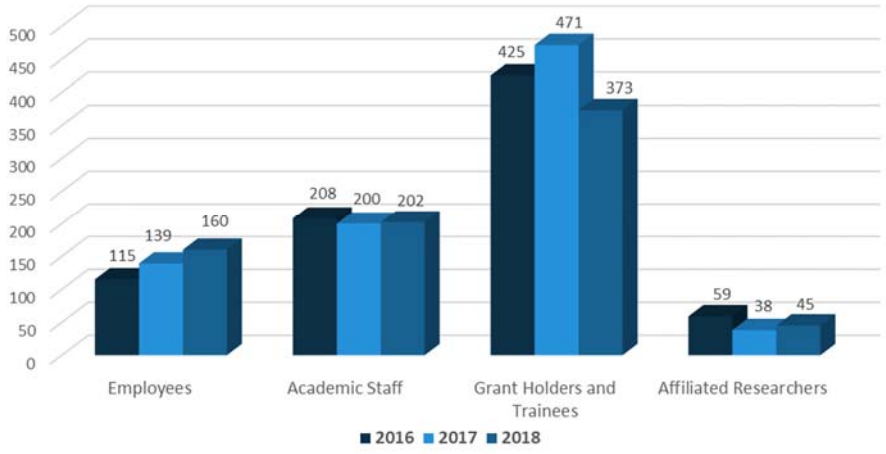

Figure 3.1 – Evolution of INESC TEC Human Resources

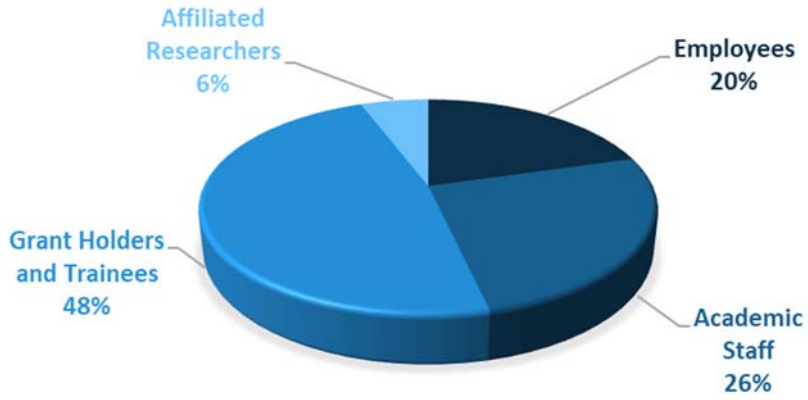

Figure 3.2 – Distribution of Human Resources (Plan 2018)

For 2018, the total number of integrated human resources decreases 8% and the number of integrated PhDs presents a marginal increase when compared with the numbers of 2017. The number of Human Resources planned for 2018 relates with the financial forecasts presented in section 3.2, which reflect the approach of the final phases of the large integrated projects and considers only ongoing projects and projects foreseen with a minimum level of certainty. The number of Human Resources, both for grant holders and PhD employees, is expected to increase along the year with the approval and start of new FCT, P2020 and European projects. The number of PhD employees is expected to increase beyond these figures, as the result of the implementation of the government policies for scientific employment.

There is a small increase on the number of human resources of the supporting services, with some grant holders and trainees being transferred to a contract position, to cope with the growth of the institute in the recent past. It is important to highlight that the percentage of increase in the support services staff is clearly lower than the increase in the global activity level of INESC TEC, reflecting an increased level of efficiency in these services.

3.1.2 R&D Centres Indicators

The detailed figures expected for the end of 2018 are given in Table 3.2 for each R&D Centre.

Table 3.2 – Human Resources by type and R&D Centre (Plan 2018)

Type of Human Resources			Total R&D Centres	R&D Centres													
				CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	CSIG	LIAAD	CRACS	HASLAB	Special Projects
Integrated HR	Core Research Team	Employees	**82**	8	5	9	2	19	13	6	1	2	12	1	1	3	
		Academic Staff	**194**	21	8	10	6	12	11	20	19	1	30	22	13	21	
		Grant Holders and Trainees	**366**	49	11	14	20	49	33	22	34	5	45	24	26	34	
		Total Core Researchers	**642**	**78**	**24**	**33**	**28**	**80**	**57**	**48**	**54**	**8**	**87**	**47**	**40**	**58**	
		Total Core PhD	**301**	**33**	**14**	**13**	**14**	**27**	**17**	**27**	**35**	**3**	**37**	**29**	**21**	**31**	
	Affiliated Researchers		**43**	5	1		4	3	2		4	5	15	4			
	Administrative and Technical	Employees	**17**	1	2	4		2	2	3	1		1		1		5
		Grant Holders and Trainees	**2**							1						1	
		Total Admin and Tech	**19**	1	2	4		2	2	4	1		1		1	1	5
	Total Integrated HR		**704**	**84**	**27**	**37**	**32**	**85**	**61**	**52**	**59**	**13**	**103**	**51**	**41**	**59**	**5**
	Total Integrated PhD		**341**	**38**	**15**	**13**	**18**	**30**	**18**	**27**	**39**	**7**	**50**	**33**	**21**	**32**	

R&D Centres:

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

3.1.3 Supporting Services Indicators

The figures expected for the end of 2018 for the Management Board and each Supporting Service is given in Table 3.3.

Table 3.3 –Human Resources by type and Service (Plan 2018)

Type of Human Resources		Total	Board and Advisors	Support Services														
				Operations and Management Services					Business Development Services				Technical Support Services					
				AG	AJ	CF	CG	RH	SAAF	SAPE	SAL	GRI	SCOM	SCI	SIG	SAS	SGI
Integrated HR	Employees	56	7	2	2	9	9	4	1	2	2		5	2	4	3	4
	Academic Staff	8	8														
	Grant Holders and Trainees	5					1			1	1		2				
	Affiliated Researchers	2	2														
	Total Integrated HR	**71**	**17**	**2**	**2**	**9**	**10**	**4**	**1**	**3**	**3**		**7**	**2**	**4**	**3**	**4**
	Total Integrated PhD	**13**	**10**			**1**				**1**	**1**						

Supporting Services:

AJ	Legal Support
CF	Accounting and Finance
CG	Management Control
RH	Human Resources
AG	Management Support [1]
SAAF	Funding Opportunities
SAPE	Industrial Partnerships
SAL	Technology Licensing
GRI	International Affairs
SCOM	Communication
SCI	Networks and Informatics
SIG	Business Informatics
SAS	System Administration
SGI	Infrastructures Management

[1] Includes Secretarial Coordination

3.2 Activity in Projects

3.2.1 Global Indicators

Table 3.4 shows the breakdown of INESC TEC funding sources and the expected evolution for 2018. Figure 3.3 illustrates the funding distribution from firm projects planned for 2018 and the comparison with the Plan for 2017.

Table 3.4 - Funding Sources and planned evolution

Sources			Value (k€) 2017	Value (k€) 2018	Δ (k€ | %) 2017-18	
Firm Projects	PN-FCT	National R&D Programmes - FCT	1 365	3 388	2 023	148%
	PN-PICT	National R&D Programmes - S&T Integrated Projects	2 748	1 965	-783	-28%
	PN-COOP	National Cooperation Programmes with Industry	1 168	1 337	169	14%
	PUE-FP	EU Framework Programmes	4 319	3 742	-577	-13%
	PUE-DIV	EU Cooperation Programmes - Other	454	796	342	75%
	SERV-NAC	R&D Services and Consulting - National	2 157	2 656	499	23%
	SERV-INT	R&D Services and Consulting - International	252	302	50	20%
	OP	Other Funding Programmes	1 113	962	-151	-14%
		Total Firm Projects	**13 576**	**15 148**	**1 572**	**12%**
Uncertain Projects			1 877	1 171	-706	-38%
National Strategic Programme - Pluriannual			3 062	2 600	-462	-15%
National Strategic Programmes - Other			126	125	-1	0%
Other Revenues			202	172	-30	-15%
		Total Revenues	**18 843**	**19 216**	**373**	**2%**

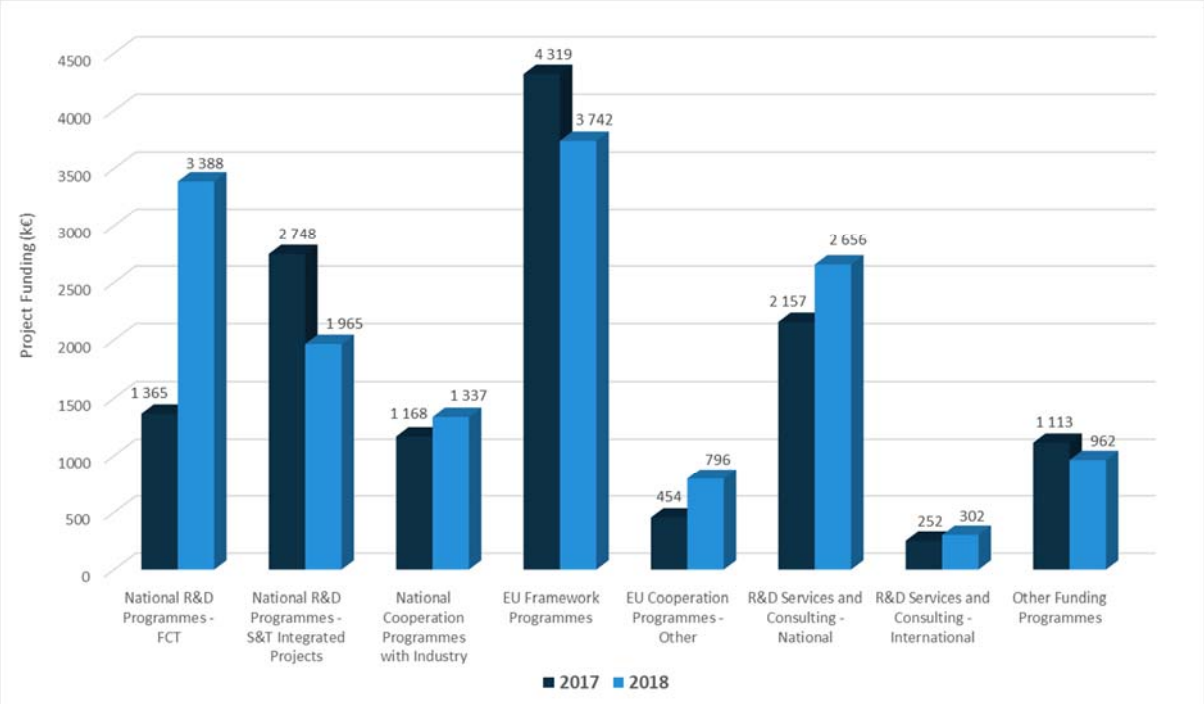

Figure 3.3 – Evolution of Funding Sources from Projects (k Euros)

Figure 3.4 shows the correspondent distribution from funding sources expected from firm projects, and the comparison with the previous plan.

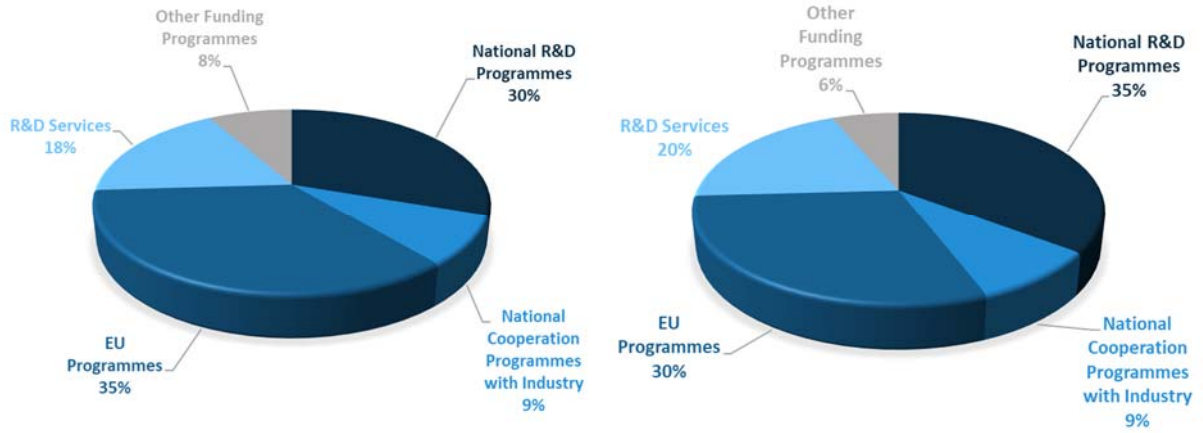

Figure 3.4 – Distribution of Funding Sources from Projects - Plan 2017 (left) and Plan 2018 (right)

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

Table 3.5 - Number of Firm Projects by Type and Average Funding (Plan 2018)

Type of Project		Total No.	Average Funding (k€)
PN-FCT	National R&D Programmes - FCT	34	100
PN-PICT	National R&D Programmes - S&T Integrated Projects	10	197
PN-COOP	National Cooperation Programmes with Industry	25	53
PUE-FP	EU Framework Programmes	33	113
PUE-DIV	EU Cooperation Programmes - Other	19	42
SERV-NAC	R&D Services and Consulting - National	74	36
SERV-INT	R&D Services and Consulting - International	13	23
OP	Other Funding Programmes	27	36
	Total	**235**	**64**

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

- The total revenue planned for 2018 accounts for 19.21 M€, 2% more than in 2017.
- There are several changes in the share of the different funding sources from 2017 to 2018. Funding from National R&D Programmes from FCT shows a large increase (148%), mainly justified by the start of the implementation of four large R&D infrastructures, two related with the Sea and two related with the Energy domains Financing from National programmes in cooperation with industry increases 14% with the start of new mobilizer projects and R&D projects in cooperation with companies within the scope of P2020 programme. The National S&T Integrated Projects show a reduction of 28%, because the ongoing projects are now in their last year and no new calls have been launched for this type of projects.

- The value indicated for National R&D Programmes from FCT includes 1.46 M€ for funding investments in the above-mentioned infrastructures (in the Sea and Energy domains), representing an increase of 473 K€ compared to 2017. This means that the operational revenue in this plan presents a small reduction compared to 2017.
- It is important to highlight that the budget for 2018 presents a significant reduction in the amount of uncertain projects (706 K€ less), which reflects, when compared to 2017, a much lower risk and a higher potential for increase along the year, as new projects are expected to be approved. This may also lead to the need to increase the number of core researchers.
- Funding from EU Programmes represents 30% of the activity planned for 2018. It shows a decrease when compared to 2017, mainly because the ending of FP7 has not been compensated totally by an equivalent increase of H2020 funding. These changes in the funding volume per programme type are nevertheless associated with the normal lifecycle of those programmes and the launch of specific calls for proposals.
- R&D and consulting Services present a relevant increase (23% at national level and 20% in projects at international level), following to a deliberate strategy to further reinforce the presence near industry and service companies.
- Support from the National Strategic Programme – "Plurianual" is an important source of funding due to its flexibility and stability, but represents relatively small proportion of the total funding sources (13.5%).
- The largest projects in terms of funding are indeed Integrated Projects and EU Framework Projects; on the opposite extreme, other EU Cooperation Programmes fund generally small projects (with complicated and often too specific rules); R&D Services and Consulting projects are expected to be under the average of funding per project, due to many short duration projects. In the group National R&D Programmes from FCT there are typically smaller projects and the four large infrastructures, which give a relatively high average funding (100K€).
- Funding from uncertain projects represents 6% of the total funding, which is 38% less than it was foreseen for 2017, reflecting a lower uncertainty level in the budget planned for 2018.

3.2.2 R&D Centres Indicators

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

Table 3.6 - Project Funding (K Euros) and Uncertainty Analysis (Plan 2018)

Funding Source		Total (k€)	R&D Centre													
			CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	CSIG	LIAAD	CRACS	HASLAB	Special Projects
Firm Projects	PN-FCT	**3 388**	329	263	920	281	573	199	177	224	20	214	58	107	23	0
	PN-PICT	**1 965**	261	180	71	243	21	108	34	188	51	224	189	220	176	0
	PN-COOP	**1 337**	309	0	164	1	61	378	143	33	0	183	39	0	24	0
	PUE-FP	**3 742**	195	0	523	0	841	521	363	0	107	401	92	89	611	0
	PUE-DIV	**796**	0	69	115	0	226	42	223	0	75	47	0	0	0	0
	SERV-NAC	**2 656**	226	0	33	30	1 125	412	297	104	9	121	178	47	60	12
	SERV-INT	**302**	17	0	125	0	141	0	13	0	0	0	0	0	5	0
	OP	**962**	29	0	0	0	20	0	0	8	12	152	4	0	139	597
	Total Firm Projects	**15 147**	**1 366**	**512**	**1 952**	**555**	**3 008**	**1 659**	**1 250**	**558**	**273**	**1 342**	**561**	**464**	**1 038**	**609**
Uncertain Projects		**1 171**	**168**	**106**	**76**	**17**	**113**	**15**	**33**	**114**	**13**	**332**	**94**	**65**	**25**	**0**
Total Funding		**16 318**	**1 534**	**618**	**2 027**	**571**	**3 122**	**1 674**	**1 283**	**672**	**286**	**1 673**	**655**	**529**	**1 063**	**609**
Uncertainty (%)		**7%**	11%	17%	4%	3%	4%	1%	3%	17%	5%	20%	14%	12%	2%	0%

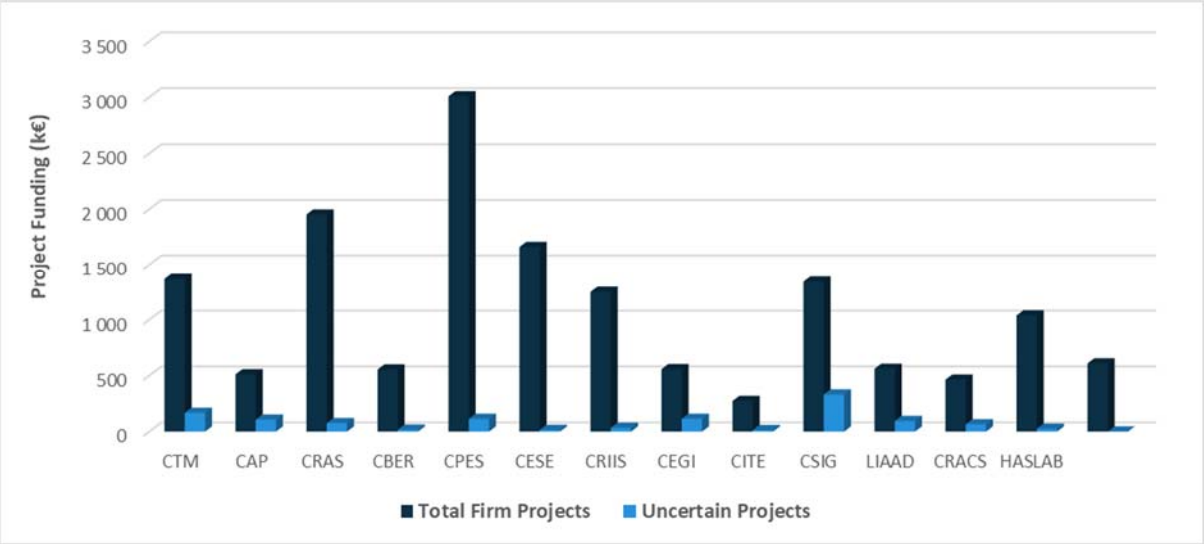

Figure 3.5 –Project Funding (K Euros) by R&D Centre (Plan 2018)

Table 3.6 also shows that uncertain projects represent 12% of the total funding from projects, although the relative weight per R&D Centre between uncertain/firm projects is quite variable, as shown in Figure 3.6.

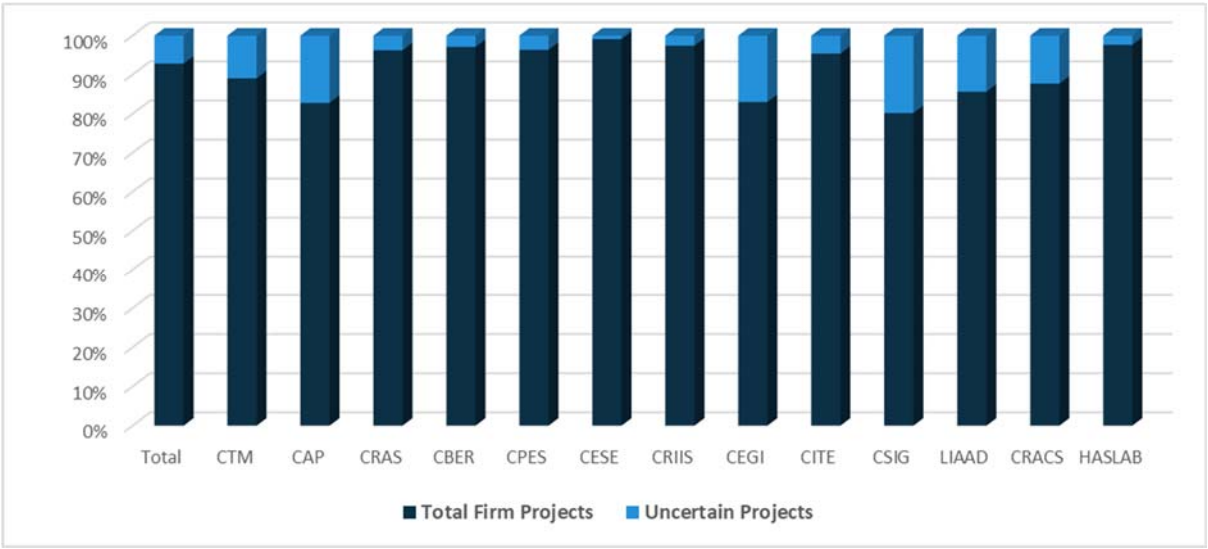

Figure 3.6 – Uncertainty Analysis by R&D Centre (Plan 2018)

3.3 Publications

3.3.1 Global Indicators

Table 3.7 and Figure 3.6 show the number of INESC TEC publications and the expected evolution for 2018.

The number of publications for 2015 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform. Publications with authors from different centres are counted individually in each Centre of the authors, but the institutional total removes repetitions of the same publication.

Values for 2016 and 2017 have been estimated using a bottom-up approach and need to be used with care. Since it was not possible to remove possible duplications, the totals obtained summing values from each Centre were reduced by the same factor derived from 2015 publications (about 10% of the articles are authored by researchers from more than one Centre).

Table 3.7 – Number of INESC TEC Publications

Publication Type	2016	2017 (Forecast)	2018 (Plan)
Indexed Journals	311	305	280
Indexed Conferences	476	396	352
Books	1	1	2
Book Chapters	37	12	12

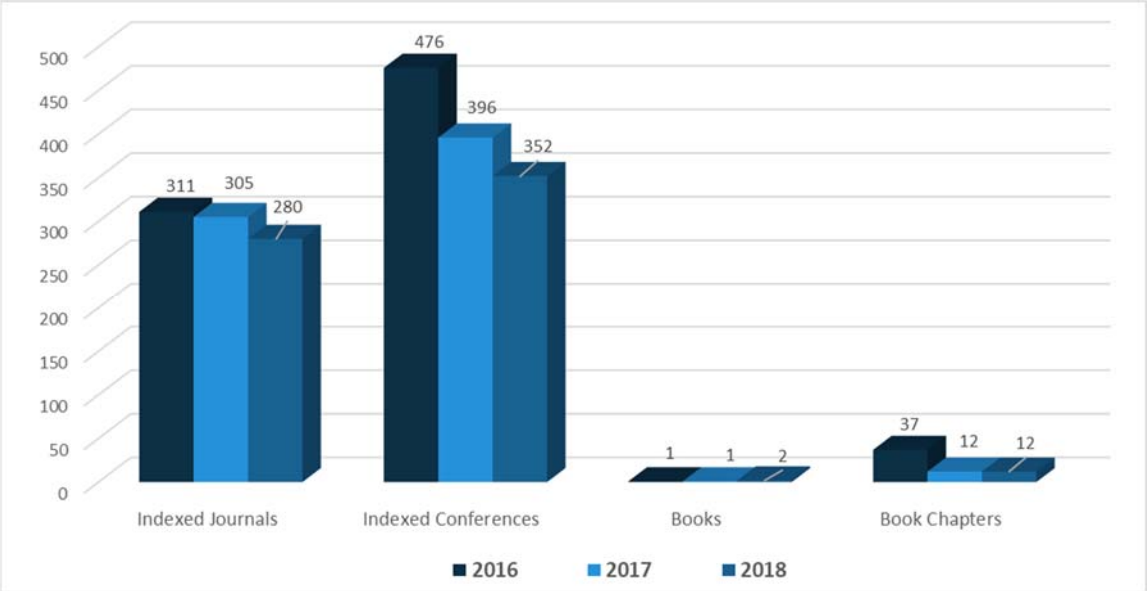

Figure 3.6 – Evolution of INESC TEC Publications

3.3.2 R&D Centres Indicators

Figure 3.7 presents the number of indexed publications in journals and conferences per R&D Centre. These figures planned for 2018 are compared with previous figures in the presentation of each R&D Centre.

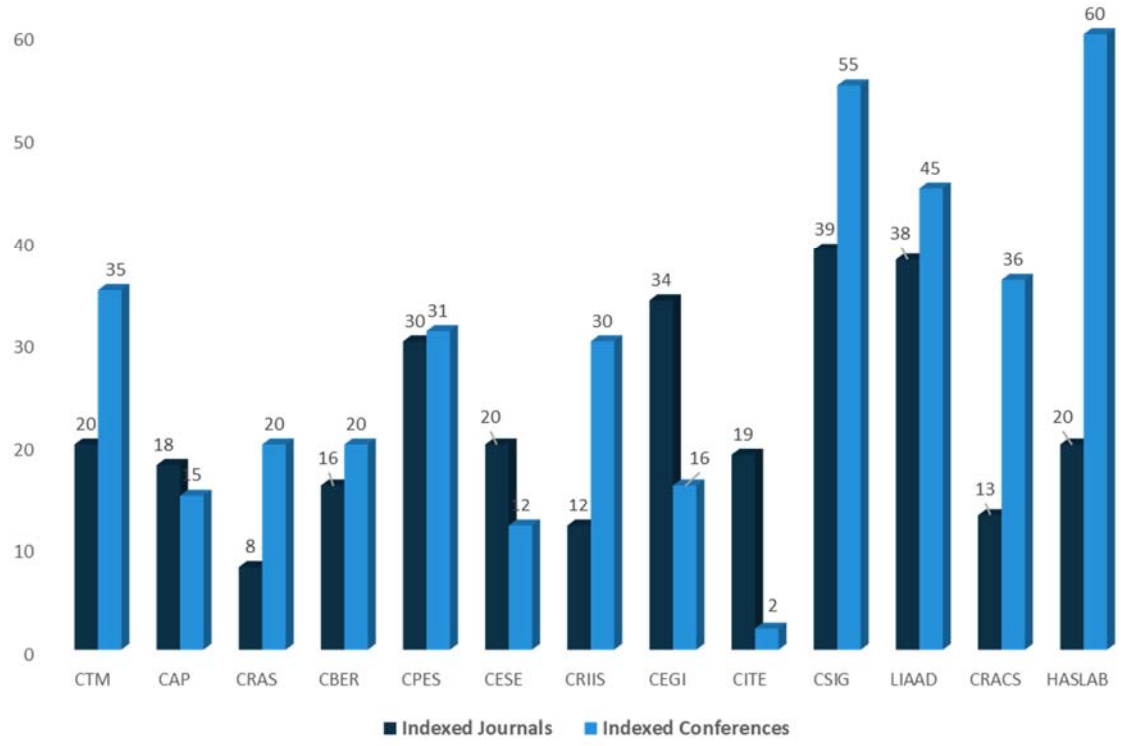

Figure 3.7 - Indexed Publications in Journals and Conferences (Plan 2018)

4 INESC TEC CLUSTERS

As mentioned in Section 2, research at INESC TEC is structured in four Clusters - Networked Intelligent Systems (NIS), Power and Energy (PE), Industry and Innovation (II) and Computer Science (CS), which are presented in the following sections.

4.1 NETWORKED INTELLIGENT SYSTEMS

Coordinator: Manuel Ricardo
Core Centres: Centre for Applied Photonics (CAP), Centre for Biomedical Engineering Research (C-BER), Centre for Robotics Autonomous Systems (CRAS), and Centre for Telecommunications and Multimedia (CTM).

4.1.1 Presentation of the Cluster

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

- CAP, addressing optical sensing and imaging, and microfabrication.
- C-BER, addressing bioinstrumentation, biomedical imaging, and neuro-engineering.
- CRAS, addressing robotics and autonomous systems operating in complex environments for data gathering, inspection, mapping, surveillance, an intervention.
- CTM, addressing radio and optical communications, electronics, communications networks, multimedia technologies, computer vision, and intelligent information processing.

The Cluster NIS carries out activities aligned with the following vision:

"We aim to create autonomous networked intelligent hybrid systems enabled by ubiquitous sensing and processing of information."

These systems should be able to operate also in extreme environments such as the deep sea or inside the human body. Examples of networked intelligent systems we aim to create include the following: underwater robotics for environment protection and resource exploitation, flying or terrestrial robotics for surveillance of borders, distributed robotics for monitoring intelligent cities, micro-robotics for monitoring human health, distributed robotics for provisioning of adaptive telecom infrastructures. The development of such systems will lead to new results in the NIS centres.

4.1.2 Objectives for the short and medium term

In cluster NIS we will continue working towards futuristic scenarios in which collections of cooperative autonomous systems, communications enabled and carrying advanced sensors, will collect information in extreme environments such as the deep sea or the human body, and process it by using artificial intelligent tools. For the medium term 3 main research lines will be active: Computer Vision, Sensing, and Autonomous Systems. The detailed short time objectives associated to these research lines are identified within each centre. The rationale and medium term objectives of the NIS cluster are identified below.

COMPUTER VISION. We will address a human health scenario. Considering that cancer is a life threatening disease and a major obstacle for the increase of human life expectancy, NIS researchers will work on the prediction, early detection and diagnosis of cancer by using holistic data and epidemiological information, by adopting computer vision and artificial intelligence methodologies. We will use multi-modality big data approaches, based on images, liquid biopsy and biological data. We will take as case studies the lung and breast cancers. This will enable us to learn powerful features and understand relationships between multisensing settings.

SENSING. We will develop a new set of sensors including miniaturized and rugged photonic sensors in fiber and planar platforms capable of performing multisensing, low power implantable sensing and neurostimulation microsystems, wearable and human implementable devices, and very compact hyperspectal imaging. Besides

developing these sensors, we will work towards their integration in autonomous systems and their ability to generate data usable by artificial intelligence tools; we will consider mostly the scenarios addressed by our current UAVs, including the SEA scenario.

AUTONOMOUS SYSTEMS. We will address mainly the SEA scenario although we expect also to start characterizing the challenges associated to miniaturized robotics. In the SEA and water environments, we will overcome the challenges associated to deep sea, including high pressures, perception, navigation, and communications. Besides the integration of new payloads of sensors, we will develop and integrate accurate navigation sub-systems, wireless communications sub-systems for broadband data exchange and real time communications, and wireless energy transfer sub-systems. Cooperation between robots will also be addressed.

The General Objectives of NIS for 2018 are the following:

- To increase the number of project proposals aligned with the NIS vision by 10%, when compared to 2017.
- To increase the number of accepted papers aligned with NIS vision by 10%, when compared to 2017.

4.2 POWER AND ENERGY CLUSTER

Coordinator: Manuel Matos
Core Centres: CPES
Associated Centres (potential): Centre for Industrial Engineering and Management (CEGI), Centre for Telecommunications and Multimedia (CTM), Artificial Intelligence and Decision Support Laboratory (LIAAD), Centre for Robotics Autonomous Systems (CRAS), Centre for Information and Computer Graphics Systems (CSIG), High-Assurance Software Laboratory (HASLab), Centre for Applied Photonics (CAP)

4.2.1 Presentation of the Cluster

The cluster is focused on traditional and emergent areas of Power and Energy Systems, for planning and operation purposes, with an emphasis on renewable energy sources (RES) integration, electric vehicles deployment, distributed energy resources (DER) management, demand response (DR), smart grids and energy analytics, through steady state and dynamic network analysis, reliability models and tools, optimization and soft computing and forecasting.

CPES is the core centre of the cluster but many of the emergent areas benefit from the involvement of associated centres (CEGI, CTM, LIAAD, CRAS, CSIG, HASLab and CAP), due to their areas of expertise and of the multidisciplinary nature of the problems to address. There are already examples of this collaboration and joint projects, in the areas of communications (CTM), datamining (LIAAD), cybersecurity (HASLab) and Asset Management (CEGI) and Combined Energy and Process Optimization in Industry (CESE). Rather than just sharing projects, the goal is to promote a multidisciplinary approach and have strong team involvement to create new knowledge at low TRL and favour new developments and tools at higher TRL.

The cluster council is presently composed by: Carlos Moreira, Jorge Pereira, Luís Seca, Manuel Matos, Ricardo Bessa (all from CPES). Representatives of the associated clusters will participate in the meetings of the cluster.

4.2.2 Objectives for the short and medium term

Structural objectives
In 2018, the cluster PE will continue the process of inclusion of other clusters of INESC TEC, addressing different topics related with the energy system where the scientific competences of other clusters can leverage a much higher impact of the research and innovation.
This effort is already giving its first results, with a set of think tank groups with clear objectives to generate methodologies and advances that can push more innovative concepts that can address the main challenges foreseen in the coming years in the sector. Digitalization, more efficient conversion systems, distributed and cyber secure systems and design of fibre optic sensors as non intrusive mean to include added value information, are some of the topics that the cluster will foster to address the more challenging operation of the electrical systems in the coming years.

Following a suggestion from the Board, the cluster will continue the process of autonomisation of the area of Power Electronics, creating a more stable critical mass that has been challenged to design autonomous and relevant objectives for the coming years, independently of the requirements coming from the grid operation.

The promotion of the area of Oil and Gas is also an objective for the coming year, being the results of a preliminary Research Line on the topic the basis for e more mature approach to the topic.

Strategic areas
For the year of 2018, the cluster identified a list of strategic areas for present and future activity. This list covers the major challenges foreseen in the next 2 years, being of the outmost importance to create scientific knowledge to address them, as is described in the following paragraphs.

Co-simulation in Electrical Networks

Simulation of the joint operation of telecommunication and electrical networks, including the transmission-distribution grids coordination and protection systems coordination. This analysis will consider the actual discussion on the use of utility owned solutions (basically PLC PRIME) or telecom infrastructure.

Multi-energy networks

Joint modelling of electricity, gas and heat network considering active demand-side management (residential and building level), energy storage and renewable energy sources. This also includes the joint modelling of transmission and distribution electrical networks.

Large-scale modelling of energy systems

- Modelling spatial-temporal dependency structures of time-series with two goals: uncertainty modelling and forecasting.
- Definition of methods and strategies for real-time monitoring and support the operation of networks by considering DER (renewable energy, storage and flexible loads) and the types of information available, at HV, MV and LV level independently or integrated. This includes knowledge extraction from synchro-phasors units installed in electric power transmission and distribution systems.
- Solve large-scale non-convex optimization and learning problems with decomposition techniques and distributed computing. Definition of methods and strategies for operation distributed energy resources (DER) locally or globally.
- Renew the concepts of load profile for analysis at LV, MV and HV levels by using different sources of information, including human behaviour, sensors, and using techniques of classification and clustering, that will be used on planning, in operation, and in reliability studies.

Weather Intelligence Applied to Power Systems

Integrate information generated from numerical weather prediction systems in power system operation and planning tasks, electricity markets and demand response actions.

Stochastic Optimization of Energy Systems

Integration of forecast uncertainty information in grid operational tools, with a human-in-the-loop approach, which aim to evaluate the future network conditions and derive a set of optimal control actions.

Predictive Maintenance and Asset Management

Multi-disciplinary approach that combines big data platforms, statistical learning and power systems theory (reliability, electric modelling, etc.) to design a probabilistic framework to support the decision-making process of asset management and renew of electrical power systems and power plants.

Towards 100% RES integration and Massive integration of power electronic-based interfaces

- Identification of challenges resulting from the massive connection of power electronic based generators in electric power systems and development of new operational methodologies for assuring system stability.
- Development of predictive algorithms for enabling the participation of renewable generation in synthetic inertia provision and frequency containment control (it requires the development of on-line tools to estimate the available inertia and primary reserve levels).

Smart-grid hardware

- Development of intelligent and autonomous control devices for smart grids network, including lab tests of integration with different components in the network and substation automation.
- Explore the hardware and software in the loop capability for testing hardware devices and software control modules for future smart grids. Take advantage of the OPAL system to perform RTDS. Enhancing RTDS through connection with similar simulators.
- Specific developments for enhancing system behavior (inverters, protections).

- Development of technological solutions for electrical mobility.

New marketplaces for energy services

New solutions for network operation and planning in an active market environment with several players and rules considering data transmission, data privacy and data security issues, including data and market hubs. Development and test of new tariff options for network use and energy (retail market options).

Cybersecurity of the grid

Define an overall security architecture for a trustful ICT environment, which covers the whole communication chain. Standard communication protocols and associated security solutions are analysed (e.g. IEC 60870-5-104, IEC 61850, OpenADR, OPC etc.) and the most appropriate selected to assure interoperability. Analyse the internet threats for the power systems and means to avoid, early detect and combat cyber attacks with a multi-disciplinary approach (information systems, data mining, software engineering).

System resilience

Procedures for black-start, self-healing and islanding operations in systems dominated by grid inverter generation.

Power system planning

- Development of algorithms for intelligent planning considering the smart grid implementation, operation and management costs, the benefits of using smart grids (flatter diagrams, the option of investment deferral, etc.) and the potential drawbacks (higher losses, higher risk, etc.).
- Development of tools for reliability analysis, namely for security of supply evaluation and reserves adequacy evaluation

Energy efficiency

Identification of the synergies between the traditional energy efficiency area and smart grid developments, originating new tools and opportunities for consulting. Explore artificial intelligence techniques to exploit information connected by internet-of-things platforms from domestic and industrial loads, aiming at optimization the energy consumption and automate energy efficiency actions. Inclusion of Applied behaviour analysis as a mean to leverage a more user-centric operation of the energy system.

4.3 INDUSTRY AND INNOVATION CLUSTER

Coordinator: António Lucas Soares
Core Centres: Centre for Enterprise Systems Engineering (CESE), Centre for Robotics and Intelligent Systems (CRIIS), Centre for Industrial Engineering and Management (CEGI), Centre for Industrial Engineering and Management (CITE)
Associated Centres: Laboratory of Artificial Intelligence and Decision Support (LIAAD)

4.3.1 Presentation of the Cluster

The Cluster Industry and Innovation at INESCTEC (c_I+I@INESCTEC) aims to research and innovate in systems and services applied to the management of value streams, from the individual organisation to networks and chains. The activities of the c_I+I@INESCTEC result in high impact systems for decision support, operations automation, management and intelligence and in the provision of technology transfer and innovative consultancy services for applications in Industry, Retail, Healthcare, Energy, Mobility and Transports, and Agriculture.

The goal is to make INESC TEC internationally recognised as a leading research centre in the industry and innovation domain and as a first choice for supporting organisations to achieve high-levels of sustainable innovation and performance.

The Cluster Industry and Innovation (I+I) consists of 4 INESC TEC centres addressing complementary scientific and technological domains:

- CESE, addressing Manufacturing and Services Operations Management, Enterprise and Industrial ICT, Collaborative Networks and Supply Chains, Manufacturing Intelligence;
- CRIIS, addressing of Industrial Robotics, Collaborative Robots and Intelligent Sensors and Dynamical Systems;
- CEGI, addressing Service Design, Decision Support, Performance Assessment, Asset Management, Prescriptive and Prescriptive Analytics;
- CITE, addressing Innovation Management, Fuzzy Front End of Innovation, Technology Management, Technology Entrepreneurship.

The four core centres of c_I+I@INESCTEC undertake research, knowledge/technology transfer, and consultancy services in complementary research domains (see Figure 4.1) strongly coupled and coordinated through the following collaboration axis: Innovation and Development of New Product/Services; Information Management and Knowledge Discovery; Robotics, Automation, Internet of Things and Cyber-Physical Systems; Design, Planning, Control and Improvement of Operations; Transportation and Mobility.

The cluster uses a range of research approaches to fulfil its mission, namely: Systems Design, Modelling, Mathematical Programming, Optimization, Simulation, Analytics, Information Management, Data Mining, Knowledge Discovery, Machine Learning, Model Based Predictive Control, 3D and Active Perception, Multimodal Sensor Fusion, Design Science and Explanatory Research, Creative Thinking and Problem Structuring.

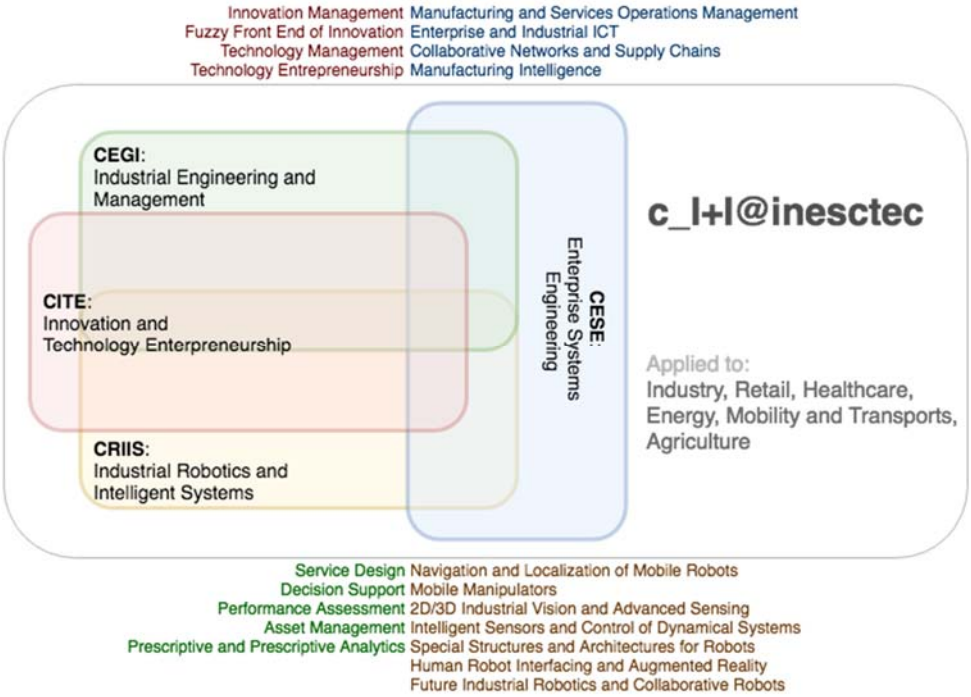

Figure 4.1: c_ I+I@INESCTEC research domains

4.3.2 Objectives for the short and medium term

The cluster reached a maturity level where it is challenged with the unique opportunity to create an high impact research program towards a sustainable production paradigm. This will answer the growing demand of manufacturing companies to have efficient tools enabling them to optimize the organization of their production 'on the fly'. This research will lead to an open, scalable production system framework to visualize, virtualize, construct, control, maintain and optimize production, bringing closer several research lines covering from intelligent systems and robots to analytics and decision support.

Another challenge is to take the digital transformation of industry beyond productivity improvement, clearly contributing to social and environmental sustainability. The remarkable interdisciplinary capability of the cluster is enabling coordinated research leading to novel vertical IOT based information architectures supporting risk and asset management, collaborative networks design, multi-dimensional performance management and crowd-servicing based services.

Innovation & Technology management research will continue to produce high impact results in the North region through the diffusion of new business concepts and models. Research will be focused on the conditions and enablers for the diffusion and adoption of CPPS and on the servitization of manufacturing to extend the scope of manufacturer's offerings into services. This will be complemented by the launch of different accelerator programmes in order to sustain the exploitation of the Industry 4.0 technologies.

The following objectives intend to address further integration of practices, improve and balance the scientific production and rationalise consultancy:

- Continue to improve the alignment between basic research, applied research and consultancy;
- To implement joint strategies to attract high quality PhD students and scholarship holders;
- To define a strategy for the technology transfer and consultancy projects portfolio;
- Consolidation of a strategic communication plan that includes the establishment of the Cluster's web presence, including a youtube channel, in articulation with the communication strategy of INESC TEC;
- To have a cluster's "Research with us" (digital) flyer as an entry point for attracting prospective, highly qualified researchers.

4.4 COMPUTER SCIENCE

Coordinator: António Gaspar
Core Centres: Centre for Information Systems and Computer Graphics (CSIG), Laboratory of Artificial Intelligence and Decision Support (LIAAD), Centre for Research in Advanced Computing Systems (CRACS), High-Assurance Software Laboratory (HASLab)

4.4.1 Presentation of the Cluster

INESC TEC aims at excelling in the control of the chain data>information>knowledge for pervasive and massive data repositories and data flows. This includes the components of new high-level languages, distributed computing, critical software, privacy protection, pervasive cyber security and generalized knowledge extraction, namely from massive spatio-temporal distributed and geo-referenced databases possibly lodged in moving media.

The Computer Science Cluster mission is to achieve excellence in both fundamental and applied research, with international impact, with a strong emphasis on technology innovation and transfer that benefits society at large. Our strong commitment encompasses many core areas from programming languages and rigorous software development, data processing and large scale computing to security and usability, to newer challenges bringing better intelligence into everything.

The Computer Science (CS) Cluster is composed by four Centres, namely:

- CRACS - Centre for Research in Advanced Computing Systems
- CSIG - Centre for Information and Computer Graphics Systems
- HASLab - High-Assurance Software Laboratory
- LIAAD - Artificial Intelligence and Decision Support Laboratory

The CS Cluster Centres address diversified, heterogeneous and yet complementary research areas. The main research areas are:

- Accessibility and Assistive Technologies
- Big Data Applications
- Computer Graphics and Virtual Environments
- Cryptography, Information Security and Privacy
- Distributed Systems
- Information Management and Information Systems
- Intelligent and Adaptive Systems
- Languages and Distributed Computing
- Machine Learning and Data Mining
- Mathematical Modeling in Decision Support
- Software Engineering
- Special Purpose Computing Systems

The Cluster is also strongly involved in Technology Transfer activities, either as Advanced ICT Consulting or Innovative Systems Development in areas such as Agriculture, Electronic Government, Energy, Healthcare, Industry, Telecommunications, Transport and Services. Major examples of these activities are:

- vCardID - Development and implementation on smartcard of a fingerprint match-on-card algorithm for the next version of the Portuguese citizen card. This project involved three CS Cluster Centres (and CTM): CRACS, CSIG and HASLab.

- WiderMoS - Implementation of a prototype of a Logistics Single Window, for multimodal cargo transport.
- DRIW2020 - Consultancy for the design of new e-infrastructures supporting navigation in river Douro.
- SIGAMP - Implementation of a Spatial Data Infrastructure (SDI) for the Porto Metropolitan Area.
- Esporão - Design and implementation of data mining solutions for increased efficiency in different stages of agricultural processes.

Additionally, several spin-off and start-up companies have been launched in the period 2015-2016, namely:

- ADYTA - a start-up company of the University of Porto with its core business in mobile security, created with 2 collaborators.
- LEANXCALE – a start-up in the area of real time analytics, producing an ultra-scalable transactional database, created in the sequence of the CumuloNimbo (EU FP7), CoherentPaaS (EU FP7) e LeanBigData projects (EU FP7). It has 10 collaborators (7 PhDs).
- MITMYNID – a spin-off in the area of e-logistics for multimodal cargo transport, resulting from MIELE (EU TEN-T) and WIDERMOS (EU TEN-T) projects, launched with 8 collaborators (1 PhD).

The Cluster is served by significant laboratory infrastructures, namely cluster and cloud computing resources located in Porto and Braga, and a multi sensorial immersive virtual reality laboratory based in Vila Real.

The computing infrastructure at Porto comprises a reliable OpenStack cloud setup implemented in the model of infrastructure-as-a-service. It is a cluster comprising 280 Intel Xeon cores with 1.5TB of memory distributed among 12 compute nodes. The architecture includes a 16TB of usable storage, a 40-Gb- Infiniband to interconnect the compute nodes and 10-Gbs copper Ethernet to connect the nodes and storage, all built to be fully redundant and fault tolerant from the network to service layers. The computing infrastructure at Braga is broken into 3 distinct components: one cluster composed of server grade machines, providing a total of 192 cores and sharing a 16TB DAS connected via 8Gb fiber; one cluster with 104 commodity machines, providing 4 cores each; one private OpenStack cloud currently providing 50 cores.

The multisensorial immersive virtual reality laboratory (MASSIVE Laboratory) has 150m2 and is organized in 7 spaces: waiting area, experimental room, multisensory experimental room, control room, survey room, researcher's workspace and maintenance area. Its main equipment is composed by omnidirectional treadmills and a VirtuSphere, sound proofed facilities, optical tracking systems, smell capture and delivery, wind blower, temperature control, eye trackers and bio sensors (EEG and ECG).

4.4.2 Objectives for the short and medium term

- Increase the level of consultancy and R&D services.
- Increase the number of publications, particularly at top level journals and conferences.
- Increase the participation in European projects and networks.
- Reinforce the partnership with other INESC TEC centres that require the use of our competences in their target domains.
- Create a joint OpenDay.
- Organise small events among Cluster Centre's researchers to promote collaboration.
- Create a web streaming infrastructure to support remote access and archive of Cluster events.

4.5 Main Indicators by Cluster

This section includes the Cluster main indicators, presenting an overview of their relative size and expected results planned for 2018.

4.5.1 Human Resources

Table 4.1 - Human Resources by Cluster (Plan 2018)

Type of Human Resources			Clusters			
			NIS	PE	II	CS
Integrated HR	Core Research Team	Employees	24	19	22	17
		Academic Staff	45	12	51	86
		Grant Holders and Trainees	94	49	94	129
		Total Core Researchers	**163**	**80**	**167**	**232**
		Total Core PhD	**74**	**27**	**82**	**118**
	Affiliated Researchers		10	3	11	19
	Administrative and Technical	Employees	7	2	6	2
		Grant Holders and Trainees	0	0	1	1
		Total Admin and Tech	**7**	**2**	**7**	**3**
	Total Integrated HR		**180**	**85**	**185**	**254**
	Total Integrated PhD		**84**	**30**	**91**	**136**

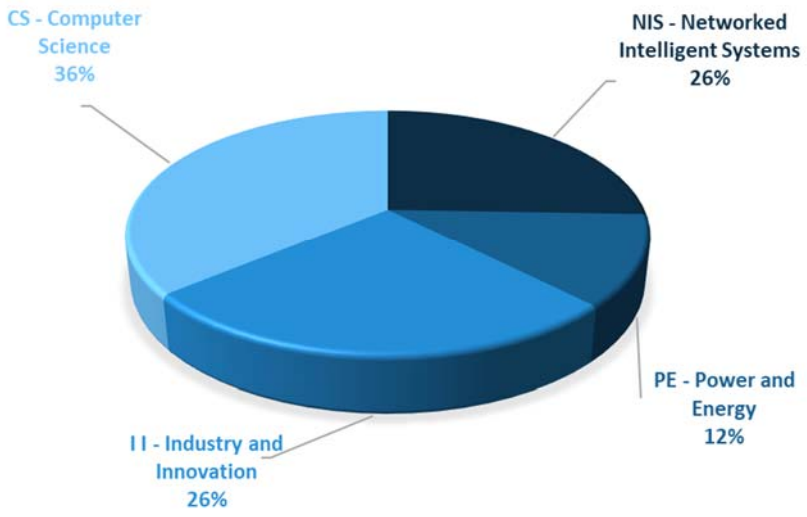

Figure 4.2 – Human Resources by Cluster (Plan 2018)

4.5.2 Activity in Projects

Table 4.2 – Activity in projects by Cluster and funding source (Plan 2018)

Funding Source			Clusters			
			NIS	PE	II	CS
Firm Projects	PN-FCT	National R&D Programmes - FCT	1 792	573	620	402
	PN-PICT	National R&D Programmes - S&T Integrated Projects	755	21	381	808
	PN-COOP	National Cooperation Programmes with Industry	475	61	555	247
	PUE-FP	EU Framework Programmes	718	841	990	1 193
	PUE-DIV	EU Cooperation Programmes - Other	184	226	339	47
	SERV-NAC	R&D Services and Consulting - National	289	1 125	822	407
	SERV-INT	R&D Services and Consulting - International	142	141	13	5
	OP	Other Funding Programmes	29	20	20	296
		Total Firm Projects	4 384	3 008	3 740	3 405
		Uncertain Projects	366	113	175	516
		Total Funding	**4 750**	**3 122**	**3 916**	**3 921**

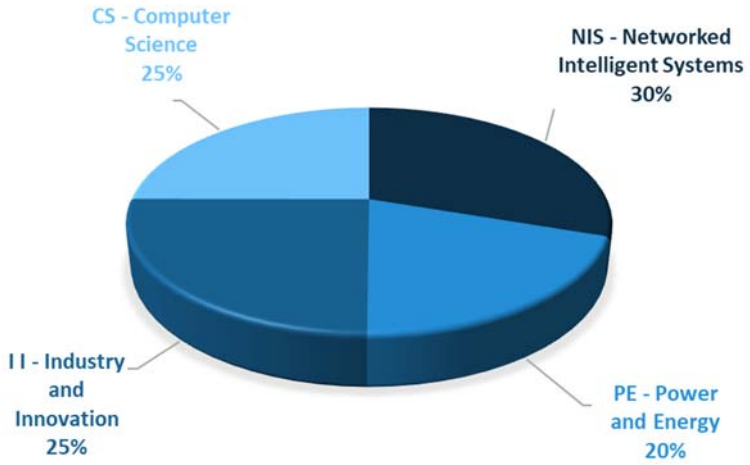

Figure 4.3 – Project Funding by Cluster (Plan 2018)

4.5.3 Publications

Table 4.3 – Publications by Cluster and publication type (Plan 2018)

Publication Type	Clusters			
	NIS	PE	II	CS
Indexed Journals	62	30	85	110
Indexed Conferences	90	31	60	196
Books	1	0	3	2
Book Chapters	5	5	16	9

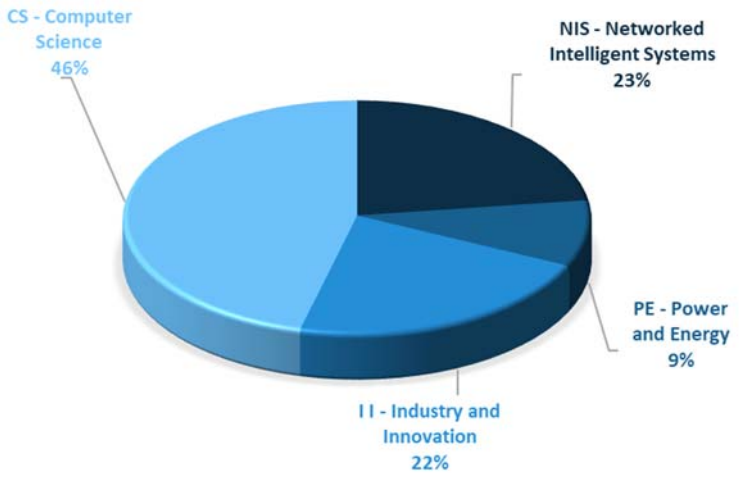

Figure 4.4 – Planned Indexed Articles by Cluster (Plan 2018)

5 RESEARCH AND DEVELOPMENT CENTRES

5.1 CTM - CENTRE FOR TELECOMMUNICATIONS AND MULTIMEDIA

Coordinator: Manuel Ricardo

5.1.1 Presentation of the Centre

The Centre for Telecommunications and Multimedia (CTM) consists of 100+ researchers addressing scientific and technologic topics related to the fields of telecommunications and multimedia. CTM is fully committed and aligned with the vision and mission of INESC TEC and specializes them as follows:

- **Vision:** A lively and sustainable world where networked intelligence enables ubiquitous interaction with sensory-rich content.
- **Mission:** Development of advanced systems and technologies enabling high capacity, efficient, and secure communications, media knowledge extraction, and immersive ubiquitous multimedia applications.

CTM accomplishes its mission, within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards 4 main areas of research: Optical and Electronic Technologies; Wireless Networks; Multimedia and Communications Technologies; Information Processing and Pattern Recognition.

5.1.2 Research and Technology Development

OET – Optical and Electronic Technologies

The main goal of this area is to technologically devise solutions for communications and intelligent systems of the future, based on the integration of advanced skills in optical communications and microwaves, signal processing, microelectronics and programmable logic.

Research activities in optical communications and microwaves addresses the development of optical and wireless communication systems, including the convergence between both wireless and optical systems, targeting future high-speed wired and wireless communication systems, in both terrestrial and maritime environments, supported in advanced modulation formats and signal processing techniques as well as on R&D of novel radio devices and antennas. Research in microelectronics and programmable logic addresses design, testability, characterization and adaptive correction of performance, RF design and transparent electronics, A/D and D/A conversion, dedicated computing applications in reconfigurable logic and adaptive transparent acceleration, and VLSI design.

WiN – Wireless Networks

The main goal of this area is to design and evaluate new networking solutions for extreme environments such as aerial and maritime. The focus is on wireless networks and mobile communications, extending infrastructure networks and enabling the Internet of Everything in terrestrial and maritime environments. This requires theoretical and simulation modelling, implementation, and experimental evaluation of communications networks and their elements.

The main research topics include medium access control, radio resource management, context-aware optimization using cross-layer techniques, and self-configuration of static and mobile multi-hop wireless networks.

MCT - Multimedia Communication Technologies

The main goal of this area is to devise solutions for capturing, producing, sharing and accessing multimedia information from users' own perspectives and experiences, over the Internet, in social media, through on demand services, or even in large spaces like a theatre or a football stadium. This includes the integration of different media formats, the ways of constructing different narratives, human-media interaction mechanisms or

the possibility of delivering and accessing distributed multimedia resources in heterogeneous environments to any user in a seamless and adaptable way.

The main research topics include the following: technologies to enable personalized access and consumption of multimedia content through context awareness; immersive multi-view experiences; content description approaches and metadata model and tools for sensing, representing and reproducing multi-sensorial real-life experiences; efficient search and content analysis methods; image, video, sound and music content analysis and knowledge extraction; pattern recognition.

IPPR - Information Processing and Pattern Recognition

IPPR pursues a never-ending information learning system to empower the next generation of intelligent systems, aiming to develop computer-based algorithms and systems by proposing computer vision and machine learning architectures to explain the input data by exploiting prior similar data. The new advances are being validated on the areas of biometry, medical image analysis, human sensing, and networks, contributing to a more enjoyable, secure and healthy environment.

5.1.3 Technology transfer

OET – Optical and Electronic Technologies

In the optical and electronics area, CTM is able to transfer technology and provide consulting services on:

- Design and characterisation of Optical and Microwave Communication Systems. Telecommunication solutions based on wireless technology, research and development in compact multi-band/integrated antennas for mobile networks, developing, testing and characterisation of RF/microwave devices, antennas and waveguides. Simultaneously we address aspects dealing with technological solutions for optical and microwave communications where researchers can test and characterise optoelectronic devices, RF/microwave circuits and waveguides. This laboratory makes it possible to develop and test optical and wireless communication systems and develop optical fibre based solutions for present and future broadband wireless applications.
- Design of (Micro)electronic Systems for Communications. Semi/full-custom designing and testing of analogue, digital and mixed (A/D) circuits and digital systems based on microprocessors and reconfigurable logic. CTM has specialised in the design of analogue and digital electronic circuits in silicon-monolithic substrates, printed circuits and reconfigurable platforms, as well as on the development of analogue or mixed-signal circuits for low and radio frequency applications, namely in the biomedical domain. Testing and built-in self-testing solutions for integrated circuits and systems, design for dependability of wearable systems, reconfigurable logic processing and computing solutions and/or embedded systems and implementing adaptive systems based on dynamic reconfiguration, are also some of the areas we focus on for technology transfer.

WiN - Wireless Networks

In the wireless networks area, CTM is able to transfer technology and provide consulting services on:

- Planning and design of broadband networks capable of supporting multimedia applications and services, including video.
- Planning and design of wireless multi-hop networks for network infrastructure extension.
- Planning and design of communications networks for autonomous vehicles (aerial, surface, and underwater).

MCT - Multimedia Communication Technologies

In the Multimedia Systems area, CTM is able to transfer technology and provide consulting services on:

- Context-aware multimedia applications in heterogeneous environments, metadata and content description approaches, content adaptation and personalization.
- Image, video, sound and music analysis, including cross-media knowledge extraction.

IPPR - Information Processing and Pattern Recognition

In information processing and pattern recognition area, CTM is able to transfer technology and provide consulting services on:

- Intelligent Recognition Products and Systems based on Vision.
- Solutions to medical decision support systems, heath-being systems, biometrics, automatically process manuscript documents and automatic surveillance systems.

5.1.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CTM – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)								
	Status (2)	Optical and Microwave Systems	(Micro)electronic Systems	Wireless Mesh Networks	Networks for robotics	Multimedia applications	Video and music analysis	Recognition Systems based on Vision	Medical and biometrics solutions
Optical and Electronic Technologies	I	H	H	M	M				H
Wireless Networks	I			H	H				
Multimedia and Communications Technologies	I					H	H		
Information Processing and Pattern Recognition	I							H	H

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.1.5 Main objectives and actions planned for 2018

5.1.5.1 General Objectives and Actions

The **General Objectives of CTM** for 2018 are the following:

- **High quality publications**. CTM aims at (1) maintaining the number of articles published in journals and (2) increasing the number of articles published in the journals classified by SCOPUS as first quartile.
- **Provide research services to community**. In 2018, CTM will have a relevant number of researchers involved in basic research (low TRLs). Besides publishing our scientific results and protecting our intellectual property, CTM will also prepare new partnerships with companies with the purpose of enabling the transference of the new results to relevant partners.
- **Increase international visibility**. The increase of CTM international visibility will also be pursued, either by participating in international fora or by organizing international conferences, with the purpose of facilitating the formation of new and strong European consortia or helping the publication of new scientific results in top ranked journals.

- **Increase research within NIS cluster**. CTM will contribute actively to the consolidation of the cluster NIS by proposing new joint research projects involving also other NIS' centres or by helping organizing internal events.

The **General Actions of CTM** for 2018 are the following:

- **Open Day 2018**. CTM will pursue its mission of communicating to the industry its more recent results in the field of Telecommunications and Multimedia. Additionally, it will also promote the discussion of SoA topics with external keynote speakers in a format that contribute to define research roadmaps that can have impact in the industry.
- **Organize international events**. At least 1 international conference will be organized, what implies the coming of international researchers and relevant invited speakers to Porto.

5.1.5.2 OET Objectives and Actions

The main Objectives of the OET area are the following:

- Develop new physical layer solutions for the Internet of things and future mobile communication systems beyond 5G.
- Design of on-chip integrated antennas for compact transceivers, up to the sub-THz frequency range; investigation of new optical-wireless interfaces based on resonant tunnelling diodes (RTDs), in the mm-wave range, for seamless integration of wireless terminals with optical fibre based networks; investigation of new hardware based solutions for indoor and outdoor localisation; exploitation of dynamic reconfiguration baseband processing for improved energy efficiency: investigate efficient short-range communication for stand-alone wireless sensors; study the effectiveness of new hardware methods for chip security.
- Develop new physical layer solutions to support communications and energy in maritime environments.
- Develop new wireless power transfer electronics solutions for battery recharging in underwater environments with integrated communications for improved efficiency; develop improved antennas and RF front-ends for short range RF underwater communications; develop new optical wireless high-speed underwater communications solutions based on LED transmitters; develop new switched-beam antennas for optimised communications above-water.
- Develop new physical layer solutions for biomedical applications. Devise new RF/microwave based technology solutions for sensing or imaging biological phenomena; investigate reconfigurable hardware design in ASIC for local efficient computation in biological applications; design and test of a short-range transmitter for biological applications.

The main Actions of OET area are the following:

- Advise of MSc and PhD students towards the proposed objectives.
- Coordinate the final demonstration in H2020 project iBROW.
- Participate in events seeking to stimulate the research along the targeted research lines, namely the iBROW THz Electronics Workshop, STRONGMAR summer/winter schools, VTS/COST IRACON winter school.
- Submission and collaboration on the submission of new project proposals along the targeted research lines.
- Participate in European COST actions within the framework of the targeted research lines.
- Participate in the technical committees of international conferences.
- Organize actions to attract new students and researchers, namely laboratory visits and demonstration of prototypes during the CTM Open Day.

5.1.5.3 WiN Objectives and Actions

The main Objectives of the WiN area are the following:

- Development of flying ad-hoc networks, including the design and adaption of: 1) Medium Access Control (MAC) protocols, namely IEEE 802.11 MAC, for enabling long distance communications; 2) routing protocols for enabling multi-hop communications within the flying network; 3) topology control algorithms for augmenting network performance and range.
- Development of long-range, broadband maritime networks, including the use of short-range radio communications and Autonomous Underwater Vehicles (AUV) as data mules for underwater communications and novel MAC and routing protocols enabling ship-to-shore communications.
- Design of green Wi-Fi networks, addressing the reduction of the energy consumption of Wi-Fi access points by dynamically configuring their operation modes (e.g., ON, OFF, LOW POWER) according to the user traffic demand.
- Strengthen partnerships and competences by reinforcing existing partnerships, seeking new partnerships at national and international levels, and deepening collaboration with other Centres at INESC TEC.

The main Actions of WiN area are the following:

- Flying network prototype and demonstration, including the integration of all hardware and software networking components to create a flying communications node, its integration in four UAV platforms, and demonstration of the 4-node flying sensor network in sea environment as part of the final demonstration of the FP7 SUNNY project in Aveiro, Portugal.
- Design and simulation of topology control algorithm for augmenting network performance and range, using Network Simulator 3 (ns-3) and considering different flying networking scenarios, namely the ones considered in the FCT WISE project.
- Design, simulation, and test of new altitude control algorithm targeting flying multi-hop maritime networks for broadband maritime communications offshore.
- Simulation framework for point-to-point underwater long-range, broadband communications links using AUVs as data mules.
- Implementation in kernel space and test in maritime environment of novel maritime MAC protocol targeting long-range communications.
- Design, simulation, implementation, and testing of smart configuration manager for Wi-Fi access points enabling the optimization of the energy consumption according to the user traffic demand.
- Submission of new project proposals enabling the continuation of the work being developed along our strategic research lines, including flying networks, maritime networks, and green networks.

5.1.5.4 MCT Objectives and Actions

The main Objectives of the MCT area are the following:

- Develop personalised media services. Develop tools that enable context-aware personalised access to media content. This includes the integration of different video formats, such as 3D and multi-view content, the development of metadata approaches for content, user and environment description, algorithms for content recommendation and new immersive and participatory services.
- Exploit new application domains namely in sports, retail, surveillance and farming environments. Background on image and video processing and cross-media knowledge extraction provides the grounds for devising enhanced tools in areas other than the media sector. Within this objective, we intend to develop work on video segmentation, object identification and tracking applied in areas such as sports, retail, surveillance and farming.

- Develop tools to help user-centric content creation. Develop tools for content analysis and manipulation, namely sound and music, to help creativity. This includes new techniques for audio and music processing, and approaches for automatic content creation.
- Promote R&D activities and partnerships that require multidisciplinary competencies. The scope of the scientific and application areas of MCT are highly multidisciplinary and research towards the definition of novel techniques for content production, distribution and consumption requires the participation of a research team with a diverse technical background. MCT aims to decisively contribute tangible advances in the digital media sector, in the relevant scientific communities and in a number of additional application areas or markets by promoting the sharing of advanced facilities to spread knowledge among communities with different backgrounds and enable creative experimentation of new ideas.

The main Actions of MCT area are the following:

- Promote the cooperation with external partners through the organization of scientific events, submission of new project proposals and the participation on international scientific committees.
- Organise a local workshop or meeting in the scope of the H2020 FotoInMotion project to enable partners getting a better knowledge of MCT work.
- Actively contributing, managing and defining the scope of the P2020 project CHIC that involves the largest Portuguese consortium in the area of the media industry.
- Actively participating in the international NEM meetings and contributing to the European research agenda.
- Develop prototypes that enable a better communication of MCT scientific knowledge and provide an integrated and multidisciplinary view of the team.
- Develop action towards the attraction of new students and researchers, namely by proposing MSc and PhD thesis and organising actions within the CTM OpenDay.

5.1.5.5 IPPR Objectives and Actions

The main Objectives of the IPPR area are the following:

- Improve the performance of learning algorithms in weakly supervised settings.
- Propose better than state of the art algorithms for fingerprint recognition in uncontrolled acquisition.
- Improve decision support systems for breast cancer screening, diagnosis, planning and rehabilitation.
- Improve decision support systems for cervical cancer screening and diagnosis.
- Open new research lines related with health being, such as: head and neck cancer, lower-limb amputees and capilar surgeries
- Strengthen partnerships and competences by reinforcing existing partnerships, seeking new partnerships at national and international levels, and deepening collaboration with other Centres at INESC TEC.

The main Actions of IPPR area are the following:

- Advise Ph.D. Students researching towards the aforementioned objectives.
- Participate in National and European projects tackling the aforementioned objectives.
- Organize and participate in events fostering the discussion in the fields related with the objectives. In particular, by organizing international events (e.g. ICIAR 2018, visum 2018), special sessions in international conferences, participation in scientific competitions and challenges.
- Lead and participate in proposals of national and international projects.
- Increase the collaboration with industrial partners.

5.1.6 Centre Organizational Structure and Research Team

The Centre for Telecommunications and Multimedia is coordinated by Prof. Manuel Ricardo and is organized in the following Areas:

- OET - Optical and Electronics Technologies - Responsible: Henrique Salgado
- WiN - Wireless Networks - Responsible: Rui Campos
- MCT - Multimedia Communication Technologies - Responsible: Paula Viana
- IPPR - Information Processing and Pattern Recognition – Responsible: Hélder Oliveira

The centre has two councils: the **CTM Coordination Council** and the **CTM Scientific Council**. The CTM Coordination Council meets every 2 week and it is composed by the CTM Coordinator, the 4 Area Leaders, the CTM Assessor, and the CTM secretary; in these meetings strategic and management decisions are made. The CTM Scientific Council meets every 2 months and it is composed by the senior CTM researchers, mostly PhD researchers; this is a consultative council and strategic topics are discussed in the meetings.

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

Table 5.2-CTM – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	7	7	8	1
		Academic Staff	21	22	21	-1
		Grant Holders and Trainees	46	54	49	-5
		Total Core Researchers	**74**	**83**	**78**	**-5**
	Affiliated Researchers		8	6	5	-1
	Administrative and Technical	Employees	1	1	1	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**1**	**1**	**1**	**0**
	Total Integrated HR		**83**	**90**	**84**	**-6**
	Total Integrated PhD		**83**	**90**	**84**	**-6**

5.1.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CTM – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT	35	42	329	287
National R&D Programmes - S&T Integrated Projects	417	563	261	-302
National Cooperation Programmes with Industry	44	182	309	127
EU Framework Programmes	533	287	195	-92
EU Cooperation Programmes - Other	121	23		-23
National R&D Services and Consulting	132	31	226	195
International R&D Services and Consulting	75	25	17	-8
Other Funding Programmes	18	74	29	-46
Uncertain Projects	49	224	168	-56
Total Funding	**1 424**	**1 451**	**1 534**	**83**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	31	23	20
International conference proceedings indexed by ISI, Scopus or DBLP	47	23	35
Books (author)	0	0	0
Chapter/paper in books	1	0	3
Total	**94**	**46**	**58**

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

Type of Result	No.
Invention disclosures	1
Software copyright registrations	0
Patent applications	0
Licence agreements	4
Spin-offs	0

Table 5.6-CTM – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	3
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	4
International events in which INESC TEC members participate in the program committees	23
Participation in events such as fairs, exhibitions or similar	7
Advanced training courses	3

Table 5.7-CTM – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	CompMash	Matthew Davies	01/10/2017	30/11/2021
PN-FCT	EVOXANT	André Marçal	15/06/2016	14/06/2019
PN-FCT	TEC4SEA-1	Rui Lopes Campos	01/09/2017	30/08/2020
PN-FCT	WISE	Manuel Ricardo	01/06/2016	31/05/2019
PN-PICT	CORAL-TOOLS-1	Rui Lopes Campos	01/01/2016	31/12/2018
PN-PICT	FOUREYES	Paula Viana	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL1-3	Henrique Salgado	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL5	Jaime Cardoso	01/07/2015	31/12/2018
PN-PICT	SMILES-6	Manuel Ricardo	01/07/2015	31/12/2018
PN-COOP	5G	Manuel Ricardo	01/01/2018	31/12/2020
PN-COOP	BCCT.Plan	Hélder Filipe Oliveira	01/11/2016	31/10/2019
PN-COOP	CHIC	Artur Pimenta Alves	01/10/2017	30/09/2020
PN-COOP	Cloud-Setup	Pedro Miguel Carvalho	01/07/2016	31/12/2018
PN-COOP	MareCom	Rui Lopes Campos	01/03/2016	31/08/2018
PN-COOP	ROMOVI-1	Manuel Cândido Santos	07/01/2017	31/08/2019
PN-COOP	WI-GREEN	Rui Lopes Campos	01/10/2016	30/09/2018
PUE-FP	AnyPLACE-1	Rui Lopes Campos	01/01/2015	30/06/2018
PUE-FP	FotoInMotion	Maria Teresa Andrade	01/01/2018	31/12/2020
PUE-FP	iBROW	Luís Manuel Pessoa	01/01/2015	30/06/2018
PUE-FP	SmarterEMC2-1	José Ruela	01/02/2015	31/01/2018
PUE-FP	STRONGMAR-1	Rui Lopes Campos	01/01/2016	31/12/2018
PUE-FP	SUNNY-1	Manuel Ricardo	01/01/2014	30/06/2018
PUE-FP	TERAPOD	Luís Manuel Pessoa	01/09/2017	31/08/2020
PUE-FP	VAMOS-2	Luís Manuel Pessoa	01/02/2015	31/07/2018
SERV-NAC	Arquitetura_IoT	Filipe André Ribeiro	01/12/2017	31/05/2018
SERV-NAC	ConnectedRefinery	Manuel Ricardo	01/01/2018	31/07/2018
SERV-NAC	Consultoria	Manuel Ricardo	01/01/2010	
SERV-NAC	UGREEN	Rui Lopes Campos	01/10/2017	30/09/2019
SERV-NAC	Where.is	Luís Pessoa	01/12/2017	30/11/2019
SERV-INT	RAWFIE-1	Rui Lopes Campos	01/09/2016	28/02/2019
OP	Visum2018	Ana Maria Rebelo	01/01/2018	31/12/2018

Type of Project:

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

5.2 CAP - CENTRE FOR APPLIED PHOTONICS

Coordinators: Paulo Marques and Ireneu Dias

5.2.1 Presentation of the Centre

CAP accomplishes its mission within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards 3 main research areas: optical sensors; integrated optics and microfabrication; advanced optical imaging. In this arrangement, optical sensors comprise Chemical/Biosensors and Physical sensors. This organization is non-hermetic and the development of solutions implies multidisciplinarity and cooperative work from the different fields of the available expertise.

A good example is the Microfabrication section, which will explore traditional top-down microfabrication techniques and non-traditional based on laser direct writing processes to support the activities of other areas. For example, microfluidics chips will be produced to implement biosensors and micro and nanostructures; Bragg gratings will be made by laser direct writing to implement new sensing heads that will lead to the development of better and more reliable sensing heads.

CAP has a task force devoted to R&D outreach activities, which deals with all the news related to the CAP research activities, the organization of scientific meetings, the collaboration with the Department of Physics and Astronomy (DFA) of the Faculty of Science of University of Porto, the scientific dissemination to the general public, etc.

Of particular importance is the insertion of the Group and the dissemination within the universe of the DFA that hosts the Research Group. In the past, the CAP Group set up a lab which provides advanced optics experiments available to both CAP researchers and also for advanced laboratory lectures of MSc and PhD teaching programs. These activities lead to better prepared students in these topics and an enhancement and widespread interest on many related subjects.

5.2.2 Research and Technology Development

INTEGRATED OPTICS AND MICROFABRICATION

- Enhancement of tri-dimensional laser direct writing station based on a femtosecond fiber laser system (second and third harmonics). Improvement of third axis and software control of the apparatus.
- Monolithic integrated optic devices in pure silica mainly for integrated sensors and communications. However, other materials, such as chalcogenide glasses, Lithium Niobate, etc. and applications such as astronomical interferometry, quantum cryptography, etc. are areas of possible work
- Hybrid devices that combine optical layers will fluids handling capabilities (opto-fluidics made by femtoetching) for sensing. The fabrication of tri-dimensional structures using multi-photon polymerization or suspended cores within channels will be investigated.
- Structures supporting whispery gallery modes are very interesting for sensing but coupling to these structures is typically based on fragile fiber tapers or similar. Alternative robust solutions based on integrated optics for excitation of whispery gallery modes will be developed.
- Implementation of a second apparatus for specialized Bragg grating fabrication mainly on optical fibers, including possibility of handling special fibers.
- Fabrication of Bragg and long period gratings and also explore “fiber-integrated optics”, i.e., using the fiber cladding as the media to write waveguides and devices. Explore multi-core fibers.

ADVANCED OPTICAL IMAGING

- Compressive sensing based imaging based in single-pixel cameras, targeting applications such as Security and defence, Quality control: spectroscopic/hyperspectral imaging, 3D LIDAR imaging, Pharmaceutics, Astronomical imaging;

- Reinforce local capabilities in high precision optical imaging, grounded on the knowledge acquired in white light interferometry imaging;
- Explore medical and bio-sciences using techniques such as Narrow Band Imaging.

PHYSICAL SENSORS

The new strategic plan in nanosensors field is proposed for the next five years, targeting ultra-high sensitivity sensors. In this part, active devices will be designed in order to improve the precision of physical parameters measurement and to apply in new platforms for new areas of research.

- Fabrication of nano/microfibers through different fabrication techniques. The CO2 laser is one of the techniques to be explored during the next years.
- Study and development of nanostructures (Bragg gratings and Fabry-Perot interferometer) fabricated through FIB technique.
- Modelling of photonic crystal structures in waveguides incorporated in special optical fibers.
- Development of Microfiber Knot Resonators as Sensors.
- Development of nano-active and nano tapers targetting very high resolution and accuracy employing metamaterials and SPR.
- Study and development of sensors based on polymer fiber.
- Study of Raman Effect for future applications in reactors for pharmaceutics.
- Expand the application of ionizing radiation dosimeters from the radiotherapy scenario to the monitoring of radiation in industrial facilities and reinforce medical physics capabilities and sensing.

BIOSENSORS

The main goal of this research plan is to explore applications in new areas using optical of Biosensors technologies that are already consolidated:

- Improve long period grating refractometric sensors, for operational conditions, exploring their potential as chemical and biological sensors in specific applications (genomic sensors for identification of species, corrosion monitoring, detection of chemical analytes with differential detection methods);
- Improve the established interrogation methods by implementing robust prototype platforms (PWM LED based colorimetric sensing, differential white light interferometric interrogation, fluorescence lifetime determination).

It is also a main priority the consolidation of emerging areas in the group:

- Optofluidics: development of monolithic optofluidic platforms combining waveguides and microfluidic channels fabricated by 3D fs laser microfabrication, in fiber tips and in planar platforms. Use of advanced sensing techniques in these platforms such as microresonators, interferometers and plasmonic sensors.

Improvement of fiber tip microstructures targeting single cell diagnostic and manipulation (analytical tweezers).

Implementations of real time composition analysis by Laser induced breakdown spectroscopy. Test of new configurations using fiber lasers. Implement robust pattern recognition strategies for identification and quantification in trace analysis.

DISSEMINATION & INTERNATIONALIZATION

The participation in doctoral programmes, namely MAP-FIS.
Continue to support the 200m2 cleanroom (ISO6/ISO7) of CEMUP-MNTEC.

However, internationalization is where the Group will make the strongest effort since our international relations have to be enhanced in order to increase the participation in European international consortiums. Participation in short term visits, sponsored by bilateral collaboration projects and others, such as COST projects, will be the key aspects leading to more European projects under the Horizon 2020 programme.

5.2.3 Technology transfer

Electronics and Photonics Integration

In the electronics and photonics area, CAP is able to transfer technology and provide consulting services on:

- Electronic PCB design, implementation, test and characterization;
- Micro and nanofabrication techniques;
- Optoelectronics assembly and packaging;
- Photonic systems implementation, test and characterization.

5.2.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CAP – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Status (2)	Areas of Technology Transfer --> relationships (3) Electronics and Photonics Integration
Integrated optics and Microfabrication	I	H
Advanced Optical Imaging	I	M
Physical Sensors	I	M
Biosensors	I	M

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.2.5 Main objectives and actions planned for 2018

Following a SWOT analysis, the recruitment of new researchers, the low participation in Horizon2020 and projects with industry partners were identified as weaknesses.

In order to raise interest in potential new researchers, the Centre intends to keep a policy of awarding scholarships for last year students so they can get acquainted with the research activity. This policy has proven to be fruitful in the past and it will be continued. A dedicated laboratory already in place with advanced photonics projects will attract also younger students.

Profiting from the network of contacts and knowledge in running and previous projects, a strong effort will be put in the submission of H2020 proposals.

5.2.6 Centre Organizational Structure and Research Team

The researchers responsible for the Areas and Sub-Areas within CAP are:

- Integrated optics and microfabrication - Paulo Marques
- Advanced optical imaging - Carla Rosa
- Sensors: physical sensors - Orlando Frazão; biosensors - Pedro Jorge
- Dissemination & internationalization - Manuel Joaquim Marques

The internal organization of the Centre follows the general model adopted at INESC TEC. It will be governed by a Coordinator and a Coordinating Council (CC). The CC is composed of 3 to 5 PhDs with responsibilities over areas of work and research. The project leaders will respond to the Coordinating Council in what refers to the execution of projects and meeting financial sustainability goals, as well as scientific productivity targets. This Coordinating Council will also suggest to the Board of INESC TEC on CAP's participation within the NIS cluster coordination.

Each of the research areas has an appointed leader. Ordinary management meetings are held every fortnight to discuss matters related to the research Group daily issues, which include acquisitions, travel, staff and student movements, and project management. The regular attendants to these meetings are the Research Group leader and co-leader together with the leaders of the research areas. Depending on the subjects to be evaluated during the meetings other research group members could be present.

The CAP has a scientific council, which is composed of all researchers holding a PhD. The scientific council will meet in quarterly meetings to analyse the progress made on the different areas of research and to discuss future work. It is also incumbency of the scientific council to propose new strategic actions.

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

Table 5.2-CAP – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	5	5	5	0
		Academic Staff	9	8	8	0
		Grant Holders and Trainees	15	14	11	-3
		Total Core Researchers	**29**	**27**	**24**	**-3**
	Affiliated Researchers		7	1	1	0
	Administrative and Technical	Employees	2	2	2	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**2**	**2**	**2**	**0**
	Total Integrated HR		**38**	**30**	**27**	**-3**
	Total Integrated PhD		**38**	**30**	**27**	**-3**

5.2.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CAP – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT			263	263
National R&D Programmes - S&T Integrated Projects	206	144	180	36
National Cooperation Programmes with Industry				
EU Framework Programmes	122	132		-132
EU Cooperation Programmes - Other	13	22	69	47
National R&D Services and Consulting				
International R&D Services and Consulting	90			
Other Funding Programmes	10	3		-3
Uncertain Projects	9	259	106	-153
Total Funding	**450**	**560**	**618**	**58**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	36	26	18
International conference proceedings indexed by ISI, Scopus or DBLP	15	33	15
Books (author)	0	0	0
Chapter/paper in books	1	0	0
Total	**60**	**59**	**33**

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

Type of Result	No.
Invention disclosures	1
Software copyright registrations	0
Patent applications	1
Licence agreements	0
Spin-offs	0

Table 5.6-CAP – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	2
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	2
Participation in events such as fairs, exhibitions or similar	0
Advanced training courses	0

Table 5.7-CAP – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	TEC4SEA-2	Pedro Jorge	01/09/2017	30/08/2020
PN-PICT	CORAL-SENSORS	Pedro Jorge	01/01/2016	31/12/2018
PN-PICT	CORAL-TOOLS-2	Pedro Jorge	01/01/2016	31/12/2018
PN-PICT	NanoStima-RL1-1	Carla Carmelo Rosa	01/07/2015	31/12/2018
PUE-FP	STRONGMAR-2	Ireneu Dias	01/01/2016	31/12/2018
PUE-FP	VAMOS-1	Pedro Jorge	01/02/2015	31/07/2018
PUE-DIV	AGRINUPES-1	Pedro Jorge	01/04/2017	31/03/2020
PUE-DIV	CostActions	José Luís Santos	01/01/2008	
PUE-DIV	SAFEWATER	Pedro Jorge	01/04/2018	31/03/2021
SERV-NAC	Consultoria	Paulo Vicente Marques	01/01/2010	
SERV-INT	TECCON2	Pedro Jorge	01/01/2016	31/12/2018
OP	Coop-Transnacional	Paulo Vicente Marques	01/01/2010	

Type of Project:

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

5.3 CRAS - CENTRE FOR ROBOTICS AND AUTONOMOUS SYSTEMS

Coordinators: Eduardo Silva and Aníbal Matos

Co-coordinator: Carlos Pinho

5.3.1 Presentation of the Centre

The Centre for Robotics and Autonomous Systems (CRAS) aggregates more than 40 researchers addressing scientific and technological topics associated to field robotics and autonomous systems. Its mission addresses the development of innovative robotic solutions for operation in complex environments for multiple operations, including data gathering, inspection, mapping, surveillance, or intervention.

CRAS accomplishes its mission within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards 4 main areas of research: autonomous navigation; long term deployments; sensing, mapping, and intervention; multiple platform operations.

5.3.2 Research and Technology Development

The activities of the centre are organized along the following major research areas:

Autonomous navigation

The major goal of this area is related to the development of solutions that allow autonomous robots to operate in dynamic and complex environments or where global positioning aiding systems are not available. Research activities address advanced navigation algorithms based on data fusion techniques, algorithms for simultaneous navigation and mapping, underwater acoustic positioning systems, situation awareness systems, obstacle detection algorithms, obstacle avoidance systems, path planning algorithms, obstacle avoidance systems, close range operations in maritime robotics, and safety behaviours.

Long term deployments

The main goal of these lines is the development of technologies and solutions that enable the long-term deployment of robotic platforms. Research activities include design of efficient propulsion systems for underwater or surface vehicles, development of long range navigation algorithms, development of energy harvesting systems for robotic platforms, and development of auxiliary systems for long term deployments (e.g. docking stations, energy transfer systems).

Sensing, mapping, and intervention

This area addresses the use of autonomous robotic systems in sensing, mapping, and intervention operations. Research activities include computer vision techniques and algorithms, sensing strategies for single or multiple robotic systems, adaptive sampling techniques, multi sensor data fusing for underwater or overwater mapping, hyperspectral, electro-optic and acoustic image processing, autonomous intervention for robotic platforms.

Multiple platform operations

This area addresses the development of technologies and solutions that take advance of the use of multiple robotics platforms that cooperate in the accomplishment of a given tasks. Activities in this area include the development of command and control solution for the coordinated operation of multiple (possibly heterogeneous) platforms, development of mobile beacons for underwater positioning and communication networks, and coordinated operations of underwater, surface, and aerial platforms.

5.3.3 Technology transfer

Autonomous navigation

In this area, CRAS is able to transfer technology and provide consulting services on:

- Design, development, and implementation of navigation systems for autonomous systems (aerial, land, surface, or underwater);
- Design, development, and implementation of underwater acoustic positioning systems;

- Design, development, and implementation of obstacle detection and avoidance systems.

Long term deployments

In this area, CRAS is able to transfer technology and provide consulting services on:

- Design and development of robotic platforms or subsystems for long term deployments;
- Design, development, and implementation of efficient propulsion systems for marine platforms.

Sensing, mapping, and intervention

In this area, CRAS is able to transfer technology and provide consulting services on:

- Implement a multi-trophic sensor;
- Design, development, and implementation of computer vision algorithms for robotics and robotic based sensing applications;
- Design, development and implement 3D acoustic image processing system;
- Design, development, and implementation of data processing and fusion strategies and algorithms for single or multiple cooperating robots;
- Design, development, and implementation of adaptive sampling algorithms;
- Design, development, and implementation of multi sensor data fusion systems for inspection and mapping.

Multiple platform operations

In this area, CRAS is able to transfer technology and provide consulting services on:

- Design and development of command and control systems for coordinated robotic platforms;
- Design, development, and implementation of mobile beacons for underwater positioning;
- Design, development, and implementation of mobile beacon for communication networks.

5.3.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CRAS – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)											
	Status (2)	Navigation	Acoustic positioning	Obstacle detection & avoidance	Robotic platforms	Underwater propulsion	Computer vision	Data fusion	Adaptive sampling	Inspection and mapping	Command and control	Mobile beacons
Autonomous navigation	I	H	H	H			M	M		H		
Long term deployments	I	M	H		H	H						
Sensing, mapping, and intervention	I						H	H	H	H		
Multiple platform operations	I	M									H	H

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution

L – Low or weak relationship / contribution;
H – High or strong relationship / contribution;
M – Medium relationship / contribution;
F – Future predicted relationship / contribution

5.3.5 Main objectives and actions planned for 2018

5.3.5.1 General Objectives

The **General Objectives of CRAS** for 2018 are the following:

- High quality publications. CRAS aims to continue increasing the number of articles published in the journals classified by SCOPUS as first quartile.
- Provide research services to community. Besides publishing scientific results in relevant fora and protecting intellectual property, CRAS will also pursue new partnerships with companies with the purpose of enabling the transference of the new results to relevant partners.
- Increase international visibility. The increase of CRAS international visibility will also be pursued, by participating in relevant international fora, by organizing international events, and by promoting the short term exchanges of researchers with partner institutions to foster the publication of new scientific results in top ranked journals.
- Improve its attractiveness, increasing the number of MSc and PhD students in CRAS.
- Increase its national recognition as a major R&D player in robotics and autonomous systems for sea related activities.

5.3.5.2 Specific Objectives and Actions

Autonomous navigation

- Development of vision based control algorithms for underwater docking;
- Development of acoustic network operation modes for one way simultaneous navigation and external tracking of multiple underwater vehicles;
- Development of obstacle avoidance algorithms for autonomous surface, underwater and aerial vehicles;
- Development, implementation and testing of mission planning algorithms for autonomous underwater vehicles;
- Aerial robot network control formation.

Long term deployments

- Development and field testing of docking systems for AUVs;
- Development and field testing of an underwater vertical profiler.

Sensing, mapping, and intervention

- Design, development, and testing of underwater visual mapping system;
- Design and development of sensing and control system for autonomous underwater manipulation;
- Design and development of automatic water sampler device;
- Design and development of underwater mining mapping;
- Design and Development underwater pseudo-Lidar system.

Multiple platform operations

- Development of small size unmanned surface vehicles for the establishment of reconfigurable communication networks over extended areas;
- Development and field testing of coordination algorithms between underwater and surface platforms;
- Implement a robotic lander network.

5.3.6 Centre Organizational Structure and Research Team

The Centre for Robotics and Autonomous Systems is coordinated by Eduardo Silva, Aníbal Matos and Carlos Pinho. The centre has a coordination council (CRAS Coordination Council) composed by the centre coordinators and by 4 other senior researchers: Alfredo Martins, José Carlos Alves, José Miguel Almeida, and Nuno Cruz. This council is responsible for the discussion, definition, and implementation of the centre research, development and innovation strategy.

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

Table 5.2-CRAS – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	5	10	9	-1
		Academic Staff	10	10	10	0
		Grant Holders and Trainees	25	39	14	-25
		Total Core Researchers	**40**	**59**	**33**	**-26**
	Affiliated Researchers		0	0	0	0
	Administrative and Technical	Employees	2	3	4	1
		Grant Holders and Trainees	1	3	0	-3
		Total Admin and Tech	**3**	**6**	**4**	**-2**
		Total Integrated HR	**43**	**65**	**37**	**-28**
		Total Integrated PhD	**43**	**65**	**37**	**-28**

5.3.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CRAS – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT	44	55	920	865
National R&D Programmes - S&T Integrated Projects	45	108	71	-37
National Cooperation Programmes with Industry		248	164	-84
EU Framework Programmes	1 175	1 424	523	-901
EU Cooperation Programmes - Other	163	74	115	41
National R&D Services and Consulting	47	102	33	-69
International R&D Services and Consulting	20	120	125	5
Other Funding Programmes	23			
Uncertain Projects	40	349	76	-273
Total Funding	**1 557**	**2 480**	**2 027**	**-453**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	2	9	8
International conference proceedings indexed by ISI, Scopus or DBLP	24	19	20
Books (author)	0	0	0
Chapter/paper in books	3	0	0
Total	**31**	**28**	**28**

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

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	2
Licence agreements	0
Spin-offs	0

Table 5.6-CRAS – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	3
Participation in events such as fairs, exhibitions or similar	2
Advanced training courses	3

Table 5.7-CRAS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	EMSO-PT	Aníbal Matos	01/07/2017	29/06/2020
PN-FCT	MyTag	Eduardo Silva	01/06/2016	31/05/2019
PN-FCT	ROSM	André Dias	01/10/2017	02/04/2019
PN-FCT	TEC4SEA	Eduardo Silva	01/09/2017	30/08/2020
PN-PICT	CORAL-SENSORS-1	Eduardo Silva	01/01/2016	31/12/2018
PN-PICT	CORAL-TOOLS	Eduardo Silva	01/01/2016	31/12/2018
PN-COOP	DeepFloat	Eduardo Silva	09/03/2016	30/06/2018
PN-COOP	SIDENAV	Eduardo Silva	01/12/2016	30/05/2018
PUE-FP	EMSODEV	Aníbal Matos	01/09/2015	31/08/2018
PUE-FP	STRONGMAR	Eduardo Silva	01/01/2016	31/12/2018
PUE-FP	SUNNY	Eduardo Silva	01/01/2014	30/06/2018
PUE-FP	UNEXMIN	Eduardo Silva	01/02/2016	31/10/2019
PUE-FP	VAMOS	Eduardo Silva	01/02/2015	31/07/2018
PUE-DIV	INTENDU	Aníbal Matos	01/03/2018	28/02/2021
PUE-DIV	PROTOATLANTIC	Eduardo Silva	01/09/2017	31/05/2019
PUE-DIV	SpilLess	Eduardo Silva	01/02/2017	31/01/2019
SERV-NAC	Consultoria	Eduardo Silva	01/01/2016	
SERV-NAC	Demo_Drone	José Miguel Almeida	01/05/2015	30/04/2018
SERV-INT	AutoMon	Aníbal Matos	01/04/2017	31/03/2019
SERV-INT	EDA-SAVEWATE	Nuno Cruz	25/01/2012	31/12/2018
SERV-INT	Evologics	Nuno Cruz	01/05/2013	30/04/2018
SERV-INT	RAWFIE	Aníbal Matos	01/09/2016	28/02/2019

Type of Project:

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

5.4 CBER - CENTRE FOR BIOMEDICAL ENGINEERING RESEARCH

Coordinators: Aurélio Campilho and João Paulo Cunha

5.4.1 Presentation of the Centre

The Centre for Biomedical Engineering Research Aggregates researchers and research activity under a mission and guided by specific goals.

Mission:
To promote knowledge through applied research advanced training and innovation in Biomedical Engineering.

Goals:

- To create interdisciplinary knowledge enabling the innovation and technology transfer with economic impact;
- To develop products, tools and methods for the prevention and early detection of different types of diseases, aging related impairments, or for human rehabilitation, physiotherapy or functional assessment;
- To contribute to the development of advanced neuro-technologies at the frontier of engineering and neurology;
- To promote strategic partnerships with other centres of INESC TEC, clinical partners, research institutes and foster international cooperation;

C-BER accomplishes its mission within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards areas of research organized under three Research Labs: Biomedical Imaging Lab, Bioinstrumentation Lab and Neuroengineering Lab.

5.4.2 Research and Technology Development

Biomedical Imaging Lab

Coordinator: Aurélio Campilho

The main focus of the Biomedical Imaging Lab is the development of advanced image processing and analysis methodologies, particularly medical and biological images, with the aim of creating computer-aided diagnosis tools to support medical decision making. The research activities at the Lab use several imaging modalities addressing different clinical departments including in Ophthalmology, Neurology, Radiology, Gynecology and Obstetrics and Gastroenterology.

The Biomedical Imaging Lab is organized in three main lines of research: Ophthalmology CAD, Lung CAD and Ultrasound CAD.

Ophthalmology CAD

The research activities under this line are:

- Screening of Diabetic Retinopathy, including the automatic detection of image quality, the automatic detection of images with pathology and the grading of retinopathy. Advanced image analysis and machine learning methodologies, including generic approaches are/will be used. The input data are retinograms.
- Analysis of eye fundus images for early detection of prevalent eye pathologies, including diabetics and hypertension. This involves the detection and segmentation of main anatomical structures and its characterization in order to derive image-based biomarkers. Advanced image analysis methodologies, including generic approaches are/will be used. The input data are retinograms.
- To determine choroid thickness and changes in the layer's structure in Optical Coherence Tomography (OCT) images and to correlate with clinical status.

Lung CAD

- Segmentation of lung structures, as lung lobes, airways and vasculature network.
- Early detection of lung pathologies in chest CT scans, with a reduced number of false positives.
- Segmentation and characterization of lung lesions.
- Computer-aided diagnosis of lung cancer and prediction of malignancy likelihood.

Ultrasound CAD

- Measurement of macro vascular characteristics, as calibers, layer thicknesses (as IMT - Intima-to-media Thickness), plaque burden and other markers in ultrasound images of the carotid.
- Characterization of Ultrasound Images in 2D, 3D and 4D and its application in Gynecology and Obstetrics.

The modular design, will allow to set-up web-based and cloud-based solutions in the research areas defined above. This will enable innovation and facilitate tech-transfer to the high-tech clinical market, either in hospital environment or business companies in medical devices.

NeuroEngineering Lab

Coordinator: João Paulo Cunha

The main goal of the NeuroEngineering lab is to perform high-level interdisciplinary R&D in engineering and computational approaches applied to basic and clinical neuroscience, namely crossing several areas, such as Physics; Engineering (Electronics; Computation; etc.); Neurology; Neurosurgery; Neurophysiology; Neuroradiology and Neurobiology.

Furthermore, we also aim to innovate and facilitate tech-transfer to the high-tech market.

The main research activity lines in the lab are:

- Brain imaging (&signals)
- Man-computer symbiosis (e.g. Brain-Computer Interfaces)
- Quantified Movement analysis in neurological diseases
- Neurosurgery Aiding Systems

BioInstrumentation lab

Coordinator: Miguel Velhote Correia

The main goal of the BioInstrumentation lab is to perform high-level interdisciplinary R&D in engineering and computational approaches applied to health, well-being, sports performance and rehabilitation namely crossing several areas, such as Physics; Engineering (Electronics; Computation; etc.); Physiology, Physiotherapy, Psychology, Psychophysics, Sports science.

Furthermore, there is also the aim to innovate and facilitate tech-transfer to the high-tech market.

The main research activity lines in the lab are:

- Sensing and biosignal acquisition technologies
- Medical electronics and devices
- Wearable monitoring systems
- Human movement analysis

5.4.3 Technology transfer

Biomedical Imaging Lab

In order to ease the technology transfer our approaches are organized in modules of direct applicability in specific clinical or general purpose domains. The researchers are asked to fill in a module lab chart, identifying the module (name, input and output), give a 3-line description and application targeted. In Biomedical Imaging C-BER is able to transfer technology and provide consulting services in:

- Planning and design Ophthalmology CAD, particularly involving image analysis of eye images, as eye fundus images and Optical Coherence Tomography eye images.
- Ultrasound (US) image analysis techniques in order to develop tools for image enhancement, lesion detection, biomarkers measurements from 2D, 3D and 4D US images.
- Planning and design Lung CAD for early detection and characterization of lung pathologies in chest CT scans.

NeuroEngineering Lab

- We do not foresee any technology transfer from this lab. We will continue to provide several advanced neuroimaging services to clinical partners from Porto and Munich.

BioInstrumentation Lab

We have been following the tech-transfer methodology by:

- Establish R&D collaborations with companies and industry clusters.
- File for patents or other exploitation paths of higher TRL developments.
- Actively search for opportunities for exploitation of the achieved patents and developments.

In recent years, we have been active in producing several patents requests, namely:

- “Medical Device with Rotational Flexible Electrodes”, 25.08.2016, INPI (This patent is the first IP result from the R&D Program Contract with Biodevices SA)
- “Biometric Method ad Device For Identifying A Person Through An Electrocardiogram (ECG)”, Pedido Provisório de Patente 20161000028874, 29.04.2016, INPI
- Mixed-signal test and measurement framework for monitoring systems, 2013/02/15, INPI
- Imager with compressive sensing capability, 2013/02/15, INPI
- Control module for multiple mixed-signal resources management, patent request PT107537; PCT/IB2015/052141; WO/2015/145347A1, Pub date 2015/10/01

After participating with a business idea in the CMU-Portugal “Entrepreneurship in Residence” (in-Res) program held from June to December 2017, which included 2 months in Pittsburgh and Silicon Valley, we intend in 2018 to start the spin-off process of the achieved patents looking for different possible paths (licensing, selling, etc.).

We are also open to provide consulting services in the Biomedical Engineering area, although we do not yet sense a large demand for this type of services in the Portuguese market.

5.4.4 Knowledge valorisation chain

The following table presents the contribution of the “Research and Technology” areas to the “Technology Transfer” areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CBER – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Status (2)	Areas of Technology Transfer --> relationships (3)								
		Ophthalmology	Neurology	Vascular Medicine	Radiology	Obstetrics/Gynecology	Geriatrics	Rehabilitation	Health and Well-being	Sports technology
Biomedical Imaging Lab	I	H	L	H	M	L				
BioInstrumentation Lab	I		M				L	H	H	H
NeuroEngineering Lab	I		H		M		L		H	

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.4.5 Main objectives and actions planned for 2018

C-BER objectives for 2018

- Develop the undergoing R&D projects as planned;
- Develop new approaches for CAD, in particular in "Gynecology and Obstetrics" and lesion detection of gastrointestinal tract in endoscopy videos;
- Increase the number of journal publications particularly in 1st quartile journals;
- Install R&D successful software applications in clinical departments;
- Continue and increase the fruitful interactions and joint R&D with other INESC TEC R&D centres, namely at the cluster level;
- Attract the best PhD and MSc students in the Biomedical Engineering area (not only from FEUP…);
- Evolve the joint R&D actions with CTM and look for new opportunities with these and other INESC TEC centres, particularly within the NIS cluster;
- Develop applications for the Ultrasound Equipment particularly for "Gynecology and Obstetrics" and "Neurology";
- Maintain or increase the production of patents,
- Continue and increase the fruitful interactions and joint R&D with other INESC TEC R&D centres, namely at the cluster level;
- Achieve the first spin-off of C-BER technology;
- Submit/be involved in one or more large H2020 or NIH project.

C-BER Actions for 2018

- Actively look for new H2020 and/or NIH projects;
- Attract the best PhD and MSc students in the Biomedical Engineering area (not only from FEUP);
- Start the first C-BER spin-off process to a start-up company;

- Further deepened the "R&D program" contract with Biodevices SA and look for new "R&D program" contracts;
- Evolve the joint R&D actions with CAP and CTM and look for new opportunities with these and other INESC TEC centres, for example by more involvement in the NIS cluster;
- Install and start operation of the MRI simulator heavy equipment;
- Increase journal papers publications;
- Continue and increase the fruitful interactions and joint R&D with other INESC TEC R&D centres, namely at the cluster level;
- Increase the interaction with sports and high performance training groups under the initiative "Health, Sports and Well-Being hub" supported by the European Platform for Sports Innovation (EPSI);
- Submit/be involved in one or more large national clusters in the health sector and the textile and shoe industries;
- Enlarge the cooperation with national and international clinical partners, to ease the translation of the developed methodologies to clinical practice;
- Enlarge scientific international cooperation, in particular in the application of advanced artificial intelligence and machine learning methodologies in medicine;
- Submit/be involved in one or more large H2020 consortium and project;
- Look for new "R&D program" contracts with industry;
- Investigate new technologies and solutions for enabling THz communication systems in beyond 5G scenarios;
- Demonstrate wireless power transfer for battery recharging in underwater environment (both freshwater and saltwater scenarios).

5.4.6 Centre Organizational Structure and Research Team

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

Table 5.2-CBER – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	1	3	2	-1
		Academic Staff	6	6	6	0
		Grant Holders and Trainees	15	21	20	-1
		Total Core Researchers	**22**	**30**	**28**	**-2**
	Affiliated Researchers		3	3	4	1
	Administrative and Technical	Employees	0	0	0	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**0**	**0**	**0**	**0**
	Total Integrated HR		**25**	**33**	**32**	**-1**
	Total Integrated PhD		**25**	**33**	**32**	**-1**

5.4.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018– participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CBER – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT	121	260	281	21
National R&D Programmes - S&T Integrated Projects	168	280	243	-37
National Cooperation Programmes with Industry			1	1
EU Framework Programmes				
EU Cooperation Programmes - Other				
National R&D Services and Consulting	30	30	30	
International R&D Services and Consulting				
Other Funding Programmes				
Uncertain Projects			17	17
Total Funding	**319**	**570**	**571**	**1**

Table 5.4-CBER – Summary of publications by members of the Centre

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	15	14	16
International conference proceedings indexed by ISI, Scopus or DBLP	18	20	20
Books (author)	0	0	1
Chapter/paper in books	1	1	2
Total	**35**	**35**	**39**

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

Type of Result	No.
Invention disclosures	2
Software copyright registrations	2
Patent applications	1
Licence agreements	2
Spin-offs	1

Table 5.6-CBER – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	4
Participation in events such as fairs, exhibitions or similar	3
Advanced training courses	0

Table 5.7-CBER – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	LNDetector	Aurélio Campilho	01/06/2016	31/05/2019
PN-FCT	SCREEN-DR	Aurélio Campilho	01/04/2016	31/03/2020
PN-FCT	VR2Market	João Paulo Cunha	15/07/2014	31/12/2018
PN-PICT	NanoStima-RL1	João Paulo Cunha	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL5-1	Aurélio Campilho	01/07/2015	31/12/2018
PN-PICT	SMILES-1	João Paulo Cunha	01/07/2015	31/12/2018
PN-COOP	TexBoost	Miguel Velhote Correia	01/07/2017	30/06/2020
SERV-NAC	Bio-Early	João Paulo Cunha	01/10/2015	30/06/2018
SERV-NAC	Consultoria	João Paulo Cunha	01/01/2016	

Type of Project:

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

5.5 CPES - CENTRE FOR POWER AND ENERGY SYSTEMS

Coordinators: Manuel Matos and Luís Seca

5.5.1 Presentation of the Centre

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

CPES activity is organized in five areas:

- DMS/EMS & System Operation
- System Planning and Reliability
- Network Studies and RES & DER integration
- Electricity Markets and Regulation
- Energy Analytics and Forecasting

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

Over the last 4 years, this centre has made several developments in the electrical network planning and operation, namely the inclusion of distributed energy resources forecasting and network optimization tools embedded in different voltage layers, exploiting the MicroGrid hierarchical concept. Relevant steps were given on the inclusion of computational intelligence in control algorithms that were demonstrated under real conditions in several pilots.

This centre is a world reference in large scale integration of Distributed Energy Resources. CPES includes 2 IEEE Fellows (one is in the IEEE Distinguished Lecturer Program) and is a strong player in EU H2020 (leader in some projects) and contracts with national and international companies, with a robust track record in technology transfer and consulting. One researcher received the IEEE PES Renewable Energy Excellence Award 2103. Another received a recognition award 2013 from CIGRE. Yet other researchers won the 2014 and 2017 IEEE PES competitions in meta-heuristics applications to difficult power systems problems. Post-graduation students won the Portugal best MSc thesis prizes by REN-ISO of Portugal in 2014/15/16, by APREN-Renewable GENCOs association in 2015 and by APRP-Pattern recognition association in 2017. Because of this expertise, INESC TEC won the recognition of best 2016 innovation partner of EDP (national utility).

The research outputs are in the range of TRL 3-8.

Members of CPES are in the Board of Societies or Steering Committees responsible for organizing some of the most important world conferences in power systems (IEEE PowerTech, PSCC, ISAP, PMAPS, IREP).

5.5.2 Research and Technology Development

The Centre addresses the following main research areas:

Decision Making, Optimisation and Computational Intelligence

Classic and emerging optimisation methods with applications in energy systems, methodologies for multi-criteria decision support, including risk models and methodologies based on metaheuristics and evolutionary computation for optimisation and decision making. Computational intelligence based models (e.g. fuzzy systems, neural networks, autoencoders) for applications in energy systems.

Forecasting
Statistical learning algorithms for univariate and multivariate time series; forecasting error analysis with probabilistic descriptions of uncertainties; distributed learning and parallel computing; classical data mining algorithms and deep learning techniques for dimension reduction and feature extraction; data-driven power system management, control and planning functions; modelling of energy systems, such as storage, renewable technologies and controllable loads.

Static and Dynamic analysis of Energy Grids
Classic and fuzzy models for steady state analysis of electricity grids, modelling and analysis of the dynamic behaviour in isolated and interconnected networks, dynamic models for energy conversion systems, dynamic simulation models for microgeneration systems and microgrids and the design of advanced system support functions/ancillary services for Distributed Energy Resources integration into electric power systems.

Reliability
Models to analyse reliability in energy systems, reliability in static, spinning and operational capacity power systems looking at renewable and variable energy production, reliability of composite distribution systems (Generation + Transmission), microgeneration and microgrids, models to represent maintenance and the transmission network.

Power Electronics
Research and development activities ranging from the fundamental technology investigation up to advanced demonstration pilot sites related to power electronic energy conversion units, conditioning and control for microgeneration units and energy storage devices with advanced grid support functionalities.

Optimization of Energy Use
Multi-temporal optimization strategies to allow a dynamic exchange of energy services between end-users of energy and market participants. Definition of energy models for devices, systems and buildings that start from imperfect initial models based on default characteristics that are able to be perfected with the use of data-driven modelling techniques to create adaptable models based on local information. Design of energy management algorithms for resource constrained computational platforms.

5.5.3 Technology transfer

DMS/EMS & System Operation
The main focus of this area is the specification, development and integration of advanced computational tools for network management systems for all voltage levels, such as:

- topology processors, smart data management, load allocation and power flow and uzzy state estimation
- voltage and reactive power control, preventive management and voltage control
- fault location, isolation and restauration (FDIR), optimal network reconfiguration, validation of switching optimized solutions
- self-healing, optimal power flow, multi-period optimal power flow, contingency analysis, economic dispatch, unit commitment
- dispatch training system, distribution state estimator including unbalanced networks.

System Planning and Reliability
The technology transfer activities developed in this area are mainly directed to transmission and distribution system planning and reliability analysis, including security of supply and reserves adequacy. Another major topic involves load research, load pattern analysis, classification and management, and the development of load and loss profiles for electricity markets. This area also addresses loss studies, comprising estimation and allocation of technical losses, and strategy scheming for the reduction of technical losses. Finally, it also focusses on the detection of non-technical losses and consumption behaviour anomalies.

Network Studies and RES & DER integration

The central focus of the Network Studies and RES & DER integration Area is the steady state, dynamic and transient modelling, analysis and control of interconnected and isolated electric power systems with increasing shares of Renewable Energy Sources (RES). The mains activities are related to RES integration studies, identification of system support functions/ancillary services from RES and the exploitation of new technologies for increasing the controllability and flexibility of transmission and distribution grids (transmission and distribution FACTS, energy storage and associated power converters, HVDC). These activities are supported by a laboratorial infrastructure where reduced-scale models can be implemented and extensively tested in a power-hardware-in-the-loop set-up. The work developed in this area has been largely carried out in collaboration with the industry through consultancy services and applied research as well as through national and European public research bodies, whose financial support enables the developed of fundamental R&D activities.

Electricity Markets and Regulation

This area addresses the organization, operation and expansion planning of power systems under market conditions as well as the development of tariff schemes to support regulated transmission and distribution activities. On one hand, it aims at developing market structures to bring gate closure closer to real time, to progressively integrate reserve markets in active power markets and to expand them into transnational mechanisms. On the other hand, it applies optimization methods and metaheuristics to develop long term expansion generation and transmission planning under uncertain conditions namely due to the presence of multiple generation agents. Finally, it addresses regulatory issues related to transmission and distribution network activities in order to incorporate dynamic tariff options in the tariff codes and to study the reshaping of network tariffs in view of the expected reduction network usage as local micro and mini generation spread in the systems.

Energy Analytics and Forecasting

This area applies statistical learning and optimization techniques to power system related problems, electricity markets and end-users. The main core activities are the development of time series forecasting algorithms for load, renewable energy and electricity prices. These techniques are the basic framework to tackle new problems like distributed and data-driven demand response strategies and knowledge extraction (data mining) from different power system data, such as phase measurement units, smart meters data and other sensors. The final goal is to embed integrate extracted knowledge in decision-aid methods problems under risk and create new paradigms for power system control and market participation and planning. The results from the R&D activities are, in general, transferred to industrial partners (system operators, retailers, consumers) and the operationalization of the computational modules is made by INESC TEC or by the final client.

Energy management is one of the areas in which energy analytics are applied to define flexibility schemes in allowing energy efficiency actions to be more effectively implemented taking into account external incentives like dynamic price tariffs and/or integration of local RES.

Advanced Training

Organising lectures and training activities on emerging issues as part of projects with international consortia, European projects or on request from companies / utilities.

5.5.4 Knowledge valorisation chain

The following table presents the contribution of the “Research and Technology” areas to the “Technology Transfer” areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CPES – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)					
			DMS/EMS System Operation	System Planning and Reliability	Network Studies and RES & DER integration	Electricity Markets and Regulation	Energy Analytics and Forecasting	Advanced Training
Decision Making, Optimisation and Computational Intelligence		I	H	H	M	H	M	
Forecasting		I	H	M		H	H	H
Static and Dynamic analysis of Energy Grids		I	M	L	H		L	H
Reliability		I	M	H		M	L	M
Power Electronics		I		L	M			
...		I						
Other Areas (1)	Communication networks (CTM)	O	H				M	
	Data Mining (LIAAD)	O	L	M			H	
	Service Design and Engineering (CEGI)	O		L			M	

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.5.5 Main objectives and actions planned for 2018

In the coming years, significant changes will occur and the current paradigm will give place to a more decentralized, data application based on a "peer to peer" approach. This will require ground-breaking concepts, mostly on the introduction of artificial intelligence, cybersecurity and asset management in the network management tools, supported by a multidisciplinary approach, towards a completely new system operation, where end users will negotiate with market agents in almost real time using secure and transparent solutions that must assure system reliability.

The cost of energy is becoming a key variable in energy-intensive consumers (buildings, factories, datacentres, etc.), which show adequate scale (both technical and economic) for a direct integration in the electricity and energy services market. This approach requires the development of data-driven optimization techniques that waive the need for complex modelling of the physical systems and automate the quantification of loads or processes flexibility.

Furthermore, citizen-centred frameworks and the empowerment of small consumers are a priority for the European Union energy policy. Nevertheless, concerns with data privacy and limited consumer engagement are also major barriers for the adoption of new technology. During this year, CPES intends to implement local and privacy-preserved optimization/ forecasting models for domestic energy management, as well as to develop consumer engagement strategies supported in behavioural sciences and human-computer interaction.

So in general terms, in 2018, CPES will develop a set of research activities involving big data handling, including knowledge extraction from the ever-growing ubiquitous sensing in distribution grids, following the current digitalization trends in power systems.

On the network level, new approaches exploiting fast active power injections to improve system frequency response in low inertia systems will be studied and new operation and coordinated control schemes to be applied in power inverter-based technologies, in order improve the global system frequency response, will be developed.

These activities will range between TRL 1 and 5, with particular focus in basic research in order to generate new knowledge that can be further explored during the following years in demonstration activities and technology transfer.

The envisaged developments for each of the research areas are detailed in the next paragraphs.

New developments in DMS/EMS & System Operation
Integration of multi-temporal optimization algorithms to improve the current Advanced Distribution Management Systems (ADMS), to deal with the presence of the distributed energy resources (storage devices, RES, electric vehicles) taking into account inter-temporal constraints. Improvements in the existing modules to be prepared and to take advantage of this new approach.

Development of advanced data management and optimization tools for the management of LV networks, taking advantage of smart metering infrastructure and new sensors installed at the secondary substation. This includes the improvement of LV state estimation algorithm through the automatic selection of real-time measurement as well as the development of new algorithms for the network phase identification and topology identification.

New developments in System Planning and Reliability
This area has been involved on the classical power systems problems including Power Systems Analysis, Operation Optimization, Load Forecasting, Characterization of Consumers and Networks, analysis of network investments for Loss Reduction, as well as on new areas arising from challenges created by the liberalization of energy markets like Conformity Analysis of the settlement procedures, Load, Losses and Microgeneration Profiles. The applied research developed by CPES has been producing innovative solutions, frequently adopted by the industry, agents acting in the energy sector, regulatory boards and by government agencies. The main short-term objective of this area is to reinforce the connection to industrial and government partners.

In 2018, this area will be involved in with the following projects:

- Development of tools for planning the DSO mandatory investments efforts for a time horizon of five years. This tool involves the estimation of the investment amount for each year as well as consumers co-participations, depending on the projected evolution of network consumption per voltage level and region, socioeconomic parameters, civil construction factors and others.
- Determination of loss profiles to be used in the electricity market in the year of 2019. The loss profiles computed by the CPES team were adopted by the Portuguese regulator (since 2008 to 2018). They are an essential piece of the current market settlement process.
- Estimation of how the evolution of distribution network quality indicators (security of service, quality of service, operational efficiency and network losses) are expected to evolve in the next years, depending on the investments scenarios. This will constitute a decision aid tool to help DSO to decide the most adequate investments on the network, according to the established network quality targets.
- Loss analysis in the Portuguese network – characterize losses (technical and non-technical) for HV, MV and LV networks. This will be the deepest study ever made in this country, as it will involve the all HV set of networks, thirty MV and thirty LV networks. Two complementary approaches will be applied: a) the traditional modelling and simulation; b) computing input-output differences and applying Dynamic Time Warping to synchronize interval energy measurements.
- Support the long-term planning (and long term forecasting) studies in a climate changing environment and increase the competences on sustainable policies. A PhD thesis in this area has just finished: “Climate changes in Brazil: the use of smart grids as a mitigation and adaptation strategy”
- Finally, in the context of Smart Cities and Communities, a coordinated operation of multi energy systems will be required in order to tackle the challenges towards a real decarbonisation of the energy sector. The merging of **different energy vectors (such as gas, electricity, district heating, water or even waste)** to be achieved through storage of some of these energy vectors, requires new approaches for planning

and operation of the whole energy system. This will require making use of distributed processing and intelligence in order to **manage massive amounts of data from different sources** and perform flexibility calculations that can increase the share of local resources' usage."

New developments in Network Studies and RES & DER integration

In scenarios with large scale integration of RES in the electric power system, the role that DG units connected to the distribution grid have in the overall system performance must be taken into account, once it may represent an important percentage of the total generated power in a given region. Therefore, in order to achieve relevant results within the networks' stability studies, especially when representing the system as whole, the distribution network modelling strategies should be revised. The active nature of the distribution grid requires that new requirements and models have to be identified. The rationale is to develop representative models that are able to characterize the existing response at DSO/TSO interfaces.

In order to operate the future power system with very high share of inverters securely and stably, appropriate control algorithms and operation procedures should be identified. The possibility of using inverter systems to partially reproducing physical properties similar to those of synchronous generators must also be investigated. Appropriate simulation models for grid stability analysis in large grid sections dominated by inverters, laboratory tests exploiting PHIL concepts and development of new grid code requirements constitute expected developments to be achieved.

Exploiting Smart Transformers (ST) within the smart grid context for increased controllability: Smart Transformers (ST) are power-electronic based components that brings new opportunities regarding the possibility of defining innovative operating strategies for Medium Voltage (MV) and Low Voltage (LV) distribution grids. ST can be exploited in the context of Multi-Microgrids (MMG) in order to enhance the possibility of their operation in both islanding an interconnected operation mode, as well as to participate in black start procedures.

Focusing on the emergency operation of distribution networks, the concept developed will be revisited in order to enable the secure operation of small islands within the MV distribution network, integrating both the LV and MV networks and exploring a more dynamic and flexible multi-microgrid concept and the flexibility of distributed storage devices and other DER connected to the distribution network.

Increasing RES integration in islands: on line security assessment of isolated system with large shares of RES, involving on-line tools to support the system operator on the re-dispatch based on the actual system conditions as well as on the short term forecast of different resources/flexibilities (involving storage solutions and demand response actions) when high risk incidents are in cause (and might result in unwanted load shedding actions).

In parallel with the research and development activities in this area, it will be reinforced the core group of researchers that have been involved in the consultancy activities in this area. This core group will be strengthened with researches with a strong background on dynamic and transient stability analysis of electric power systems.

New developments in Electricity Markets and Regulation

Along 2018 new developments will be made with the design of new models to contract flexibility services by end consumers and to schedule the operation of batteries in market environment. As more DER resources are connected to distribution networks, namely to LV and MV, and given that the number of EV´s is now increasing at a faster rate, it becomes crucial for DSO's to have the possibility to use new resources not only to facilitate the expansion and reinforcement of the networks but also to operate them in better conditions. In this scope, new models will be developed so that flexibility aggregators can contract flexibility services from end consumers and provide this new resource to the DSO's. On the other hand, research will continue regarding the development of models to schedule batteries in view of the fact that the corresponding investment can only be justified if they provide multiservice, namely in terms of price arbitrage, participation in reserve markets, provision of flexibility and load shifting. TRL 5.

Finally, continuing the efforts that have been made for several years from now, attention will continue to be given to the development of long term Transmission Expansion Planning, TEP, problem and solution algorithms in a market environment. In this area, given the complexity and the combinatorial nature of the TEP problem, it

will be developed an integrated approach that includes an initial step in which a solution space reduction will be performed followed by the use of a specific metaheuristic designed to address multi periods investment scheduling problems.

New developments in Energy Analytics and Forecasting
Starting in 2018, the energy analytics area will explore three main areas of basic research for a mid-term horizon:

a) Decentralized intelligence for renewable energy/flexibility forecasting and distributed energy resources optimization at the device level and ensuring data privacy. The target are domestic consumers and renewable energy sites.

b) Mathematical methods for stochastic preventive/predictive optimization of distribution grids including information from forecast uncertainty.

c) In contrast to the mathematical optimization techniques from point b), apply reinforcement learning techniques for prescriptive analysis and data-driven optimization under forecast uncertainty of smart grids and distributed energy resources. The focus are distribution grids and energy-intensive consumers (energy efficiency).

On the short term, the area will be focused on the development of a data-driven predictive control algorithm, which relies in reinforcement learning, for the optimization of the energy consumption of a wastewater treatment facility. This method will be able to significantly reduce the energy consumption without the physical system complete characterization, learning just through interaction with the physical system. The inclusion of wastewater intake rate probabilistic forecasts allows the algorithm to anticipate critical periods of wastewater inflow and adjust the operation accordingly. CPES is expecting to submit (together with Águas do Tejo Atlântico) a patent request during 2018 to protect this energy efficiency method. Moreover, the same principle will be applied to the real-time control of distributed energy resources associated to a virtual power plant and predictive battery storage optimization.

A "virtual battery" model will be formulated for modelling the domestic consumers' flexibility and to keep behind-the-meter data private. This result will be integrated in a home energy management system prototype.

A cognitive architecture (Deep SpatioTemporal Inference Network - DeSTIN) will be explored to extract information from low voltage (LV) network smart meters (active power, voltage magnitude) that improves the visualization of alarms by human operators and helps to better distinguish normal and emergency operating conditions. The mid-term objective is to integrate this information in reinforcement learning algorithms (state vector) to optimize LV network operation.

For energy management in industrial consumers, the following actions will be applied to increase the competences of INESC TEC:

a) CPES and CESE, in the framework of the project *Intelligence for advanced Manufacturing Systems* (iMAN), will elaborate a paper titled "Literature Survey on Synergies between Industry 4.0 and Smart Grids". The expected outcome is the definition of a common framework for the future work of both centers in this area and identify research gaps to be addressed in the following years.

b) Exploit the wastewater stations use case, from European Project InteGrid, to develop generalized data-driven flexibility quantification and optimization methods for industrial processes energy consumption. In this context, CPES is expecting to establish a collaboration with NOS to improve the energy efficiency of data centers cooling systems, where a preliminary work is expected ("offline" analysis) with an H2020 Call (LC-SC3-EE-7-2020) in the horizon.

Creation of data-driven energy models for devices, systems, spaces and buildings that are able to provide a complete energy characterization of different energy envelopes and provide relevant information that allows the exploitation of different energy vectors optimization in a multi-temporal way. Make use of IoT and M2M solutions as sources of information towards the creation of dynamic models that can more accurately describe the energy behaviour of devices, systems, spaces and building.

Finally, CPES and HASLab will create an internal "think-tank" and elaborate an internal seed project for electrical mobility, which will consists in a multi-disciplinary approach oriented to develop (e.g. blockchain, big data

platform, data analytics) technology that enables innovative business models. The involvement of other centers is expected in the future.

All these scientific developments include partnership with international partners like ARMINES (France), University of Strathclyde (UK), Technical University of Denmark (DTU).

New developments in Decision Making, Optimisation and Computational Intelligence RTD
Research on the stochastic optimal power flow (OPF) problem by combining chance-constrained optimization, convex relaxation and linear approximation to manage computational tractability of the problem. Application of alternating direction method of multipliers (ADMM) to the three-phase unbalanced OPF problem, which creates conditions for distributed optimization and development of peer-to-peer energy markets.

Data-driven optimization of energy-intensive processes by exploring reinforcement-learning algorithms, where the main novelty is the inclusion of forecast information in the state vector and truncating the generalized advantage estimation function by the time horizon length.

An FCT funded project was approved, UNiTED - *Unlocking demand response potential with Next generation innovative optimization Tools Empowering prosumers and Distribution grid benefits*. The project will develop innovative optimization tools to leverage demand response services from residential consumers/prosumers, commercial buildings, microgrids and virtual power plants (VPPs), turning citizens into active contributors to a stable operation of distribution grids with increasing share of renewable energy.

New developments in Forecasting RTD
CPES will continue developing techniques to extract information from geographically distributed measurements collected by sensors (e.g. smart meters, wind turbines) aiming at improving load and renewable energy forecasting skill. In particular, the development a non-linear vector autoregression model with data-privacy preserved is planned. Factor copulas will be explored for spatial-temporal modelling of forecast uncertainty, but this work is only expected to start in the last quarter of the year.

Recent advances in deep learning, namely long short-term memory (LSTM) units, will be adapted and modified to forecast active/reactive power load in smart grids. Moreover, in the framework of a DTU MSc student internship at CPES, LSTM will be applied to forecast the residual curves of the wholesale electricity market.

Neural networks will be used to analyse the available wholesale electricity market data and characterize circumstances that affect the evolution of prices, in order to allow the identification of states that promote price instability and to confirm that class segmentation allows increasing price forecast performance.

Finally, in collaboration with the Centre of Mathematics of the University of Porto (CMUP), conditional extreme value theory will be explored for modelling the extreme tails of price and renewable energy forecasting.

New developments in Reliability RTD
Development of tools for the adequacy assessment of MV/LV 3-phase unbalanced grids with renewables and storage systems. These tools will allow to quantify the benefits in terms of continuity of supply and/or renewable energy not used by installing distributed storage in these grids with different capacities and strategies of operation. In addition, tools for the adequacy assessment of the static and operational reserve in a multiarea environment will also be implemented aiming to quantify the overall benefits from the having the possibility of energy and reserve exchanges between different areas of control.

New developments in Static and Dynamic Analysis of Energy Grids RTD
In order to answer the challenges presented by the emerging Smart Grid paradigm, CPES concluded with success the conceptualisation and development of a set of new algorithms for monitoring, controlling and managing LV distribution networks, both in normal and emergency conditions. These algorithms allow the control of distributed energy resources (storage devices, PV panels and Electric Vehicles charging and discharging) and the integration of active demand response.

An innovative control system was built upon these results, that was experimentally validated in the Laboratory of Smart Grids and Electric Vehicles. The modules related to monitoring and control were transferred to industry,

adding value to a commercial product, and were tested in real environment networks of EDP-D, namely in the smart grids pilot in Évora, Portugal.

New developments in Power Electronics RTD

Power electronics has become a ubiquitous technology, which is widely present in many applications, in particular on power systems. This technology therefore constitutes one of the main pillars to reduce energy consumption and carbon dioxide impacts in our society. Its design, including the control methods and all the key components from early stages, are crucial to ensure their reliability and efficiency. In this context, along 2018 new developments will be made with the design of new control techniques of electronic power processors applied to electrical distributed generation systems, energy storage devices and electric drives. Specific short and long term goals:

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

New inter-area projects

On-going collaboration between CPES and HASLab in the H2020 project INTEGRID (Demonstration of INTElligent grid technologies for renewables INTEgration and INTEractive consumer participation enabling INTEroperable market solutions and INTErconnected stakeholders), duration 42 months, budget INESC TEC 1 297 050 € (total project 11 320 811 €), which started in January 2017.

Joint project of CPES and CEGI for EDP Produção in the asset management area, focused in the calculation of a health index for power transformers and causality analysis. The duration of the project is 6 months and it will start in March 2018.

Start (1st January) of the National project ESGRID on the smart grids domain and that covers three main topics: (a) demand response; (b) new algorithms for monitoring, forecasting and control of distribution grids; (c) new market models and regulatory frameworks. The duration is 36 months.

Proposals
The Centre is engaged in a number of consortia to answer different calls from the European Union, in the framework of H2020. NB: Since the proposals are still in negotiation and there are pending NDA, no further information can be disclosed in this document.

A proposal for energy efficiency and distributed energy resources (DER) sizing in the agriculture sector (was submitted to Horizon 2020 funds (DT-RUR-12-2018, *ICT Innovation for agriculture – Digital Innovation Hubs for Agriculture*), in collaboration with CRIIS.

A proposal for an R&D contract with IKEA was submitted for energy planning of their factories.

A proposal about weather intelligence for smart energy grids was submitted to Marie Skłodowska-Curie Innovative Training Networks (MSCA-ITN-2018). The work of CPES (one full-time PhD student in University of Porto) is focused in data-driven predictive distribution grid management.

CPES and CEGI will submit with EFACEC a proposal about power transformer monitoring and maintenance planning for National funds (Portugal 2020).

Organization of scientific events
CPES will organize dedicated events for the ongoing H2020 projects, in order to enhance the main scientific achievements in each one of them.

Advanced Training
The Centre will organize a course for REN technical staff on emergent topics of modern power systems.
The Centre also participates in the organization with EFACEC of a course about management functions for transmission and distribution networks for operators from Angola.

In the framework of the EES-UETP consortium a new course on “Advanced Data Analytics for Energy Systems” will be organized in September 3rd-5th, 2018.

5.5.6 Centre Organizational Structure and Research Team

The Centre for Power and Energy Systems is coordinated by Manuel Matos and Luís Seca and is organized in the following Areas:

- DMS/EMS & System Operation - Responsible: Jorge Pereira
- System Planning and Reliability - Responsible: José Nuno Fidalgo
- Network Studies and RES & DER integration - Responsible: Carlos Moreira
- Electricity Markets and Regulation - Responsible: João Tomé Saraiva
- Energy Analytics and Forecasting - Responsible: Ricardo Bessa

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

Table 5.2-CPES – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	12	16	19	3
		Academic Staff	12	12	12	0
		Grant Holders and Trainees	51	44	49	5
		Total Core Researchers	**75**	**72**	**80**	**8**
	Affiliated Researchers		3	3	3	0
	Administrative and Technical	Employees	2	2	2	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**2**	**2**	**2**	**0**
		Total Integrated HR	**80**	**77**	**85**	**8**
		Total Integrated PhD	**80**	**77**	**85**	**8**

5.5.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CPES – Project funding

Funding Source	Total Funding (K€)			
	2015	2016 (Forecast)	2017 (Plan)	Δ 2016 - 2017
National R&D Programmes - FCT	71	345	573	228
National R&D Programmes - S&T Integrated Projects	14	24	21	-3
National Cooperation Programmes with Industry		63	61	-2
EU Framework Programmes	1 144	842	841	-1
EU Cooperation Programmes - Other	182	183	226	43
National R&D Services and Consulting	566	812	1 125	313
International R&D Services and Consulting	77	103	141	38
Other Funding Programmes	135	160	20	-140
Uncertain Projects	25	99	113	14
Total Funding	**2 214**	**2 631**	**3 122**	**491**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	36	63	30
International conference proceedings indexed by ISI, Scopus or DBLP	70	82	31
Books (author)	0	0	0
Chapter/paper in books	3	1	5
Total	**117**	**146**	**66**

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

Type of Result	No.
Invention disclosures	1
Software copyright registrations	0
Patent applications	1
Licence agreements	2
Spin-offs	0

Table 5.6-CPES – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	8
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	0
International events in which INESC TEC members participate in the program committees	2
Participation in events such as fairs, exhibitions or similar	3
Advanced training courses	1

Table 5.7-CPES – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	ESGRIDS	João Peças Lopes	01/01/2017	31/12/2019
PN-FCT	INFUSE	Vladimiro Miranda	01/04/2016	31/03/2019
PN-FCT	SGEVL	Luís Seca	01/07/2017	29/06/2020
PN-FCT	SusCity	Manuel Matos	01/01/2015	30/06/2018
PN-PICT	CORAL-TOOLS-4	Carlos Moreira	01/01/2016	31/12/2018
PN-PICT	iMAN-5	Luís Seca	01/07/2015	31/12/2018
PN-COOP	NEXTSTEP	Clara Sofia Gouveia	01/12/2016	30/11/2019
PUE-FP	AnyPLACE	David Emanuel Rua	01/01/2015	30/06/2018
PUE-FP	EleCtra	José Nuno Fidalgo	01/12/2013	28/02/2018
PUE-FP	EU-SysFlex	Bernardo Amaral Silva	01/11/2017	31/10/2021

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	ESGRIDS	João Peças Lopes	01/01/2017	31/12/2019
PN-FCT	INFUSE	Vladimiro Miranda	01/04/2016	31/03/2019
PN-FCT	SGEVL	Luís Seca	01/07/2017	29/06/2020
PN-FCT	SusCity	Manuel Matos	01/01/2015	30/06/2018
PN-PICT	CORAL-TOOLS-4	Carlos Moreira	01/01/2016	31/12/2018
PN-PICT	iMAN-5	Luís Seca	01/07/2015	31/12/2018
PN-COOP	NEXTSTEP	Clara Sofia Gouveia	01/12/2016	30/11/2019
PUE-FP	AnyPLACE	David Emanuel Rua	01/01/2015	30/06/2018
PUE-FP	FEEdBACk	Filipe Joel Soares	01/11/2017	31/10/2020
PUE-FP	InteGrid	Ricardo Jorge Bessa	01/01/2017	30/06/2020
PUE-FP	SENSIBLE	Ricardo Jorge Bessa	01/02/2015	31/07/2018
PUE-FP	SmarterEMC2	David Emanuel Rua	01/02/2015	31/01/2018
PUE-FP	TDX-ASSIST	Leonel Magalhães Carvalho	01/10/2017	30/09/2020
PUE-FP	UPGRID	Luís Seca	01/02/2015	31/01/2018
PUE-DIV	GReSBAS	Filipe Joel Soares	01/04/2016	31/03/2019
PUE-DIV	INDuGRID	Carlos Moreira	01/09/2016	31/08/2019
PUE-DIV	REStable	Carlos Moreira	01/04/2016	31/03/2019
PUE-DIV	Smares	Carlos Moreira	01/04/2016	30/09/2018
PUE-DIV	SmartGuide	André Guimarães Madureira	01/04/2016	31/03/2019
SERV-NAC	ADMS4LV	Clara Sofia Gouveia	01/04/2016	31/03/2018
SERV-NAC	AO_Perdas	José Nuno Fidalgo	01/01/2018	31/12/2018
SERV-NAC	Automacao_Faial	Clara Sofia Gouveia	01/01/2016	30/04/2018
SERV-NAC	Automaçao_S.Miguel	Jorge Correia Pereira	01/01/2018	31/12/2018
SERV-NAC	Cidade_sustentavel	Filipe Joel Soares	01/01/2016	30/06/2018
SERV-NAC	Consultoria	Manuel Matos	01/01/2008	
SERV-NAC	CP_T_Dinamicas	João Tomé Saraiva	01/02/2015	30/06/2018
SERV-NAC	EFACEC-DMS	Jorge Correia Pereira	15/04/2001	
SERV-NAC	EstinvestQoS	José Nuno Fidalgo	01/12/2017	31/07/2018
SERV-NAC	Generation_RAM	João Peças Lopes	30/11/2016	29/03/2018
SERV-NAC	Graciosa	João Peças Lopes	25/11/2016	24/05/2018
SERV-NAC	GridCodeMadeira	João Peças Lopes	01/01/2018	31/05/2018
SERV-NAC	Hídrica_Flores	Carlos Moreira	01/02/2018	31/07/2018
SERV-NAC	Hidrica_reversivel	João Peças Lopes	01/03/2016	30/04/2018
SERV-NAC	HIP-1	Ricardo Jorge Bessa	10/01/2018	30/06/2018
SERV-NAC	INFRA_PT	João Peças Lopes	20/07/2017	06/11/2018
SERV-NAC	INTERLIG_PT_MA	Bernardo Amaral Silva	01/03/2017	31/08/2018
SERV-NAC	MIBEL	Filipe Joel Soares	11/09/2017	10/03/2018
SERV-NAC	MORA	Leonel Magalhães Carvalho	05/04/2016	04/04/2018
SERV-NAC	OTGEN3	João Peças Lopes	01/09/2017	31/05/2018
SERV-NAC	PANACea	José Nuno Fidalgo	08/08/2016	07/03/2018
SERV-NAC	Perfis_Perdas_2018	José Nuno Fidalgo	30/11/2017	01/03/2018

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	ESGRIDS	João Peças Lopes	01/01/2017	31/12/2019
PN-FCT	INFUSE	Vladimiro Miranda	01/04/2016	31/03/2019
PN-FCT	SGEVL	Luís Seca	01/07/2017	29/06/2020
PN-FCT	SusCity	Manuel Matos	01/01/2015	30/06/2018
PN-PICT	CORAL-TOOLS-4	Carlos Moreira	01/01/2016	31/12/2018
PN-PICT	iMAN-5	Luís Seca	01/07/2015	31/12/2018
PN-COOP	NEXTSTEP	Clara Sofia Gouveia	01/12/2016	30/11/2019
PUE-FP	AnyPLACE	David Emanuel Rua	01/01/2015	30/06/2018
SERV-NAC	Prob2	José Nuno Fidalgo	01/12/2017	31/07/2018
SERV-NAC	SACC	Filipe Joel Soares	01/01/2016	30/06/2018
SERV-NAC	SOLAR4DR	Ricardo Jorge Bessa	01/05/2017	30/06/2018
SERV-NAC	Tarif_Dinam_Acores	João Saraiva	01/12/2015	31/01/2018
SERV-NAC	Tarif_Dinam_Madeira	João Tomé Saraiva	01/02/2016	30/06/2018
SERV-INT	fof.PLAN	Ricardo Jorge Bessa	01/01/2018	31/07/2018
SERV-INT	Itesla_IPST	Helena Vasconcelos	01/06/2017	31/05/2018
SERV-INT	Med_TSO	Leonel Magalhães Carvalho	28/04/2017	27/04/2018
SERV-INT	SECRETS	Luís Seca	01/12/2013	31/05/2018
OP	CoordEES-UETP	João Peças Lopes	01/04/2007	

Type of Project:

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

5.6 CESE - CENTRE FOR ENTERPRISE SYSTEMS ENGINEERING

Coordinators: Américo Lopes Azevedo and António Lucas Soares

5.6.1 Presentation of the Centre

CESE accomplishes its mission, within the Cluster I+I - Industry and Innovation, by undertaking multi-disciplinary, system-oriented research and technology development for the strategic and operational management of industrial enterprises and networks. It uses the knowledge generated in research to provide high value-added niche services to the industrial enterprises in areas such as Manufacturing Systems Design, Manufacturing Systems Planning and Management, Collaborative Platforms, Supply Chain Strategy, Manufacturing Intelligence or Construction Information Management.

CESE mission is to advance the scientific knowledge in enterprise systems engineering, fostering high impact management and ICT systems and generating innovative services for industrial organisations. CESE wants to be recognised as a leading research centre in enterprise systems engineering and as a first choice in helping industrial organisations to achieve sustainable, high-performance levels.

CESE uses the following research approaches to fulfil its mission: Systems Design, Operational Research (Modelling and Optimization and Simulation), Information Management and Analytics, Design Science and Explanatory Research, and Creative Thinking and Problem Structuring. These approaches support CESE RTD activities which are organized in the following research domains: Manufacturing and Services Operations Management, Enterprise and Industrial ICT, Collaborative Networks and Supply Chains, Business Analytics and Decision Support Systems and Transports, Logistics and Mobility.

5.6.2 Research and Technology Development

Manufacturing and Services Operations Management

CESE research activities in the Manufacturing and Services Operations Management research domain address applied research in operations management encompassing Factories Design and Operation, Production Planning, Scheduling and Control and Business Processes Management.

Factories Design and Operation: Industries of the future must be driven by adaptability of the factory design and of its processes. This requires innovative and multidisciplinary approaches to address the increasing complexity and scale of decision-making. CESE research in this line is centered on intelligent manufacturing technologies and methodologies, developed on top of analytical modelling approaches such as simulation and optimization. The research efforts are aimed at (i) the conceptual factory design and layout planning; (ii) integrated design and operation of smart manufacturing systems; (iii) virtual commissioning and operators training; and (iv) real-time performance monitoring and optimization.

Production Planning, Scheduling and Control: This line is a major research area of CESE over the past 15 years. It involves the development of planning and scheduling methods and IT tools for complex production processes. Application areas include footwear, metalwork, and forestry.

Two specific topics are currently researched:

- to advance existing optimization models and heuristics to dealt with tailored production processes, for small series, high-customization; this is particularly important in the case of new installed footwear assembly lines demand a sophisticated planning of resources, namely in what concerns the balancing of mixed model lines and the real-time sequencing of operations. Resources and materials saving in cutting and packing problems will also be studied;
- to evolve planning & scheduling tools to work with other data collection tools within an Internet of Things environment. In fact, the myriad of sensors are other data collection technologies existing today enable remote monitoring of production processes and should be the basis for real-time planning.

Business Processes Management: Business processes in industrial organizations and networks need are characterised by being partly documented and executed with the partial support of a wide range of information systems. Furthermore, organizations increasingly need to deal with unstructured processes that ordinary

Business Process Management (BPM) solutions were not designed to cope with. Research in this line aims at coping with the challenge of managing unstructured or semi-structured processes that are collaborative, knowledge and content-intensive, and subject to constant change.

Research activities are focused in:

- improvement of business processes management by exploiting the linking between operations management, operations research and six sigma methodologies; and
- cost and risk management methodologies for business process environments.

Enterprise and Industrial ICT

The Enterprise and Industrial ICT research domain addresses the design and use of ICT in industrial organisations and networks along the instrumental, architectural and impact dimensions.

In the instrumental dimension, research is focused on the creation of design knowledge for industrial information systems; this is materialised in innovative design concepts and prototypes that cover the upper decision-making levels - performance management, information management, supply-chain management, business process management - as well as the lower levels - manufacturing operations management (including, among-others, production planning systems and manufacturing execution systems);

The architectural dimension addresses research along two lines:

- novel architectures for Cyber-Physical Systems and (Industrial) Internet-of-Things; the focus is on devising new ways of integrating computing and communication with physical and virtual processes across all levels of production, from processes through machines up to production and logistics networks;
- architectures for efficient large amounts of streaming data collected from machines and processes; combination of off-the-shelf big data technology and in-house developments to support different types of data sources, including IoT, as well as other decision support technologies, including analytics, optimization and simulation, delivered as part of enterprise and industrial systems.

In the impact dimension addresses the ex-ante and ex-post assessment of instrumental systems and architectures in industrial organisations and networks. The activities within this dimension also run along two lines:

- technological evaluation: characterisation of the available architectures, technologies and solutions covering the MOM domain (including MES); evaluation of the different possibilities around integration technologies for Industrial Information Systems; and the development of frameworks for the selection and implementation of information systems in enterprises and supply chains.
- socio-technical studies of industrial ICT: empirical studies on the adoption and impact of information systems in industrial organisations and networks.

Collaborative Networks and Supply Chains

Collaborative Networks and Supply-Chains is a multi-disciplinary research domain covering the design of collaborative and supply networks, network business models and processes and the study and design of information and knowledge management in collaborative networks.

Design of Collaborative and Supply Networks: The design of collaborative networks involves determining which structural governance forms would be most appropriate for network success, implementing and managing the structure and recognizing when structure should change based on network and participant needs. Digital platforms have a strong role in shaping the behaviour and sustainability of collaboration in the network. One research line along these needs is to create design knowledge on how digital platforms can be used instrumentally to transform networks in sustainable collaborative networks. Another research line is focused on global supply networks. Current research includes information management for risk management in supply-chains and the design supply networks towards increasing the technological capabilities of regions.

Knowledge and Collaboration Management in collaborative networks: Successful management of enterprise networks strongly depends on the ability of the network members to collaborate towards solving increasingly

complex problems. If it is consensual that collaboration is a means to an end, it is not the case in what concerns to how collaboration should be governed within a network. Collaboration nowadays is intertwined with powerful information and communication (digital) platforms whose diversity poses demanding problems of socio-technical optimisation. The research topics addressed in this line are (i) new concepts for the design of collaborative spaces for decision making involving complex information and sense making; (ii) new concepts, models, methods and tools for information and knowledge management in collaborative networks and (iii) to explain information behaviour and knowledge representation processes in collaborative networks.

Business Models and Processes Design: The sharing economy enabled the creation of new business models that leveraged scattered knowledge and spare capacities linked through websites. The objective of this research line is to extend this concept to industry, by studying novel business models for product-services systems that tap into the under-utilized prototyping and manufacturing capacity. The implementation of these business models requires enhanced collaboration and information exchange among the members of the extended value chain to map the existing technology infrastructure, spare capacity, and scattered knowledge.

Business Analytics and Decision Support Systems

Business Analytics and Decision Support Systems research domain involves three research lines: Manufacturing Intelligence and Analytics Systems, Performance Management Systems and Decision Support Systems.

Manufacturing Intelligence and Analytics Systems: As IoT becomes more predominant the need for process improvement based on data arises naturally. Research in this line deals with the application and adaptation of traditional machine learning and data mining methods to the opportunities and challenges raised in this context, including new application areas (e.g. predictive performance management systems and predictive maintenance), new algorithms (e.g. anomaly detection methods) and integration with other approaches (e.g. with simulation and optimization, to design flexible maintenance planning solutions). Recommender systems are another important topic that includes the use spatial context data (from general space coordinates to business-specific information such as the closest shelf to the customer) and product characteristics (e.g. colour of fashion product).

Performance Management Systems: There is an increasingly important challenge for manufacturing organizations to find the strategic decisions that best fit the underlying organization complexity, and the need to evaluate the impact that the strategic decisions will have in the future performance. Research in this line addresses the development of hybrid methods for improved performance management, focusing on exploring the use of hybrid simulation approaches to predict the operational performance, namely for quantifying the impact of operational decisions in the future system's performance. Hybrid approaches, with combined qualitative and quantitative methods, allow for a better understanding of the past operational choices made by the manufacturing organization and of the decisions the organization intends to make in the future. These approaches also help to predict how future operational choices will impact the system's performance.

Decision Support Systems: The ever-growing utilization of more advanced business analytics approaches, along with sophisticated optimization and simulation tools, naturally creates the need for integrated and innovative forms of Decision Support Systems (DSS), that will hopefully complement quantitative methods and algorithms with an active "participation" of human decision-makers. Interfaces design and other ways to address the "human dimension" in DSS development is still an important research topic world-wide. Related with the latter, another important research topic is the use of DSS in a multiple decision-maker environment, including collaborative planning and decision-making processes. It is key to make use of novel collaborative planning methods, that provide a fair distribution of the benefits generated by the collaboration.

Transport, Logistics and Mobility

Transport, Logistics and Mobility is a new domain research at CESE, arising from the challenges that globally distributed industrial organisations and networks pose. It encompasses three research lines, from the natural extension of logistics to the application of CESE's expertise in simulation, optimizations and information and knowledge management.

Transportation Systems and Logistics: Modern manufacturing and supply networks are becoming more and more complex, geographically distributed and fragmented. This is the natural result of the increasing complexity of products and the benefits of specialization associated with new, more efficient forms of collaboration. Sophisticated, complex products involve quite disperse manufacturing and logistic actors, with a huge component of moving raw materials, parts and components, and therefore with a higher role of transportation

systems and logistics. Due to this complexity, research in this area is obviously of a multi-disciplinary nature, and with quite dynamic demand patterns, uncertainty (at different levels and with different sources) becomes an important factor to consider in the design or operation of logistic services.

Urban Logistics and Mobility: Mobility of people in urban and metropolitan areas has an enormous importance in the organization of cities and in the quality of life. Huge costs are involved in daily commuting, with a large weight for private cars. Environmental impacts of transport in cities are also at an unacceptable level. Better designing and operating transport services is therefore critical, especially in a time when demand patterns are more and more diverse, and when inter-modality is the basis of urban mobility. Still in the city context, in urban logistics multiple interesting research topics have emerged, to design more efficient services and to better manage operations.

Intelligent Transportation Systems: Embedded “intelligence” in vehicles and in transportation systems has since a long time been an important topic of research, from different perspectives and in various scientific disciplines. However, recent, extraordinary technological advances have created a still more promising landscape for multi-disciplinary research, particularly concerning urban mobility systems. Sensors networks, the co-creation of knowledge, information sharing, big data, or the Internet-of-Things paradigm, are creating the ground for new, promising research projects, strongly aligned with the interests and competences of CESE.

5.6.3 Technology transfer

An important part of the centre’s mission is dedicated to provide innovative, high value-added technology based services to industrial companies and networks. These services are sustained by the RTD activities described above.

A major priority of CESE is to transfer to IT companies - technology up takers - the knowledge and technology resulting from the RTD activities undertaken in the scope of the research domains. For this purpose, the collaborative projects commonly include at least one technology up taker company with interest in the commercial exploitation of the research results generated in the project. However, additional actions are needed for successful transfer of the technology related with manufacturing systems planning, including

- new collaborative research projects to produce market-ready products based on CESE research results;
- new commercial agreements with technology up takers, foreseeing the royalties schema related with the CESE property rights over the exploitable results;
- support to the commercialization efforts of our partners technology up takers, including the parameterization of the CESE developed modules to new clients/end-users as pre-selling initiatives; or adapting the CESE modules to evolving needs of existing end-users. An example is the long-lasting relationship with developers of ERP systems, that incorporate our research results and gives us access to large final clients; partnerships with MES/MOM providers are also being done; and
- initiatives to disseminate research results and seek for new partnerships with technology up takers and end-users, including the participation in sectorial associations, such as Produtech and AIFF and the participation in national and international fairs and seminars.

The more active areas of knowledge and technology transfer and services providing are the following:

Manufacturing Systems Management: Consultancy services in Manufacturing Systems Design including conceptual and functional design of resource-efficient factories, modelling and simulation of manufacturing systems and resource-constrained production processes, development of ICT solutions for designing and managing high-performance manufacturing systems. Business Processes Management as well as Information Systems specification and implementation management are also an important share of the services provided in this area. The centre is also beginning to provide services at a more strategic level regarding operations and technology management. An example is a strategic roadmap for Industry 4.0 developed for a sectorial association.

Logistics Systems: The centre develops intra and inter-organisational logistics systems. Furthermore, it provides services to enable companies to integrate IoT components and orchestrate manufacturing modules, such as planning, scheduling, balancing with internal logistics to increase the flexibility of the manufacturing systems. In

the inter-organisational area, novel methods for transportation/distribution planning, combined with other upstream and downstream supply chain processes. Examples are applications in biomass and wood-based products distribution across forest-based supply chains. CESE also develops multi-disciplinary approaches (based on advanced decision support tools) to design transport networks or inter-modal logistic solutions, integrated in broader distributed manufacturing systems. This includes problems such as: fleet sizing and management; vehicle routing planning (for product distribution or collection); or the design of logistic networks.

Digital platforms for networks and supply chains: Levered in the research domain of Collaborative Networks and Supply-Chains, the centre is providing consultancy and development services on digital platforms for managing several types of collaborative networks. Contracts are being made with enterprise associations and sectorial clusters to develop collaborative platforms for managing information, communication and collaboration together with networks and collaboration governance models. The distinctive aspect of the centre's offer is the integrated approach to network governance and digital platform development.

Business Intelligence: The research line Manufacturing Intelligence and Analytics Systems together with the research in Enterprise and Industrial ICT domain is producing results that are being used to setup services in Business Intelligence for several types of organizations. Furthermore, recommender systems are now raising interest on several industrial companies, mainly in the areas of predictive maintenance and performance and customer oriented services.

Urban Mobility: CESE provides consultancy services and develop customized decision support systems to help municipalities, authorities, public agencies, transport operators, and logistic providers, in designing and managing transport and logistic services. Specific services and decision support tools can be designed for urban mobility, based on the principles and techniques of data science, knowledge management, optimization and simulation, or multi-criteria analysis. Particularly interesting applications can be developed in areas such as: demand responsive transport (DRT) services; vehicle and crew scheduling systems; demand data management; urban logistics services.

Construction Information and Knowledge Management: The lifecycle management of large civil construction buildings and facilities requires complex computer information systems the deal simultaneously with teamwork over the internet, relational and non-relational data, large datasets, synchronous and asynchronous document generation, certification, tight security, among others. Having developed and worked more than a decade with conventional multi-tier applications, we became aware of some of its limitations and we're now developing a novel architecture and framework that will allow fast development of new apps and streamline the access and treatment of information. Consultancy services in this area are being provided to the Portuguese central administration.

5.6.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CESE – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)					
			Manufacturing Systems Management	Logistics Systems	Digital Platforms for Networks and Supply Chains	Business Intelligence	Urban Mobility	Construction Information and Knowledge Management
Manufacturing and Services Operations Management		I	H	M	L	L	M	L
Enterprise and Industrial ICT		I	H	M	M	H	L	H
Collaborative Networks and Supply Chain		I	M	L	H	L	M	M
Business Analytics and Decision Support Systems		I	H	M	L	H	M	L
Transport, Logistics and Mobility		I	M	H	L		H	
Other areas (1)	CEGI	O	M	H	M	H	H	L
	CRIIS	O	M	H	L	L	L	L
	CITE	O	M	L	H	M	L	M
	LIAAD	O	L	L	M	H	L	M
	CSIG	O	L	L	H	H	L	H

1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer

(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership

(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.6.5 Main objectives and actions planned for 2018

During 2016, CESE started a process to refocus its strategic research domains and to reinvent the consulting services. Part of this process is articulated with the formation and development of the Industry&Innovation cluster of INESC TEC which aggregates, besides CESE, the CEGI, CITE and CRIIS.

In 2018, and in general terms, the centre main objectives are:

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

To achieve these objectives, the following activities are planned.

In 2018 we will continue to develop the new research domain on Natural Resources Management. This aims at applying several techniques and tools developed under the CESE strategic research domains in the specific context of natural-resources based supply chains. The goal for 2018 is to put in place a critical mass of projects in this area in collaboration with other INESCTEC research Units under the framework of the Cluster Industry&Innovation.

For the existing research domains, consolidation means to advance in the complexity and scope of the tackled problems through the following new research topics:

Manufacturing and Services Operations Management

- Research new planning and scheduling heuristics and optimization and simulation tools to deal with tailored production processes, for small series, high-customization;
- Research and develop novel optimization-simulation approaches to address uncertainty in production scheduling and planning;
- Study the barriers and enablers for the adoption of Industry 4.0 technologies.

Enterprise and Industrial ICT

- Continue the development of Plug&Produce software for advanced robotics in logistic and production areas (DM4Manufacturing project);
- Consolidate the methodologies for analysis and selection of methods and software tools aiming to model cyber-physical systems and of new software-based tools to increase the level of intelligence on automation devices (PLC, intelligent sensors);
- Development of a conceptual framework addressing the design, management and monitoring of unstructured or semi-structured processes (active case management) and simulation for BPM.

Collaborative Networks and Supply Chains

- Consolidation of a research line aimed at covering from studies to design of methods and tools for the transformation of existing networks into collaborative networks;
- Identification and characterization of enablers for the increasing participation of regions in global supply chains: the Portuguese role in the aircraft interior industry;
- Development of methodologies for the selection of practices for supply chain management towards increasing resource-efficiency and resilience;

Business Analytics and Decision Support Systems

- Research to extend the range of RS applications to other parts of the production process, such as feeding the product design process with patterns in user preferences;
- Strengthen the contributions in terms of model management and infrastructure integration;
- Integration of knowledge discovering with information management models and techniques;
- Research to deal with growing uncertainty levels and risks, in strongly dynamic environments which are not obvious for traditional, commercially available optimization software solutions through powerful and ergonomic Decision Support Systems.

Transport, Logistics and Mobility

- Research in advanced optimization and simulation models, along with data and knowledge management procedures. As an example, the research will focus on the development of novel optimization-simulation approaches for the distribution of biomass and wood along forest-based supply chains;
- Research handling big quantities of data, the extraction and management of knowledge, the optimization of transport networks and services (involving important resources) and the planning and management of those services;
- Interesting project topics are being discussed with municipalities, public agencies, authorities, and transport operators. Promising applied research is therefore envisaged for 2018, in national locally funded projects, and in broader European initiatives.

5.6.6 Centre Organizational Structure and Research Team

The Centre for Enterprise Systems Engineering is coordinated by Américo Azevedo and António Lucas Soares and is organized in the following Areas:

- Manufacturing and Services Operations Management – Responsible: Américo Azevedo and Alexandra Marques
- Enterprise and Industrial ICT – Responsible: César Toscano
- Collaborative Networks and Supply Chains – Responsible: António Lucas Soares and Ana Barros
- Business Analytics and Decision Support Systems – Responsible: Carlos Soares
- Transport, Logistics and Mobility – Responsible: Jorge Pinho de Sousa

The Centre has a coordination board and a scientific board that assist the coordinators.

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

Table 5.2-CESE – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	12	11	13	2
		Academic Staff	11	11	11	0
		Grant Holders and Trainees	33	49	33	-16
		Total Core Researchers	**56**	**71**	**57**	**-14**
	Affiliated Researchers		4	2	2	0
	Administrative and Technical	Employees	2	2	2	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**2**	**2**	**2**	**0**
	Total Integrated HR		**62**	**75**	**61**	**-14**
	Total Integrated PhD		**62**	**75**	**61**	**-14**

5.6.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CESE – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT	66	127	199	72
National R&D Programmes - S&T Integrated Projects	129	167	108	-59
National Cooperation Programmes with Industry	103	380	378	-2
EU Framework Programmes	389	290	521	231
EU Cooperation Programmes - Other	103	63	42	-21
National R&D Services and Consulting	133	187	412	225
International R&D Services and Consulting	15	4		-4
Other Funding Programmes	53			
Uncertain Projects	265	316	15	-301
Total Funding	**1 256**	**1 534**	**1 674**	**140**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	18	16	20
International conference proceedings indexed by ISI, Scopus or DBLP	38	22	12
Books (author)	0	0	0
Chapter/paper in books	3	2	3
Total	**68**	**40**	**35**

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

Type of Result	No.
Invention disclosures	0
Software copyright registrations	2
Patent applications	0
Licence agreements	6
Spin-offs	0

Table 5.6-CESE – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	4
Conferences organized by INESC TEC members (in the organizing 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	3
Advanced training courses	2

Table 5.7-CESE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	3SLM	António Lucas Soares	10/08/2017	05/02/2019
PN-FCT	DM4Manufacturing-1	César Toscano	01/11/2016	31/10/2019
PN-FCT	E2Web	Ana Cristina Barros	01/06/2014	31/05/2018
PN-FCT	EasyFlow	Alexandra Sofia Marques	01/06/2016	31/05/2019
PN-FCT	VR2Market-1	Ana Cristina Barros	15/07/2014	31/12/2018
PN-PICT	iMAN	Américo Azevedo	01/07/2015	31/12/2018
PN-PICT	SMILES-4	Américo Azevedo	01/07/2015	31/12/2018
PN-COOP	3GEnergy	António Lucas Soares	01/09/2016	31/08/2018
PN-COOP	AdaptPack	Pedro Ribeiro	01/09/2016	31/08/2019
PN-COOP	ADIRA_I4.0	António Correia Alves	01/09/2016	31/08/2019
PN-COOP	ATM	António Correia Alves	01/09/2016	28/02/2018
PN-COOP	FAMEST	Rui Diogo Rebelo	01/11/2017	31/10/2020
PN-COOP	GOTECFOR-1	Alexandra Sofia Marques	01/01/2017	31/12/2020

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-COOP	MAPPLE	António Correia Alves	01/09/2016	28/02/2018
PN-COOP	PERSONA-1	Rui Diogo Rebelo	01/03/2017	30/06/2019
PN-COOP	PrecisionCork	Pedro Ribeiro	15/05/2016	14/11/2018
PN-COOP	PRODUTECH_SIF	António Correia Alves	01/10/2017	30/09/2020
PUE-FP	BEinCPPS	César Toscano	01/10/2015	31/10/2018
PUE-FP	DIVA-1	Alexandra Sofia Marques	01/01/2018	31/12/2020
PUE-FP	Fasten	Samuel Moniz	01/11/2017	31/10/2020
PUE-FP	Futuring	António Lucas Soares	01/09/2016	28/02/2018
PUE-FP	MANU-SQUARE	Ana Cristina Barros	01/01/2018	31/12/2020
PUE-FP	NEXT-NET	Ana Cristina Barros	01/10/2017	30/09/2019
PUE-FP	ScalABLE4.0-1	César Toscano	01/01/2017	30/06/2020
PUE-DIV	BIOTECFOR-1	Alexandra Sofia Marques	01/01/2017	31/12/2018
PUE-DIV	MANTIS	Hugo Miguel Ferreira	01/05/2015	30/04/2018
PUE-DIV	MANUFACTUR4.0-1	Ana Cristina Barros	17/04/2017	31/12/2019
SERV-NAC	CFERRA	António Correia Alves	01/12/2017	30/11/2018
SERV-NAC	Consultoria	Luís Carneiro	01/01/2009	

Type of Project:

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

5.7 CRIIS - CENTRE FOR ROBOTICS IN INDUSTRY AND INTELLIGENT SYSTEMS

Coordinator: António Paulo Moreira

5.7.1 Presentation of the Centre

CRIIS accomplishes its mission, within the Cluster I+I - Industry and Innovation, by designing and implementing innovative solutions within the areas of industrial robotics and intelligent systems.

The Centre works in close cooperation with Companies, other INESC TEC Centres and other Institutes and Universities, following the lemma from Research and Development to Innovation, passing through Design, Prototyping and Implementation.

5.7.2 Research and Technology Development

Navigation and Localization of Mobile Robots
Industrial and indoor robotics, industrial robotic manipulators, Automated Guided Vehicles (AGVs), navigation solutions for indoor and outdoor environments.

The Centre for Robotics and Intelligent Systems (CRIIS) develops mobile robotic systems that can be applied in industry, indoor and outdoor environments.

Intelligent Sensors and Control of Dynamical Systems
Research in Dynamics and Control can be applied in several systems from robots to industrial process and is crucial to the efficient control and design of complex and optimized systems. Using the mathematics and physics laws, we build a model based approach, namely model based predictive controllers, and apply it to a wide range of systems from process control to robotics and industrial production lines. To have a correct and cost-effective monitoring and control the use of sophisticated sensors is mandatory. The development of smart-sensors, software-sensors and networked sensors is also a main research topic for CRIIS.

2D/3D Industrial Vision and Advanced Sensing
Sensing is a key component on modern industrial robotics systems. The advent of 3D point-cloud based perception systems opens a wide variety of opportunities to deal not only with dynamic environments, where parts are placed in unknown places, but also to deal with robot accuracy limitations and part dimensional deviations. Furthermore the widespread use of different sensing technologies, including force-sensing, laser range finders or sonar, for example, are key element in the development of upcoming robotics systems. The research line followed by the centre is focused on the development of algorithms tailored for industrial use, robotics in particular, with special emphasis on multimodal sensor fusion, integrated machine learning, active perception among others.

Mobile Manipulators
During the last years, the Centre had a strong focus on the development of Mobile Manipulators. These robotics systems present high flexibility and are particularly adapted to the needs of existing production systems, where layout reconfiguration are difficult. The application of such systems goes from internal logistics to novel applications such as on-site construction. This research line had been developed with extensive international collaborations in the context of 3 European projects (FP7 - CARLoS, FP7- STAMINA and H2020 ColRobot) with reference end-users such as PSA - Peugeot Citroen, Renault or Thales-Alenia Aerospace. For the upcoming years, the goal is to push the mobile manipulators systems closer full production systems, either through the development of basic technologies, but also the development of higher TRL projects namely through the application of the previous developments industrial settings.

Special Structures and Architectures for Robots
Many robotics applications still require novel robotic structures to fulfil its requirements. The unit has experience in the development of completely new robotics structures, such as cable robots e.g. and will continue to explore such systems with novel robotic systems in mind.

Human Robot Interfacing and Augmented Reality
Together with machine vision, human robot interfacing is a key element on the development of flexible robotics systems. Although a topic of extensive research in the past, also by the Centre, the potential of applications unleashed by the human intervention in robotic systems is still very significant. The approach will explore previous developments on Programming-by-demonstration, CAD based programming but will put a strong emphasis on techniques for uncertainty handling on robotic systems, namely through the combination of augmented reality (projection mapping) in which the Centre has proven expertise.

Future Industrial Robotics and Collaborative Robots
Future industrial robotics will move from a robot centred perspective of a robotics work cell, to an integrated approach that involves perception, multiple sources of information (either sensors or IT support systems), close collaboration with humans and continuous process learning. This requires a multidisciplinary work that includes the above-mentioned development of Human Robot interfaces and advanced 2D / 3D sensing but also the in depth evaluation of the strengths and weaknesses of the use of safe collaborative robots.

Collaborative robotics are commonly evaluated as a game-changing technology in the future of industrial robotised operations. However, for these robots to be used spread out in industry, there is still the need for applied research applications that would show the success of the concept. The research approach will be the development of accessing tools that include the safety analysis according to the ISO technical standard 15066 and the related norms ISO 10218-1, and also on the economic analysis of the use of such systems.

Vertical Integration, IoT, Industry 4.0
The success of industrial and mobile robotics application is heavily dependent on the integration with the connected factory of the future. In this regard the unit will further develop integration tools with a network of partners, namely within INESC TEC with the CESE and CEGI centres. The role of robotics in the Industry 4.0 is an open challenge that requires a change of approach from a work-cell integration to a factory or even inter-factory level integration. In a connected factory scenario, advanced mobile robots play a differentiated role from other Industry 4.0 actors, namely due to the advanced sensing capabilities, CPU/GPU processing power inherent to the robot. Therefore, in the mobile robotics sector, the approach will explore the concept of a robot as a mobile sensor that can dynamically populate the digital shadow of the manufacturing plant. Concerning collaborative robots, the approach will explore the impact of such systems in the upper layers of the connected factory, namely through the development of decision-making strategies that consider the new capabilities/limitations of collaborative robots and their balance with the human operators. The Centre previous experience in vertically integrated projects, namely the STAMINA project, is the foundation for Centre offer of consultancy services

5.7.3 Technology transfer

Internal Logistics
The Centre has a strong activity in internal logistic system that goes from the development of simple AGV systems in partnership with Portuguese companies, to the development of advanced mobile manipulators in Flagship European projects such as STAMINA and ColRobot. The Centre offers consultancy services for the installation of existing and mature robotics systems, such as the LeanAGV, but is also capable of developing novel robotics systems, namely mobile manipulators for high flexible logistics operations. The Centre developed a well-proven network of competences, both internally at INESC TEC as well as with external companies, that provides the Centre with the capabilities to provide complete logistics systems that vertically integrates the robotic system in the production environment.

Robotics for Agriculture and Forestry
The Agriculture and Forestry R&D line has a 10-year road-map, considering the Portuguese reality (needs and desires) and the European Robotics agenda. It is focused in three application topics: Vineyards (Steep Slope), Forest biomass harvesting, and Greenhouses (urban and traditional). Our main efforts are concentrated to develop cost effective visual-based sensors, manipulators and small machinery with advanced localization, mapping, control and perception algorithms (where we believe that can occur technology transference). This R&D line has started in 2015, and in 2017 we will have 2 active national projects in co-promotion with national companies/associations (Tekever, ADVID, Prodfarmer, Herdade do Esporão, Herdade Maria da Guarda) and 2 international projects in co-promotion with international companies/associations (Wageningen University & Research, Aveleda, isardSAT, AIB University, IMAMOTER). In addition to these ongoing projects, other ones with

reference institutions/companies (INIAV, Forestis, CTAG, ENERMETER, FERTIPRADO, WHITUS, HIDROSOPH, CERSUL, INCREASE and ELAIA 2) are being evaluated under P2020, POCTEP, and PDR2020 programs. We are working together with Pulverizadores Rocha, Herculano Alfaias Agrícolas, Aveleda and WiseCrop in order to set new goals and common projects. The technology transference by intellectual property, start-up/spin-off creation is targeted to the midterm of 2018.

Flexible Production using Robotics

The Centre presents a proven track record of successful robotics based Flexible production systems that were installed and transferred to the market. The use of Industrial robotic systems on SME's is a strong demand on the Portuguese and European markets, and requires novel approaches that combine Advanced sensing, human machine interfacing, high level programming, augmented reality, among others. The centre accumulated expertise in the different scientific/technological areas and a well-established network of partnerships, gives the Centre a large set of tools to answer to the most demanding challenges.

Inspection, Control and Embedded Systems

Machine vision is widely applied in quality control (non-conformity detection, dimensional control, ...) using or not industrial robotics systems. Some success projects have already been developed and applied in the industry (CONTINENTAL, GISLOTICA, Rail-Inspect) and other are in progress .

The application of the control theory for Dynamics Systems is now used in a wide range of different systems, from classic process control systems to production lines and logistic systems all using similar dynamical models. With these models we use model based predictive controllers (project FOCUS).

To the efficient control, modelling and monitoring of complex and optimized systems it is mandatory the acquisition of large amounts of information (sensors data and inputs from operators) and so the development of the appropriate devices that facilitates the integration with the connected factory of the future is under progress, following the paradigms of the Industry 4.0.

New challenges in Robotics

The Centre has a strong track record on the development of novel robotics systems for new application sectors, such as Surveillance (RobVigil), Architecture and construction (RobArc) or the health sector (TriHo). The Centre broad range of expertise allows multidisciplinary approaches for the development of software and hardware customized for specific applicationsKnowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CRIIS – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)				
			Internal Logistics	Robotics for Agriculture and Forestry	Flexible Production using Robotics	Inspection, Control and Emb. Systems	New challenges in Robotics
Navigation and Localization of Mobile Robots		I	H	H	H	L	M
Intelligent Sensors and Control of Dynamical Systems		I	L	H	M	H	M
2D/3D Industrial Vision and Advanced Sensing		I	L	H	H	H	H
Mobile Manipulators		I	H	M	H	L	H
Special Structures and Architectures for Robots		I	L	M	H	M	H
Human Robot interfacing and Augmented Reality		I	L	M	H	M	H
Future Industrial Robotics and Collaborative Robots		I	M	L	H	M	H
Other areas (1)	Vertical Integration, IoT, Industry 4.0 (CESE, CEGI)	O	H	M	H	H	H

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.7.4 Main objectives and actions planned for 2018

Strategic Objectives, Main initiatives / actions planned

- Improve the alignment between basic research, applied research and consultancy;
- Maximize the impact of the Centre's activity in the companies, and promote the valorisation of results;
- Establish strategic partnerships with international research key players, industries and stakeholders, allowing the alignment of the research activities with future industrial projects;
- Improve internal competences by developing the motivation of human resources and creating conditions for attracting high level national and international researchers;
- Improve the Centre's external visibility, through the organisation and participation in key national and international scientific and industrial events;
- 2018 continues to be a consolidation and confirmation year for the new application area Agriculture Robotics. With some seed projects already running, this year will be focused on the growth of the team dedicated to the area, with special emphasis on the increase of the available equipment infrastructure, and finally the diversification of funding, namely European Projects and direct contracts;
- Consolidation of the strategic communication plan established in 2017 that includes the establishment of Centre's dedicated website, youtube channel in articulation with the communication strategy of INESC TEC;
- Analysis and establishment of a team to evaluate the potential of new technology transfer areas. Two main candidate are identified based on previous projects: (1) Robotics for health applications (2) Robotics for architecture and construction;
- Consolidation of a tight national network of partners in the scientific areas Vertical Integration, IoT, Industry 4.0 (CEG-IST, UC, IPB), Human Robot Interfacing and Future Industrial Robotics (UC, UA), Navigation and Localization of Mobile Robots (LarSys and DEMEC both from IST);
- In terms of sources of funding the Centre will try to keep the 2017 balance between fundamental (FCT), applied research (P2020 – Co-promotion), European funded projects (H2020) and direct contracts. The goal is to have 40-50% of the latest two (H2020 and direct contracts);
- Team - The objective is the maintenance of the permanent staff (4-5 contracts) the increasing of the number of scholarships to 10-12, and restructuring the non-research contracts. In detail the focus will be sharing of resources with other units and the answer to specific needs in technical support;
- Increase the number of financed PhD students by external programmes, FCT, N2020, MIT, CMU and others;
- Significant development of the activities under the FABTEC umbrella, including new research project proposals, advanced formation and technology transfer;
- Develop new partnerships with national and international research organizations, leaders in fields near or complementary to the Centre's activity;
- Maintain/Increase the Centre participation and the visibility in European projects;
- Consolidate partnerships with international research key players, industries and stakeholders and continue direct contact with large number of companies, in Portugal and abroad;

- Promote an internal regular discussion on research opportunities and project organization. In particular, 2018 is the consolidation year for the robotics LabMeetings, held together with the CRAS Centre;
- Define plans for the valorisation of the intellectual property of the Centre.
- Search for a new industrial laboratory installation, large enough to accommodate industrial robots (manipulators and AGVs) and the activities related with Industry 4.0.

Future research

- Control of mobile manipulators for non-logistic processes. The focus will be on the integrated kinematics development, safety and process control;
- Multi robot coordination methodologies for automatic generation of mission plans; supervision of autonomous platform operations; cooperative operation of multiple platforms;
- Concerning vision based real time sensors: perception systems as a sensor for on board sensing; real time stereo, and 3D point-cloud sensing for mapping, self-localization and objects detection; low latency and robust feature extraction in semi controlled environments;
- In the field robotics area: modelling and control of mobile robots; navigation and localization in out-door semi structured environments (using natural and artificial landmarks);
- Industrial robotic manipulators: vision and manipulator coordination; advanced sensing: measurements and testing of features; rapid teaching and programming interfaces;
- Intelligent control and smart sensors: control algorithms for complex dynamic systems. New sensing strategies.

5.7.5 Centre Organizational Structure and Research Team

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

- Navigation and Localization of Mobile Robots - Responsible: Paulo Costa / Héber Sobreira
- Collaborative Robots - Responsible: J. Lima / Luis Rocha
- Intelligent Sensors and Control of Dynamical Systems - Responsible: J. Boaventura / Filipe Santos
- 2D/3D Industrial Vision - Responsible: Hélio Mendonça / Luís Rocha
- Mobile Manipulators – Responsible: Germano Veiga / Héber Sobreira
- Special Structures and Architectures for Robots – Responsible: Manuel Silva / Filipe Santos
- Human Robot Interfacing - Responsible: Germano Veiga / Rafael Arrais
- Future Industrial Robotics - Responsible: Pedro Costa / Germano Veiga
- Vertical Integration, IoT, Industry 4.0 – Responsible: Hélio Mendonça / Rafael Arrais

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

Table 5.2-CRIIS – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	3	6	6	0
		Academic Staff	21	20	20	0
		Grant Holders and Trainees	15	21	22	1
		Total Core Researchers	**39**	**47**	**48**	**1**
	Affiliated Researchers		0	0	0	0
	Administrative and Technical	Employees	2	1	3	2
		Grant Holders and Trainees	1	0	1	1
		Total Admin and Tech	**3**	**1**	**4**	**3**
		Total Integrated HR	**42**	**48**	**52**	**4**
		Total Integrated PhD	**42**	**48**	**52**	**4**

5.7.6 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CRIIS – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT		75	177	102
National R&D Programmes - S&T Integrated Projects	52	50	34	-16
National Cooperation Programmes with Industry	72	158	143	-15
EU Framework Programmes	284	154	363	209
EU Cooperation Programmes - Other		28	223	195
National R&D Services and Consulting	70	411	297	-114
International R&D Services and Consulting			13	13
Other Funding Programmes				
Uncertain Projects	117	28	33	5
Total Funding	**595**	**904**	**1 283**	**379**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	27	20	12
International conference proceedings indexed by ISI, Scopus or DBLP	62	37	30
Books (author)	1	0	1
Chapter/paper in books	6	0	2
Total	**101**	**57**	**45**

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

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	1
Licence agreements	0
Spin-offs	0

Table 5.6-CRIIS – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	12
Participation in events such as fairs, exhibitions or similar	2
Advanced training courses	0

Table 5.7-CRIIS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DM4Manufacturing	Germano Veiga	01/11/2016	31/10/2019
PN-PICT	iMAN-3	António Paulo Moreira	01/07/2015	31/12/2018
PN-COOP	AdaptPack-1	Manuel Santos Silva	01/09/2016	31/08/2019
PN-COOP	ATM-1	António Paulo Moreira	01/09/2016	28/02/2018
PN-COOP	FAMEST-1	Héber Miguel Sobreira	01/11/2017	31/10/2020
PN-COOP	FDControlo	Filipe Neves Santos	02/01/2018	01/01/2022
PN-COOP	GOTECFOR	Filipe Neves Santos	01/01/2017	31/12/2020
PN-COOP	PrecisionCork-1	Hélio Mendonça	15/05/2016	14/11/2018
PN-COOP	PRODUTECH_SIF-1	António Paulo Moreira	01/10/2017	30/09/2020
PN-COOP	ROMOVI	Filipe Neves Santos	07/01/2017	31/08/2019
PN-COOP	SmartFarming	Filipe Neves Santos	01/10/2016	30/09/2018
PUE-FP	ColRobot	Germano Veiga	01/02/2016	31/01/2019
PUE-FP	DIVA-2	Filipe Neves Santos	01/01/2018	31/12/2020
PUE-FP	Fasten-1	Rafael Lírio Arrais	01/11/2017	31/10/2020
PUE-FP	ScalABLE4.0	Germano Veiga	01/01/2017	30/06/2020
PUE-DIV	AGRINUPES	José Boaventura	01/04/2017	31/03/2020
PUE-DIV	BIOTECFOR	Filipe Neves Santos	01/01/2017	31/12/2018
PUE-DIV	MANUFACTUR4.0	Luís Freitas Rocha	17/04/2017	31/12/2019
PUE-DIV	Water4Ever	Filipe Neves Santos	01/04/2017	31/03/2020
SERV-NAC	AutoClassII	António Paulo Moreira	01/01/2015	31/08/2018
SERV-NAC	Consultoria	António Paulo Moreira	01/01/2014	
SERV-NAC	Palcus	Pedro Gomes Costa	15/03/2017	14/03/2018
SERV-NAC	RIDDIG-1	Germano Veiga	03/05/2017	31/08/2018
SERV-NAC	SistemaDPA	Filipe Neves Santos	01/05/2017	28/02/2018
SERV-NAC	TEXTILPRINT	Hélio Mendonça	04/01/2016	28/05/2018
SERV-NAC	TRiHo	Germano Veiga	01/07/2016	31/03/2018
SERV-NAC	UnVirtual	Filipe Neves Santos	01/01/2017	31/03/2018
SERV-INT	DroneTool	Filipe Neves Santos	01/11/2017	30/04/2019

Type of Project:

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

5.8 CEGI – CENTRE FOR INDUSTRIAL ENGINEERING AND MANAGEMENT

Coordinator: Ana Viana and Pedro Amorim

5.8.1 Presentation of the Centre

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

Core areas of application of CEGI include Mobility/Transports, Retail/Industry and Healthcare, with significant contributions also in the Energy Sector and a strengthened collaboration with CPES. In the last years, CEGI made a substantial contribution to Industry 4.0 initiatives (improving scheduling rules based on the additional information available in manufacturing systems). In the upcoming years, the work in Industry 4.0 and the cross-fertilization of analytics fields will continue.

5.8.2 Research and Technology Development

SERVICE DESIGN

In the service design knowledge field there are three intertwined goals to be addressed:

- Design and engineering of complex service systems and value networks, creating new services in the context of distributed and interconnected value co-creating actors, such as health care.
- Design for the customer experience, pursuing a holistic understanding of the customer experience and a human-centered design approach that continuously feeds the service design process with customer experience input.
- Design and engineering of technology enabled services, integrating multiple disciplines such as ICT (Information and Communication Technologies), Human Computer Interaction, Service Design and Service Management, to support the transition from technology development to creation of innovative services that create value for customers and organizations, particularly in the areas of mobile services, smart services, and social networks.

BUSINESS ANALYTICS

In this knowledge field, researchers design, develop and implement quantitative models, methods and tools to solve operations management problems. These problems involve different decision making procedures, planning horizons, entities and objectives, and are usually classified according to their hierarchical level:

- Strategic (e.g., Capacity Planning).
- Tactical (e.g., Resource Allocation).
- Operational (e.g., Scheduling and Control).

Main focus of research is Business Intelligence and Prescriptive Analytics. Activity in Business Intelligence includes Data Mining, Data Analysis and Statistical methods (applied to companies' management). The goal is to conveniently extract knowledge from data that could be leveraged to increase, for example, revenues of a business. To that end, new analytical techniques are required. Currently, the challenges placed by large data sets lead to a redefinition of the processes of data analysis to find patterns and relationships between data elements in large and noisy data sets. Prescriptive analytics have a place of its own at CEGI. The RG is particularly focused in addressing challenges in the following four streams:

- Mathematical modelling and programming;

- Robust and efficient optimization algorithms to produce resilient solutions, adaptable to frequent changes in the operating conditions;
- Matheuristics that exploit the hybridization of mathematical programming techniques in (meta)heuristic frameworks;
- Simulation-based Optimization that integrate optimization techniques into simulation analysis.

PERFORMANCE ASSESSMENT

Regarding the performance assessment stream, there are several goals to be addressed:

- Performance assessment exploring Data Envelopment Analysis, econometric and statistical techniques.
- Development of enhanced efficiency and productivity measurement models that can identify the drivers of good performance in companies.
- Enhancement of organizational performance in different sectors, and promotion of robust benchmarking.
- Exploration of new methodologies to assess and improve quality of life and livability of urban areas, as they are essential to the sustainable development of countries given their role in the attractiveness of human capital.

ASSET MANAGEMENT

CEGI core competences on asset management and reliability can be divided in the following two areas:

- Predictive maintenance and asset management.
- Power system planning, in particular in the development of tools for reliability analysis, for security of supply evaluation and reserves adequacy evaluation.

CEGI has been involved in several R&D projects with utilities companies in asset management. Its expertise has already been shared and discussed with several stakeholders and there is a large potential for future collaboration.

5.8.3 Technology transfer

ENERGY

The energy application area is a core area for CEGI in terms of technology transfer. Both asset management, decision support and prescriptive analytics have been used to significantly improve processes in this industry.

RETAIL

The retail area is also a core area for CEGI. Prescriptive analytics, decision support and business analytics have contributed significantly to the advance of business processes in this area.

INDUSTRY

The industry application area is the area where CEGI has historically been more active, and covers both the industrial and the service sectors. CEGI provides services for this application area that build on top of the distinct research areas.

HEALTHCARE

The healthcare area has evolved due to the close collaboration between CEGI and several entities of the public sector, namely hospitals and central regulatory entities.
Both Service Design and Decision Support/Prescriptive Analytics have contributed with best practices to this sector.

MOBILITY AND TRANSPORTS

CEGI has historically lead several research projects in the area of Mobility connecting research streams so diverse as Operations Research, Human-Machine Interface and Information Technology. Recently, CEGI has also collaborated in several Transports related projects covering mainly optimization problems in this field.

5.8.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CEGI – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)				
			Energy	Mobility and Transports	Retail	Industry	Health
Service Design		I	M	M	L	H	M
Business Analytics		I	H	M	H	H	H
Performance Management		I				M	M
Asset Management		I	H			M	
Other areas (1)	Energy (CPES)	O	M	L			
	Operations (CESE)	O				M	

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.8.5 Main objectives and actions planned for 2018

It is foreseen that in 2018 significant breakthroughs will be obtained at the interconnection between the research areas in CEGI. Two examples are given below.

- Enhancement of the focus of intelligent systems to also include a strategic level, taking into account performance measurement information. The optimization of systems involving massive data will demand for performance assessment information within the decision support system. This will enable decision makers to benchmark the components of the system, or to explore the evolution of performance over time. The analysis and comparison of the solutions proposed by optimization techniques and the decisions that were taken under real conditions will help to better understand complex decision processes and to enhance decision making.
- The Servitization of manufacturing – extending the scope of manufacturers offerings into services – poses significant research challenges at the borders of service innovation and intelligent systems to support the reshape of service support supply chains, optimizing Service Networks and Value Chain. Servitization is being enabled by new information and communication technologies. The optimum extent (level) of servitization for different types of industries is an open research question that CEGI intends to address.

Through CIPS - Centre for Innovation and Development of Products and Services, recently launched that was promoted and is co-coordinated by CEGI members – a Service Design Lab will foster the development of new service design methodologies, and support the development of new service concepts at its different stages. The identification of medium and long term trends involving ICT and Service Engineering and Design in the 2020 horizon will be sought.

In prescriptive analytics and decision support, the incorporation of Network design issues in Production and Distribution Planning Models and Algorithms, as well as Risk Management in Sustainable (Green) Supply Chains (in light of the strong uncertainties that the current supply chains face), will enable the development of the new

generation of advanced supply chain decision support systems (containing novel mathematical programming-based algorithms). After many breakthroughs obtained for deterministic problems, CEGI makes a step forward to cope with uncertainty by means of developing simulation-optimization, stochastic programming and robust optimization approaches that will enhance the resilience of planning, allocation and scheduling. New flexible solutions, capable of adapting to environment changes (under the paradigm of IoT/Physical Internet) will also be a focus of research.

For the healthcare sector, a target will be on the joint use of predictive and prescriptive analytics. In particular, advance optimised solutions for different possible scenarios, provided by predictive analytics, both in healthcare logistics, planning and policies.

The strategic objectives for the Business Intelligence area include the use of data mining techniques in direct marketing initiatives, and the development of enhanced models to evaluate the effect of promotions in customer lifetime value and prevention of churn. Web mining will be explored, given the increased importance of e-business.

In the area of Performance Management, the use of frontier techniques to evaluate performance will be explored focusing on contexts requiring the analysis of big data in companies (namely in mobility and industry). Another research area concerns performance measurement in contexts where corporate/social sustainability and quality issues are key concerns.

5.8.6 Centre Organizational Structure and Research Team

The Centre for Industrial Engineering and Management is coordinated by Ana Viana and Pedro Amorim and is organized in the following Areas:

- Service Design - Responsible: Lia Patrício and Jorge Teixeira
- Decision Support - Responsible: João Pedro Pedroso and Gonçalo Figueira
- Performance Assessment - Responsible: Ana Camanho
- Business Intelligence - Responsible: José Luís Borges and Vera Miguéis
- Prescriptive Analytics - Responsible: José Fernando Oliveira
- Moreover, there is an advisory board to assist the coordination.

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

Table 5.2-CEGI – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	0	0	1	1
		Academic Staff	19	19	19	0
		Grant Holders and Trainees	34	37	34	-3
		Total Core Researchers	**53**	**56**	**54**	**-2**
	Affiliated Researchers		3	3	4	1
	Administrative and Technical	Employees	0	0	1	1
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**0**	**0**	**1**	**1**
	Total Integrated HR		**56**	**59**	**59**	**0**
	Total Integrated PhD		**56**	**59**	**59**	**0**

5.8.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 6 and new projects to be signed during the year.

Table 5.3-CEGI – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT	50	146	224	78
National R&D Programmes - S&T Integrated Projects	115	197	188	-9
National Cooperation Programmes with Industry		20	33	13
EU Framework Programmes	57	20		-20
EU Cooperation Programmes - Other				
National R&D Services and Consulting	155	59	104	45
International R&D Services and Consulting				
Other Funding Programmes		27	8	-19
Uncertain Projects	65	119	114	-5
Total Funding	**442**	**588**	**672**	**84**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	32	29	34
International conference proceedings indexed by ISI, Scopus or DBLP	16	13	16
Books (author)	0	1	0
Chapter/paper in books	5	0	5
Total	**60**	**43**	**55**

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

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0
Licence agreements	0
Spin-offs	0

Table 5.6-CEGI – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	4
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	14
Participation in events such as fairs, exhibitions or similar	0
Advanced training courses	0

Table 5.7-CEGI – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DM4Manufacturing-2	Pedro Amorim	01/11/2016	31/10/2019
PN-FCT	DoubleChain	Pedro Amorim	02/01/2018	01/01/2019
PN-FCT	EasyFlow-1	Pedro Amorim	01/06/2016	31/05/2019
PN-FCT	HHRPLAN	Almada Lobo	01/04/2016	31/03/2018
PN-FCT	mKEP	Ana Viana	01/04/2016	31/03/2019
PN-PICT	CORAL-TOOLS-6	João Pedro Pedroso	01/01/2016	31/12/2018
PN-PICT	iMAN-2	Luís Guimarães	01/07/2015	31/12/2018
PN-PICT	SMILES-8	João Pedro Pedroso	01/07/2015	31/12/2018
PN-COOP	KnowLOGIS	Ana Viana	01/04/2017	27/09/2019
PUE-FP	UPGRID-1	Lia Patrício	01/02/2015	31/01/2018
SERV-NAC	Consultoria	Almada Lobo	01/01/2014	
SERV-NAC	HEAD	Luís Guimarães	01/01/2018	31/10/2018
SERV-NAC	HIP	Luís Guimarães	10/01/2018	30/06/2018
SERV-NAC	PricingSdL	Maria Antónia Carravilla	28/01/2017	30/04/2018
SERV-NAC	UPGASII	Luís Guimarães	26/06/2017	30/06/2018
OP	Atena	Maria Antónia Carravilla	14/10/2016	13/10/2019
PN-FCT	DM4Manufacturing-2	Pedro Amorim	01/11/2016	31/10/2019

Type of Project:

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

5.9 CITE – CENTRE FOR INNOVATION, TECHNOLOGY AND ENTREPRENEURSHIP

Coordinator: Alexandra Lobo Xavier

5.9.1 Presentation of the Centre

CITE is part of the Cluster Industry and Innovation. CITE's specific expertise in Innovation and Technology Management & Policy and Technology Entrepreneurship, fosters a cross-cutting approach to all INESC TEC's Clusters. CITE's activities promote the development of conceptual frameworks, methodologies and tools used both in advanced consulting and executive training programs for private and public organizations.

The CITE was created in 2007 to consolidate the significant investments and experience of INESC Porto in the development of internal processes and tools to manage R&D results, and organize the resulting knowledge and competences in order to enable a higher level of responsibility and leadership of the process of knowledge valorisation. In this context, the main goal of the Group at the time of its creation was to develop and promote innovation management practices, acting directly in the internal processes, and supporting entrepreneurship activities helping business development as well as incubation.

CITE relies on state-of-art methodologies and tools and experienced partners to build the best approaches to innovation and technology management and technology entrepreneurship, contributing towards the economic and social development of society.

CITE has been developing and exploiting a set of national and international research opportunities in collaborations with international partners such as the Executive Agency for SMEs , ISO/TC 279 - Innovation Management; UT Austin Portugal, MIT Portugal and Carnegie Mellon Portugal in Engineering and Public Policy.

5.9.2 Research and Technology Development

Innovation Management:

- Developed innovation management processes and tools as well as frameworks to measure innovation;
- Development of ideation methodologies and tools based on user centered innovation and problem solving approaches;
- Combination of methods and tools based on advanced concepts in various areas, such as, business integration, information and communication technologies and business analysis and modelling, to develop multidisciplinary approaches suited to the Fuzzy Front End of Innovation.

Technology Management & Policy :

- look into the ways companies create, appropriate, and deliver value from technology, to improve the understanding of how it can be used to create and sustain competitive advantage;
- study strategies and policies for the use and control of technology for the benefit of communities; priority is to be given to the design of complex networked infrastructures with flexibility, to enhance their performance in relation to uncertain future conditions of operation, and to improving methods for the design of engineering systems aiming at achieving a better integration of engineering, management and social sciences aspects that are traditionally considered individually.

Technology Entrepreneurship

Improving the knowledge of how new technological businesses form, survive and grow; a focus is placed on understanding the factors that support, delay, or block entrepreneurial intentions and activities of university researchers, in the earliest stages of entrepreneurial ventures, and the ways different organisational solutions, such as pre-incubation and proof-of-concept centres address the equity gap problem in the early stages of commercialisation:

- Definition and implementation of acceleration programmes supported by new methodologies and tools to foster the development of technological entrepreneurial projects;
- Create entrepreneurial awareness through the organization of training actions, development of tools, and giving direct support to entrepreneurs in the process of turning ideas and technologies into business;
- Develop open innovation approaches to facilitate the relationship between companies and researchers, in order to facilitate knowledge and technology exploitation.

Complementing the technology management focus on how technology is delivered to customers, there is a second focus on the way operations are organized by academic spin-offs to be able to properly create, appropriate and deliver the value to customers, and how they change along the several stages of evolution of the start-ups as its business model is adapted to achieve the best product-market fit.

5.9.3 Technology transfer

LET in: An umbrella project for Technology Entrepreneurship
In order to pursue with the mission embraced in 2007 to promote academic entrepreneurship, LET-in, INESC TEC's proof of concept and innovation lab, has grown from an internal service into an encompassing programme providing a set of services and projects targeting actors beyond INESC TEC's community.

LET-In is a service promoted by CITE that offers mentoring, coaching, technological and business consultancy, supporting the development of technology-based entrepreneurial projects related to the institution's core areas.

- Create entrepreneurial awareness through the organization by implementing training actions, seminars and workshops and giving direct support to entrepreneurs in the process of turning ideas and technologies into business;
- Develop and use case studies to disseminate creative entrepreneurship projects that will be examples for emerging new entrepreneurial projects;
- Implement accelerator programmes to facilitate the development of new technological early stage projects.

The Conference on Entrepreneurship Education. The CEE'2017 was the 1st step towards its internationalization, by opening the conference to the Spain and the Iberian American community. This is to be further expanded for 2018 and the coming years.

The Journal of Innovation Management encourages the submission of papers addressing the multidisciplinary nature of the innovation process combining principles and concepts originating from a myriad of scientific areas, from social sciences to technology research and development. The journal encompasses all phases of the process of technological innovation from conceptualization of a new technology-based product/service process through commercialization. This Journal is Indexed by ProQuest as Scholarly Journal at ABI/Inform, under the Subject Business and Economics (Pub ID: 2046363).

Executive programmes
CITE's R&D activities related to technology entrepreneurship result in the design of new conceptual frameworks, tools, and executive programs to be provided to private and public organizations.

CITE's R&D activities related to technology management result in the design of new conceptual frameworks, tools, and executive programs to be provided to private and public organizations.

Consulting
CITE's R&D activities related to innovation management result in the design of new conceptual frameworks, tools, to be applying by our consulting team to private and public organizations.

EEN Portugal and EEN Innovation

Participate in European Enterprise Network to facilitate the access of SMEs to international markets and to enhance their innovation capacities.

Innovation Labs

CITE will go on organizing Innovation Labs for companies interested in strengthening their innovation culture and innovation management process or new concepts for products, services and business models.

5.9.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CITE – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Status (2)	Areas of Technology Transfer --> relationships (3)				
		LET IN	Executive programmes	EEN Portugal and EEN Innovation	Innovation Labs	Consulting
Innovation Management	I	M	H	H	M	H
Technology Management & Policy	I	M	L	M	L	F
Technology Entrepreneurship	I/E	H	M	M	M	F

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.9.5 Main objectives and actions planned for 2018

Continue develop training programmes focused on technology entrepreneurship as an examples:

- BIP – Business Ignition Programme: a programme design to researchers in order to improve their capacities to be part of the process of the technology exploitation. Running the third edition.
- LET IN Catalyst – present and implement an internal entrepreneurship programme to support INESC TEC researchers in their entrepreneurship initiatives. Support INESC TEC entrepreneurship initiatives.
- Organize the CEE'2018, the Conference on Entrepreneurship Education.

CITE will go on acting as a host organization of Enterprise Europe Network, providing advisory, partnering and tailored innovation services for SMEs, including startups and scaleups. 4 projects are included here: EEN-Portugal, EEN-Innovative PT, Scale Up Portugal and TouriSMEshare. Undes this projects CITES aims to:

- Implement Innovation Management services into at least fifteen SMES, under the EEN Innovation Project;
- Provide support to company's benefits from SME Instrument, under the EEN Innovation Project.

Implement the advisory support services to SME´s under the EEN Portugal consortium.

5.9.6 Centre Organizational Structure and Research Team

The Centre CITE is coordinated by Alexandra Xavier and is organized in the following Areas:

- Innovation Management - Responsible: Alexandra Xavier & João José Pinto Ferreira
- Technology Management - Responsible: João Claro
- Technology Entrepreneurship - Responsible: Alexandra Xavier & João Claro

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

Table 5.2-CITE– Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	2	2	2	0
		Academic Staff	1	2	1	-1
		Grant Holders and Trainees	4	7	5	-2
		Total Core Researchers	**7**	**11**	**8**	**-3**
	Affiliated Researchers		6	3	5	2
	Administrative and Technical	Employees	0	0	0	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**0**	**0**	**0**	**0**
	Total Integrated HR		**13**	**14**	**13**	**-1**
	Total Integrated PhD		**13**	**14**	**13**	**-1**

5.9.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2017 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CITE – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT	2	5	20	15
National R&D Programmes - S&T Integrated Projects	9	47	51	4
National Cooperation Programmes with Industry	36			
EU Framework Programmes	57	56	107	51
EU Cooperation Programmes - Other	35	38	75	37
National R&D Services and Consulting			9	9
International R&D Services and Consulting				
Other Funding Programmes		92	12	-80
Uncertain Projects	1	43	13	-30
Total Funding	**140**	**281**	**286**	**5**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	8	15	19
International conference proceedings indexed by ISI, Scopus or DBLP	0	0	2
Books (author)	0	0	2
Chapter/paper in books	2	1	6
Total	**10**	**16**	**29**

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

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0
Licence agreements	0
Spin-offs	1

Table 5.6-CITE – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	9
Conferences organized by INESC TEC members (in the organizing 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	2
Advanced training courses	3

Table 5.7-CITE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	SCREEN-DR-1	Catarina Maia	01/04/2016	31/03/2020
PN-FCT	VR2Market-2	Catarina Maia	15/07/2014	31/12/2018
PN-PICT	CORAL-SENSORS-2	João Claro	01/01/2016	31/12/2018
PN-PICT	FOUREYES-1	João Claro	01/07/2015	31/12/2018
PN-PICT	iMAN-1	João Claro	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL1-2	João Claro	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL2-1	João Claro	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL3-1	João Claro	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL4-1	João Claro	01/07/2015	31/12/2018
PN-PICT	SMILES-2	João Claro	01/07/2015	31/12/2018
PUE-FP	DIVA	Alexandra Xavier	01/01/2018	31/12/2020
PUE-FP	EEN-InnovatePT	Alexandra Xavier	01/01/2017	31/12/2018

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	SCREEN-DR-1	Catarina Maia	01/04/2016	31/03/2020
PN-FCT	VR2Market-2	Catarina Maia	15/07/2014	31/12/2018
PN-PICT	CORAL-SENSORS-2	João Claro	01/01/2016	31/12/2018
PN-PICT	FOUREYES-1	João Claro	01/07/2015	31/12/2018
PN-PICT	iMAN-1	João Claro	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL1-2	João Claro	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL2-1	João Claro	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL3-1	João Claro	01/07/2015	31/12/2018
PUE-FP	SafeCloud-1	João Claro	01/09/2015	31/08/2018
PUE-DIV	EEN2017/2018	Alexandra Xavier	01/01/2017	31/12/2018
PUE-DIV	ScaleUp-PORTUGAL	Alexandra Xavier	01/07/2017	31/12/2018
PUE-DIV	TouriSMEShare	Alexandra Xavier	15/12/2017	30/11/2019
SERV-NAC	Consultoria	Alexandra Xavier	01/01/2008	
OP	BIP	Alexandra Xavier	01/02/2016	31/01/2018

Type of Project:

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

5.10 CSIG – CENTRE FOR INFORMATION SYSTEMS AND COMPUTER GRAPHICS

Coordinators: António Gaspar and Ângelo Martins

5.10.1 Presentation of the Centre

The Centre for Information Systems and Computer Graphics (CSIG) mission, accomplished within the Computer Science Cluster, is to pursue high quality research, strongly linked to industrial partnerships, consultancy and technology transfer, in five main areas: Computer Graphics and Virtual Environments, Information Management and Information Systems, Software Engineering, Accessibility and Assistive Technologies and Special Purpose Computing Systems/Embedded Systems.

The Centre excels in Systems Engineering (SysE) and technology transfer, taking the central role of systems architect and integrator in a wide range of international and national projects and as contractor.

The Centre is particularly well positioned to address complex and difficult engineering problems faced by industry as it has the expertise to analyse, design, mine and implement large information systems, using best software engineering practices for design, development and testing, and also provide the visual and user interaction components such a solution may require. Furthermore, the Centre is also strongly committed to the training of young researchers and professionals.

Presently its researchers originate from the University of Porto, Polytechnic of Porto, University of Trás-os-Montes e Alto Douro, Universidade Aberta and University of Minho.

5.10.2 Research and Technology Development

Computer Graphics and Virtual Environments

The Computer Graphics and Virtual Environments research area is focused in Image Synthesis and Visual Perception, Human Computer Interaction, Geospatial Systems, Virtual Environments and Digital Games.

In the area of Virtual Environments, the main focus of research is Multisensory Virtual Reality, Augmented Reality, Multimodal Interaction, Procedural Modelling of Urban Environments and Virtual Environments for Learning.

In the area of Digital Games, special focus has been given to Serious Games, particularly in training, education and health. This includes Authoring tools, Procedural Content Generation, Pervasive/Location-based Games and Game/Learning Analytics.

Within Geospatial Systems, research topics include geospatial and sensor Web semantics, time-space rationalisation and visualisation, which can be applied in spatial data infrastructures and environment sensor networks, as well as Ambient Assisted Living.

There are also two transversal areas of research regarding Usability, User Experience and Parallel Processing and GPU programming.

Information Management and Information Systems

The Information Management and Information Systems research area has its research focus in the areas of Information Management, Information Retrieval, Information Processing, Digital Preservation and Research Data Management. These areas include work in frameworks for information management, retrieval and processing in contexts such as Web Mining, Social Web, Semantic Web, and Text Mining for Health. Work in digital preservation includes models, methods and tools for digital preservation, particularly in the area of Database Preservation, Research Data Repository Management and e-Science.

Software Engineering

The Software Engineering research area investigates in the areas of Software Test Automation, Software Process Engineering and Knowledge Management, Software Architecture and Design, and Gamification in software engineering. This area includes work on automated pattern-based testing of interactive applications (mobile, web and desktop), model-based development and testing of real-time distributed and heterogeneous systems for IoT, automated software process performance analysis and improvement recommendation, recommender

systems for requirements maintenance, platforms for collaborative framework understanding, software documentation with adaptive software artifacts, and serious games for software engineering education.

Accessibility and Assistive Technologies

The Accessibility and Assistive Technologies research area investigates in the domain of Human Computer Interaction in particular the areas of Accessibility, Usability, Assistive and Collaborative Technologies, Sports, health and wellbeing. This research area includes the design and development of technologies to help people with special needs, with particular focus on people with disabilities and the elderly, enhancing their life and autonomy, health and wellbeing.

Special Purpose Computing Systems/Embedded Systems

The Special Purpose Computing Systems area focuses its activities on research and development of Domain-Specific Languages, tools, and methods, to develop and map applications to heterogeneous computer architectures consisting of multi-/many-cores and hardware accelerators. The research mainly addresses compiler transformations and the efficient mapping (in terms of performance, power and energy consumptions) of computations to hardware accelerators using GPGPUs and FPGAs.

5.10.3 Technology transfer

Advanced ICT Consulting

Advanced ICT consulting activities are performed typically for enterprises and institutions that require technical support in their decision processes or for coordinating complex projects. Whenever needed, additional competences from other INESC TEC Centres are incorporated.

Innovative Systems Development

These activities take place whenever a partner has specific systems development needs not addressed by the market and requiring an innovative approach. It has been mostly based on competencies in information systems and software engineering, but a larger involvement is expected in the use of multisensorial immersive virtual reality systems.

The main areas of technology transfer have been public administration, namely local authorities and transport, particularly ports.

5.10.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CSIG – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)	
			Advanced ICT Consulting	Innovative Systems Development
Computer Graphics and Virtual Environments		I	M	H
Software Engineering		I	H	H
Information Management and Systems		I	H	H
Accessibility		I	M	M
Special Purpose Computing Systems		I	L	M
Other areas (1)	Communication Networks (CTM)	O	M	-
	Machine Learning	O	-	M

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.10.5 Main objectives and actions planned for 2018

CSIG global main objectives are:

- Achieve a balanced economic operation;
- Increase scientific production, especially in terms of top-level international journals and conferences;
- Obtain at least one new H2020 project;
- Obtain at least two FCT projects;
- Increase collaboration with main partners, contracting at least four Technology Transfer contracts;
- Leverage the MASSIVE Lab's unique competencies to diversify collaborations and attract new partners, obtaining at least two Technology Transfer contracts;
- Increase collaboration with other centers from the CS cluster (especially LIAAD) and other clusters, especially Power Systems, with whom we currently have 2 EU projects and a new one will start in 2018.

Main objectives per scientific area are:

Computer Graphics and Virtual Environments

In the area of Serious Games, the H2020 BEACONNG project is entering the last year providing a system to design, develop and manage pervasive games for learning. The major SW components are being concluded and large pilots will be validating and disseminating. Another project in this area is GRISBAS, a gamified platform to reduce the energy costs in buildings, which is leading the focus on games for behaviour change. The results of this project has led to the approval of a new H2020 project called Feedback, focused on how energy savings can be gamified but maintaining the levels of confort of the users, with large scale pilots across Europe. The link of Serious Games and e-Learning platforms for Health will be continued in projects like RECAP and E-COMPARED, but also will be pushed forward as the results of recent applications on serious games in medical training, with project SIMPROVE.
In the area of Virtual Environments, the MASSIVE project is undergoing its second phase, starting in 2017 with the inauguration of the Vila Real Research Lab. Research in Usability and User Experience will be taken to a new level of quality and impact. Google DNI will also explore how immersive environments can improve the impact of the media in the audience and will develop new tools for journalists. The Tele-Media-Art project is complete and data analysis will yield new insights on the accessibility affordances for the blind of audio rendering of motion for dance and theatre classes.

The project FOUREYES will also be pushed to a new level to provide integration of these research lines with other INESC TEC centres. This integration will provide opportunities to new applications at both national and international scopes.

The Geospatial Systems area will continue its support to the national industry in distinct national projects. The EDP Expert System DCMK will be complete, providing insight on the performance of algorithms for automatic classification and retrieval of electricity customers' feedback.

Information Management and Information Systems

In the area of Information Management and Information Systems, several objectives are set for 2018. In Research Data Management (RDM), the work in the context of project TAIL continues with the publication of datasets, described according to domain-dependent models. The Dendro platform, used experimentally in INESC TEC and the University of Porto, will be promoted as the support for data organisation and description within projects in research groups. The international collaboration with the EUDAT European infrastructure will progress with the

proposal of INESC TEC as a member of the EUDAT Common Data Infrastructure. Collaboration in the national Open Science Working Group provides the continuation of the work on national RDM policy.

Work on the windscanner.pt e-infrastructure will progress, with an e-Science platform for supporting field experiments under development, together with the collaboration in the New European Wind Atlas. The SeaBioData project has resulted in a data repository for marine research, based on the European INSPIRE directive and a Sensor Observation Service with specific extensions. This work will be continued with a prototype oriented to the IoT.

We will continue our work on the development of tools that help laypeople search the web for health information. Most of the work will be associated with the NanoSTIMA project. We plan to proceed with the development of a Portuguese version of a consumer health vocabulary through HealthTranslations; to work towards a method to assess the readability of Portuguese health contents; to proceed with the development of HealthTalks and evaluate it in a naturalistic environment; to advance previous work on the influence of health literacy on health search behaviours; to explore the Wikipedia as a source of health information; to work on the classification of queries on the health domain; to compare automatic methods to classify messages shared in online health communities and to progress with the development of HealthSuggestions. In addition, we will also explore techniques to provide useful information to clinicians treating patients through the retrieval of existing knowledge.

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

Software Engineering

In the scope of the NanoSTIMA project, we will continue the work on automated scenario-based testing of distributed and heterogeneous systems, initiated in 2016, with an increasing focus on real-time and IoT scenarios. After the development of controllability and observability checking algorithms in 2017, the next steps will be focused on the development of decentralized algorithms for model-based test generation and execution, with application examples in the e-health and IoT domains. In case the FCT project proposal submitted in 2017 on "MBT4IoT - Automated Model-Based Testing of Real-Time Distributed Systems for IoT" is approved, additional resources will be dedicated to this research line. In the same line, in 2018, we will be involved in a new workshop we promoted in the scope of the 11th IEEE Conference on Software Testing, Validation and Verification (ICST 2018): the First International Workshop on Verification and Validation of Internet of Things (VVIoT). We also plan to submit an European project proposal on "Model-based development and testing of IoT systems" in partnership with the Simula Research Lab in Norway, to start still in 2018.

In the scope of the SIMPROVE project (The Biomedical Simulation Centre of the Future), we expect to contribute in software engineering aspects, namely regarding architectural design and quality assurance.

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

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

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

Accessibility and Assistive Technologies

In the area of Accessibility and Assistive Technologies we will continue the work developing and integrating technologies to help blind people in their daily life and for enhancing their autonomy. Based on the previous experience we will develop a accessible game engine under the BEACONING project and integrate it with the existing blind navigation system in order to allow blind people to play serious geo-location games. Under the scope of sports, health and wellbeing several solutions are being developed in cooperation with CIDESD under the NanoSTIMA project. The solutions integrate Research Line 2 (RL2) aiming the development of smart interfaces for data acquisition of the elderly physics activity. An innovative monitoring platform for arterial peripheral disease patients is being tested with a group of users, that had participated in a rehabilitation program promoted by CIDESD. Moreover, a monitoring pervasive platform for the elderly is also being developed under NanoSTIMA RL2 that will provide data about the health condition of the elderly in their everyday life. In the field of sport, the Swish application for the processing and visualization of player location data is being developed that allows analyzing variables of collective tactical performance in an easy and intuitive way. The Natural Interfaces for the Elderly project -NIE - will explore new ways of interaction for the elderly using mobile devices and robots. This project is being developed in cooperation with UTAD nursery school. In cooperation with Human Computer Interaction Institute of Carnegie Mellon University and the Instituto Dom Luiz we will explore the usage of expert crowdsourcing for semantic annotation of atmospheric phenomena under the project eCSAAP.

We plan prepare 3 proposals for the Horizon 2020 in this of Accessibility and Assistive Technologies. We will disseminate and promote the AAT area organizing special sessions and publishing in scientific conferences of this area, namely in the HCII 2018, DSAI 2018, TISHW 2018 and publishing as well as in scientific journals.
The work of the Web Accessibility Barometer of the web sites of private companies will be continued.

Special Purpose Computing Systems/Embedded Systems

In 2018, the Special Purpose Computing Systems (SPeCS) area will continue to address compiler transformations and the efficient mapping of computations to hardware accelerators using GPGPUs and FPGAs. The mapping methods and approaches will take into account performance, energy and power consumption figures. The area also intends to provide custom solutions for data-intensive algorithms, mainly considering classification and recommendation systems, such as the ones to be developed in the context of the projects CONTEXTWA and SMILES.
The SPeCS area will continue to research new techniques to map efficiently (in terms of performance and energy consumption) matrix-oriented computations. This mapping process will continue to be focused on the translation of MATLAB/Octave models to C/OpenCL both targeting multicore architectures and hardware accelerators (GPGPUs and FPGAs). The new techniques will be used in the MATISSE compiler to provide a prototype of a recommendation system (in the context of an interdisciplinary work between members of SMILES and FOUREYES).

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

In 2018, the SPeCS area intends to participate in at least two H2020 proposals.

5.10.6 Centre Organizational Structure and Research Team

The Centre for Information Systems and Computer Graphics is coordinated by António Gaspar and Ângelo Martins and is organized in the following scientific areas:

- Computer Graphics and Virtual Environments - Responsible: António Coelho
- Information Management and Information Systems - Responsible: Cristina Ribeiro
- Software Engineering - Responsible: João Pascoal Faria
- Accessibility - Responsible: João Barroso
- Special Purpose Computing Systems - Responsible: João Paiva Cardoso

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

Table 5.2-CSIG – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	7	10	12	2
		Academic Staff	26	26	30	4
		Grant Holders and Trainees	35	52	45	-7
		Total Core Researchers	**68**	**88**	**87**	**-1**
	Affiliated Researchers		15	13	15	2
	Administrative and Technical	Employees	1	1	1	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**1**	**1**	**1**	**0**
		Total Integrated HR	**84**	**102**	**103**	**1**
		Total Integrated PhD	**84**	**102**	**103**	**1**

5.10.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CSIG – Project funding

Funding Source		Total Income (k€)			
		2016	2017 (Plan)	2018 (Plan)	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	123	107	214	107
PN-PICT	National R&D Programmes - S&T Integrated Projects	242	341	224	-117
PN-COOP	National Cooperation Programmes with Industry			183	183
PUE-FP	EU Framework Programmes	261	285	401	116
PUE-DIV	EU Cooperation Programmes - Other	110	23	47	24
SERV-NAC	R&D Services and Consulting - National	474	215	121	-94
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes		134	152	18
Uncertain Projects		255	339	332	-7
	Total Funding	**1 465**	**1 444**	**1 673**	**229**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	33	38	39
International conference proceedings indexed by ISI, Scopus or DBLP	87	47	55
Books (author)	0	0	0
Chapter/paper in books	5	2	2
Total	**125**	**87**	**96**

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

Type of Result	No.
Invention disclosures	1
Software copyright registrations	0
Patent applications	1
Licence agreements	0
Spin-offs	0

Table 5.6-CSIG – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	14
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	12
International events in which INESC TEC members participate in the program committees	47
Participation in events such as fairs, exhibitions or similar	18
Advanced training courses	4

Table 5.7-CSIG – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	C4G	Artur Rocha	15/06/2017	13/06/2020
PN-FCT	CONTEXTWA	João Paiva Cardoso	01/06/2016	31/05/2019
PN-FCT	eCSAAP	Hugo Paredes	01/02/2018	31/01/2019
PN-FCT	Icarefordepression	Artur Rocha	01/06/2016	31/05/2019
PN-FCT	NIE	João Barroso	18/10/2017	15/04/2019
PN-FCT	TAIL	Cristina Ribeiro	30/05/2016	29/05/2019
PN-FCT	WindScanner	João Correia Lopes	23/10/2017	21/10/2020
PN-PICT	CORAL-SENSORS-3	Susana Alexandra Barbosa	01/01/2016	31/12/2018
PN-PICT	CORAL-TOOLS-3	Artur Rocha	01/01/2016	31/12/2018
PN-PICT	FOUREYES-2	Sérgio Nunes	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL2	João Barroso	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL3-2	Ângelo Martins	01/07/2015	31/12/2018

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-PICT	NanoStima-RL4-3	Carla Lopes	01/07/2015	31/12/2018
PN-PICT	SMILES-5	João Paiva Cardoso	01/07/2015	31/12/2018
PN-COOP	FDControlo-1	Lino Oliveira	02/01/2018	01/01/2022
PN-COOP	Simprove	António Gaspar	15/03/2017	14/03/2019
PUE-FP	BEACONING	António Coelho	01/01/2016	31/12/2018
PUE-FP	FEEdBACk-1	António Coelho	01/11/2017	31/10/2020
PUE-FP	InteGrid-2	António Gaspar	01/01/2017	30/06/2020
PUE-FP	Meloa	Artur Rocha	01/12/2017	28/02/2021
PUE-FP	RECAP	Artur Rocha	01/01/2017	31/03/2021
PUE-DIV	GReSBAS-1	António Coelho	01/04/2016	31/03/2019
PUE-DIV	MarRisk	Artur Rocha	01/07/2017	30/06/2020
SERV-NAC	ARQNET	José Correia	26/10/2016	30/06/2018
SERV-NAC	AUTOTESTSW	João Pascoal Faria	01/07/2017	31/01/2018
SERV-NAC	CCDRN-EA	António Gaspar	21/10/2010	
SERV-NAC	Consultoria	António Gaspar	01/01/2008	
SERV-NAC	EYEFRYPLUS	José Correia	01/01/2018	30/04/2018
SERV-NAC	IMOPORTAL	José Correia	01/07/2016	30/06/2018
SERV-NAC	RCD	Ricardo Henriques	01/06/2017	30/06/2018
SERV-NAC	SIGMAIA	Lígia Silva	01/07/2017	30/06/2018
OP	Atena-1	Carla Lopes	14/10/2016	13/10/2019
OP	AV360-DNI	Rui Pedro Rodrigues	01/03/2017	31/08/2018
OP	EuroVis2019	António Coelho	27/09/2017	26/06/2019
OP	HDR4RTT	Maximino Bessa	30/09/2016	29/09/2018
OP	PilotoEUDAT	Cristina Ribeiro	01/07/2017	31/07/2018
OP	StopPropagHate	Sérgio Sobral Nunes	01/03/2018	28/02/2019
OP	TPDL/DublinCore	Cristina Ribeiro	23/10/2017	22/09/2018

Type of Project:

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

5.11 LIAAD – ARTIFICIAL INTELLIGENCE AND DECISION SUPPORT LABORATORY

Coordinator: Alípio Jorge

5.11.1 Presentation of the Centre

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

LIAAD aims to produce high quality cutting-edge research, to be in the international forefront of our research areas and promote transfer of knowledge and technology. This centre is in the very strategic area of Data Science that has a growing importance in the world and is critical to all areas of human activity. The huge amounts of collected data (Big Data) and the ubiquity of devices with sensors and/or processing power offer opportunities and challenges to scientists and engineers. On the other hand, the demand for complex models for objective decision support is spreading in business, health, science, e-government and e-learning, motivating our investment in different approaches to modelling. Our overall strategy is to take advantage of the data flood and data diversification and invest in research lines that will help shorten the gap between collected data and useful data, as well as offering diverse modelling solutions.

The scientific foundations of LIAAD are machine learning, statistics, optimization and mathematics.

5.11.2 Research and Technology Development

Data Streams

Allow the treatment of continuous and voluminous streams of data generated by sensors or other sources. Actionable patterns can be found in different contexts, such as: Internet-of-Things, Industry, Transportation and the Web.

Temporal and Spatial data analysis

The ubiquitous and permanent data collection implies awareness of time and space; new algorithms are needed for prediction and monitoring of unusual events within spatio-temporal context converting predictions into useful decisions in subsequent decision making steps.

Web, Text and Media data analysis

The growth of the size and importance of the Web and social networks, and the increasing variety of contents require increasing data analysis capabilities of huge and complex data that enable powerful applications (including: information extraction, sentiment analysis, information retrieval, recommender systems, social network analysis).

Complex data analysis

Data comes in varied and new formats, containing more and more information, from domains ranging from genetics to urban mobility (including ILP, symbolic data analysis, network data, data fusion, variable selection and grouping, active learning).

Meta learning

The growing dynamics of data requires systems that are self-aware and capable of adapting to new problems with little human intervention.

Simulation and optimization

Focusing on solutions for decision problems in management science and other application areas; Exploiting meta-heuristics and optimization techniques based on genetic algorithms, ant colony systems, among others; methods using AI-based approaches, such as multi-agent framework, that enable the simulation of the society or the economy and the interplay between their agents.

Mathematical modelling
Focusing on dynamical systems and game theory: applicable to mathematical physics, mathematical biology, time series analysis, mathematical economy and finances and models of industrial organization.

5.11.3 Technology transfer

Recommender systems and personalization
We have extensive experience in recommender systems and personalization: the algorithms and the applications. We are able to put recommendation algorithms to work in production in various domains such as music recommendation, e-learning and commerce. The variety of data about products, customers, consumers coming from web browsing, shopping and movement can be exploited to understand and predict user behaviour as well as to support users in coping with vast amounts of choices.

Data science in action
Data mining and machine learning are our core areas. We can help businesses and services to make sense of the growing pools of data they collect to improve their actions. We have experience in algorithm development and evaluation, data transformation and system deployment. We help companies and institutions to integrate data science and machine learning into their production flow and Business Intelligence from Business Understanding to Deployment. We currently work in domains such as telecommunications, agriculture, commerce, urban transports and power management, using a variety of data mining algorithms and techniques.

Consultancy in Data science
We are able to help companies and institutions in their effort to develop their own data science teams. We can advise on hiring specialized personnel and in help in the supervision of the data science team. We are able to identify opportunities for data valorisation and provide recommendations on the best practice to follow.

Surveys and Data Analysis
We have competencies in statistical data analysis, including survey design, data collection, data cleaning and understanding, exploratory data analysis, development of predictive models and reporting. These are particularly useful for market studies, analysis of treatments and to measure any specific set of indicators.

Extracting information from text
Much of the data in companies and services is stored as text. People express their views as consumers and citizens on social networks. Relevant information emerges everyday in news, reports, scientific articles and on the Web. We are able to extract information from texts, including named entities, topics, relevant dates and sentiment. This information can be integrated in the data science workflow, exploited for decision making processes or used for producing new content.

Event and Anomaly detection
We develop algorithms for the detection of events and anomalies. We are able to design and deploy solutions in domains such as predictive maintenance, commercial fraud, telecommunications, smart cities, ecological systems and water management.

5.11.4 Knowledge valorisation chain

The following table presents the contribution of the “Research and Technology” areas to the “Technology Transfer” areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-LIAAD – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)				
			RecSys	Data Science	Data Analysis	Text mining	Anomaly detection
Data Streams		I	H	H	L	M	H
Temporal and Spatial data analysis		I		H	H	H	H
Web, Text and Media data analysis		I	H			H	L
Complex data analysis		I	M		H		M
Meta learning		I		M			
Simulation and optimization		I		M			M
Mathematical modelling		I		M	L		M
Other areas (1)	Business Intelligence (CESE)	O	M	H			L

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.11.5 Main objectives and actions planned for 2018

- Promote the contracting of consultancy services by start-ups and other companies (3 contracts);
- Reinforce the partnerships with centres in INESC TEC that are closer to domain areas to boost participation more actively in technology transfer (2 new joint projects);
- Promote the participation in European projects and networks (participation in 4 new proposals);
- Continue the exploration of the application of data science to new application domains: Oil and Gas, Internet-of-Things, Farming (10 papers in new areas, 2 events).

5.11.6 Centre Organizational Structure and Research Team

The Centre has one coordinator, a management board, a management assistant and is organized in the following Areas:

- Machine Learning and Data Mining - João Gama / Luís Torgo
- Data Mining from Structured Data - Alípio Jorge / Pavel Brazdil / Rui Camacho
- Data Analysis and Statistical Methods - Maria Paula Brito
- Modeling & Optimization - Dalila Fontes / Alberto Pinto

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

Table 5.2-LIAAD – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	0	0	1	1
		Academic Staff	29	23	22	-1
		Grant Holders and Trainees	38	42	24	-18
		Total Core Researchers	**67**	**65**	**47**	**-18**
	Affiliated Researchers		5	2	4	2
	Administrative and Technical	Employees	0	0	0	0
		Grant Holders and Trainees	0	0	0	0
		Total Admin and Tech	**0**	**0**	**0**	**0**
		Total Integrated HR	**72**	**67**	**51**	**-16**
		Total Integrated PhD	**72**	**67**	**51**	**-16**

5.11.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-LIAAD – Project funding

Funding Source		Total Income (k€)			
		2016	2017 (Plan)	2018 (Plan)	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	30	62	58	-4
PN-PICT	National R&D Programmes - S&T Integrated Projects	188	347	189	-158
PN-COOP	National Cooperation Programmes with Industry		88	39	-49
PUE-FP	EU Framework Programmes	108	94	92	-2
PUE-DIV	EU Cooperation Programmes - Other	9			
SERV-NAC	R&D Services and Consulting - National		34	178	144
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	102	5	4	-1
Uncertain Projects		55	14	94	80
	Total Funding	**492**	**644**	**655**	**11**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	36	32	38
International conference proceedings indexed by ISI, Scopus or DBLP	48	38	45
Books (author)	0	1	1
Chapter/paper in books	5	5	5
Total	**89**	**76**	**89**

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

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	1
Licence agreements	1
Spin-offs	0

Table 5.6-LIAAD – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	6
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	6
International events in which INESC TEC members participate in the program committees	25
Participation in events such as fairs, exhibitions or similar	0
Advanced training courses	2

Table 5.7-LIAAD – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Dynamics2	Alberto Pinto	01/06/2016	31/05/2019
PN-FCT	FOTOCATGRAF-1	Luís Torgo	01/06/2015	31/05/2018
PN-PICT	CORAL-TOOLS-5	Luís Torgo	01/01/2016	31/12/2018
PN-PICT	FOUREYES-3	Alípio Jorge	01/07/2015	31/12/2018
PN-PICT	iMAN-4	Dalila Fontes	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL3-3	Rui Camacho	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL4-2	Rui Camacho	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL5-2	Carlos Ferreira	01/07/2015	31/12/2018
PN-PICT	SMILES-7	João Gama	01/07/2015	31/12/2018
PN-COOP	PERSONA	Alípio Jorge	01/03/2017	30/06/2019
PN-COOP	SmartFarming-1	Carlos Ferreira	01/10/2016	30/09/2018
PUE-FP	NEXT-NET-1	Pedro Campos	01/10/2017	30/09/2019
PUE-FP	RECAP-1	Rui Camacho	01/01/2017	31/03/2021
SERV-NAC	Consultoria	Alípio Jorge	01/01/2010	
SERV-NAC	FLOWTEE	Alípio Jorge	01/01/2018	31/12/2019

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Dynamics2	Alberto Pinto	01/06/2016	31/05/2019
PN-FCT	FOTOCATGRAF-1	Luís Torgo	01/06/2015	31/05/2018
PN-PICT	CORAL-TOOLS-5	Luís Torgo	01/01/2016	31/12/2018
PN-PICT	FOUREYES-3	Alípio Jorge	01/07/2015	31/12/2018
PN-PICT	iMAN-4	Dalila Fontes	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL3-3	Rui Camacho	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL4-2	Rui Camacho	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL5-2	Carlos Ferreira	01/07/2015	31/12/2018
SERV-NAC	MDIGIREC-1	Alípio Jorge	01/12/2017	30/11/2018
SERV-NAC	PANACea-1	João Gama	08/08/2016	07/03/2018
SERV-NAC	PERS@TOMI	Alípio Jorge	19/12/2017	18/12/2019
OP	Coop_India	João Gama	01/01/2018	31/12/2019

Type of Project:

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

5.12 CRACS – CENTRE FOR RESEARCH IN ADVANCED COMPUTING SYSTEMS

Coordinato: Fernando Silva

5.12.1 Presentation of the Centre

The mission of CRACS, accomplished within the Computer Science Cluster, is to pursue scientific excellence in the areas of programming languages, parallel and distributed computing, security and privacy, information mining, and Web based systems with a focus on developing scalable software systems for challenging, multidisciplinary applications. The research team is currently composed by around 54 members, of which 14 are senior researchers, mostly faculty at the CS department at FCUP, and 7 post-docs. The research environment is enriched with junior talented researchers that together with senior researchers build the necessary critical mass and scientific competences to fulfil our mission.

5.12.2 Research and Technology Development

Languages and Distributed Computing

Our team leads in the design of high-level programming languages that integrate logical and probabilistic reasoning, supporting negation, tabling, and parallelism; languages for mobile distributed environments that are "correct-by-design", namely, in wireless sensor networks (WSN), aiming to simplify programming and debugging; middleware frameworks capable of supporting sensing and actuation in large WSN deployments, with a focus on scalability, energy efficiency and seamless management; innovative middleware for crowd-sensing and crowd-sourcing applications running on top of edge-clouds. A synopsis of our main intervention in this area is:

- Programming Languages Theory and Implementation
- Parallel and Distributed Computing
- Middleware for WSN and Edge-Clouds

Security and Privacy

We focus on algorithms and methodologies to improve the usability of privacy and security in software and systems, namely on user-controlled identity management systems that respect user privacy and protect personally identifiable information; secure identity cards and authentication mechanisms with a view to ensure access control to physical locations or networks, as well as to enable identity verification in online transactions or governmental services communications to guarantee its data integrity and non-repudiation properties; specialized algorithms and tools for sharing sensitive data while preserving privacy; ethical hacking and penetration testing for pre-emptive vulnerability detection. We have been collaborating with the Portuguese Data Protection Commission as consultants in national projects and with Portuguese National Security Agency on auditing systems and developing solutions to secure mobile communications. A synopsis of our main intervention in this area is:

- Identity Management Systems
- Secure Tokens for eID
- Privacy Enhancing Technologies

Knowledge in a World of Data

We work on the bridge between logic, probabilities, data structures and learning. Our focus is on applications that tie our work together with domains such as author identification, semantic relatedness, sentiment discovery, complex networks, motifs discovery, sensor data streams, medical records data, and high-throughput genomics data. A synopsis of our main intervention in this area is:

- Machine Learning and Discovery
- Big Data Applications
- e-Learning Environments and Tools

5.12.3 Technology transfer

YAP Prolog

We are a leading group on the implementation of sequential and parallel logic programming systems. Yap Prolog is a highly regarded system in the research community, especially for machine learning, being distributed by Fedora Linux distribution. It supports just-in-time compilation, multiple forms of parallelism, multithreading, tabling, constraints handling, probabilistic inductive logic programming, etc. It is widely used as a teaching, research and development tool.

Authenticus

We developed the Authenticus national repository of scientific publications metadata authored by researchers from Portuguese institutions. The system automatically uploads publications from multiple indexing databases, automatically associates publication authors with known researchers and institutions, provides specialised interfaces to researchers and institutions to confirm or dismiss proposed associations, allows interoperability with other CRIS systems, provides synchronisation with ORCID, both for import and export, among many other functionalities. It currently has 2,700 registered active users and over 420,000 publication records from 4 sources (ISI, Scopus, DBLP, and Crossref). It has been supported by FCT, University of Porto and INESC TEC.

FotoCatGraf

In FOTOCATGRAF, in cooperation with REQUIMTE, we developed a small, cheap, electrochemical sensor that allows the measurement of the concentrations of a class of emerging pollutants — pharmaceutical substances and their metabolites. The sensor is designed to be seamlessly integrated into wireless sensor networks to be deployed in wastewater treatment plants for automatic, high cadence, collection of data to monitor the concentration of the most harmful pollutants. The resulting data-sets can then be mined to detect patterns that allow a deeper understanding of the usage and life-cycle of these pollutants in the environment and, also, to support environmental and public health policy decisions. Currently, we are looking for an industrial partner to take over this technology.

vCardID – Match-On-Card (MoC) for the Portuguese Citizen Card. CRACS developed and implemented a biometric fingerprint MoC algorithm for Javacard, that is currently being deployed into the Portuguese citizen card, in the context of a contract from INCM. We have also specified an efficient fingerprint minutiae format, appropriate for secure and accurate MoC operations on smartcards and developed specialized tools supporting smartcard personalization with biometric data. The implementation consists on a Javacard applet that is capable of performing fast and accurate MoC operations on any standard Javacard2.1 compliant smartcard. CRACS was also responsible for the development of software supporting the modular integration of several different biometric image acquisition readers from different vendors, into the Portuguese Government back office systems, that are responsible for the acquisition of personalization data for each individual citizen card.

Edge-Computing and Edge-Clouds

Mobile devices have become ubiquitous and traditionally viewed as “thin clients” or “edge devices” that serve primarily as user-input devices. More recently, with their increased computing and storage capabilities, their potential is now viewed as “thick clients,” and going even further, to rethink them as “thin servers”. Given the proliferation and enhanced capabilities of mobile devices, it is now a real possibility for a “wireless cloud of nearby smartphones” to pose an interesting-enough collective computational/storage resource. Our group has expertise in the development of middleware for edge computing and for building innovative proximity-aware applications that pool nearby devices data and processing power to construct hyperlocal edge clouds. HYRAX is project in the context of the CMU-Portugal initiative that addresses the crowdsourcing of mobile devices for edge computing.

Cloud Computing Services

Our group has experience in the design and deployment reliable cloud infrastructures using OpenStack and Ovirt, comprising both storage and infrastructure-as-a-service (IaaS). We were responsible for the setup of INESC TEC Cloud-CA, a cloud comprising 280 computing cores, 1.5TB of main memory and 16TB of storage that was built to be fully redundant and fault tolerant from the network to the service layers.

Privacy Enhancing Technologies and eID

Our group has expertise in privacy enhancing technologies as described in (EU 2007), namely on the "design of information and communication systems and services in a way that minimises the collection and use of personal data and facilitates compliance with data protection rules making breaches more difficult and/or helping to detect them". We have a long history of collaboration with the Portuguese Data Protection Authority, exemplified with the C3Priv project whose main goal was to return the control of the data to the users, and the Break-the-Glass work that originated a PhD thesis that won the Fraunhofer best PhD thesis with practical application, later its implementation on the second largest hospital won the CNPD privacy prize. Some of our researchers collaborate on the International Working Group on Data Protection in Telecommunications and are actively involved in the new European General Data Protection Regulation and may provide some guidance and consultancy on its implementation.

5.12.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CRACS – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Status (2)	Areas of Technology Transfer --> relationships (3)							
		Yap Prolog	Mooshak	vCardID	Authenticus	FotoCatGraf	HLTSYS	ADYTA	INTERRELATE
Programming Languages Theory and Implementation	I	H	M		L	L			
Parallel and Distributed Computing	I	H	L		L	M			
Middleware for Mobile Computing	I					M			
Identity Management Systems	I						H		
Secure Tokens for eID	I			H				H	
Privacy Enhancing Technologies	I						H		
Machine Learning and Discovery	I	H			M				H
Big Data Applications	I	H			L				M
e-Learning Environments and Tools	I		H						

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.12.5 Main objectives and actions planned for 2018

The main objectives of CRACS for 2018 are to consolidate or even strengthen the research core areas with an emphasis on accomplishing goals and deliverables of the on-going projects, increasing our publications output, and continuing developing the research lines that we proposed as strategic for INESC TEC, particularly for the Computer Science cluster, namely mobile edge computing, big data and security. These are areas that connect well with other areas of competence within INESC TEC to tackle application areas with high societal impact, namely in health, climate change, oceans, and energy. In order to achieve these objectives we set the following actions:

- Setup a monthly CRACS workshop in which at least two researchers will give a presentation on their current work. This should foster internal awareness of on-going work, which also simplifies sharing with

other sister centres of INESC TEC. These presentations will be complemented with invited seminars from external collaborators or visitors.

- Be successful in at least 2 new projects, preferentially 1 European. We expect to at least maintain our average funding level from projects.

5.12.6 Centre Organizational Structure and Research Team

The Centre is coordinated by Fernando Silva, who ensures scientific coordination jointly with Luís Antunes. The Centre is organized in the following Areas:

- Languages and Distributed Computing - Responsible: Luís Lopes and Ricardo Rocha
- Security and Privacy - Responsible: Luís Antunes
- Knowledge in a World of Data - Responsible: Vítor Santos Costa

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

Table 5.2-CRACS – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	2	2	1	-1
		Academic Staff	14	12	13	1
		Grant Holders and Trainees	41	31	26	-5
		Total Core Researchers	**57**	**45**	**40**	**-5**
	Affiliated Researchers		2	0	0	0
	Administrative and Technical	Employees	1	1	1	0
		Grant Holders and Trainees	1	0	0	0
		Total Admin and Tech	**2**	**1**	**1**	**0**
	Total Integrated HR		**61**	**46**	**41**	**-5**
	Total Integrated PhD		**61**	**46**	**41**	**-5**

5.12.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-CRACS – Project funding

Funding Source		Total Income (k€)			
		2016	2017 (Plan)	2018 (Plan)	Δ 2017-2018
PN-FCT	National R&D Programmes - FCT	171	123	107	-16
PN-PICT	National R&D Programmes - S&T Integrated Projects	208	280	220	-60
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	65	100	89	-11
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	157	190	47	-143
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes				
Uncertain Projects		10		65	65
	Total Funding	**611**	**693**	**529**	**-164**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	9	13	13
International conference proceedings indexed by ISI, Scopus or DBLP	29	33	36
Books (author)	0	0	1
Chapter/paper in books	3	1	2
Total	**48**	**47**	**52**

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

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	1
Licence agreements	1
Spin-offs	0

Table 5.6-CRACS – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	3
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	6
International events in which INESC TEC members participate in the program committees	12
Participation in events such as fairs, exhibitions or similar	1
Advanced training courses	1

Table 5.7-CRACS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Angerona	Luís Filipe Antunes	01/02/2018	31/01/2019
PN-FCT	ELVEN	Vítor Santos Costa	01/07/2016	30/06/2019
PN-FCT	FOTOCATGRAF	Luís Lopes	01/06/2015	31/05/2018
PN-FCT	Hyrax	Fernando Silva	21/04/2014	20/04/2018
PN-PICT	FOUREYES-4	José Paulo Leal	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL3	Luís Filipe Antunes	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL4	Luís Filipe Antunes	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL5-3	Luís Filipe Antunes	01/07/2015	31/12/2018
PN-PICT	SMILES-3	Fernando Silva	01/07/2015	31/12/2018
PUE-FP	Digi-NewB	Luís Filipe Antunes	01/03/2016	29/02/2020
SERV-NAC	Consultoria	Fernando Silva	01/01/2010	
SERV-NAC	vCardID2-1	Fernando Silva	01/12/2016	30/04/2018

Type of Project:

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

5.13 HASLAB – HIGH-ASSURANCE SOFTWARE

Coordinators: Alcino Cunha and Manuel Barbosa

5.13.1 Presentation of the Centre

HASLab is focused on the design and implementation of high-assurance software systems: software that is correct by design and resilient to environment faults and malicious attacks. HASLab accomplishes its mission within the Computer Science Cluster, anchoring its research on a rigorous approach to three areas of Computer Science: Software Engineering, Distributed Systems, and Cryptography and Information Security. The contributions of HASLab to these areas range from fundamental research on formal methods and algorithms, to applied research on developing tools and middleware that address real-world demands stemming from long-term collaborations with industry.

5.13.2 Research and Technology Development

Software Engineering

Our research on Software Engineering focuses mainly on developing formal methods for system design and program verification, in order to achieve high-quality software. In particular, we develop formal languages and tools for specification, verification (model checking), and design of complex systems, including stochastic, continuous, and systems where human-computer interaction plays a central role. This work is supported by a strong research line on the structural and foundational aspects of computer science. We also develop static and dynamic (automatic) analysis techniques for checking several software quality aspects, for example execution safety or energy consumption, and for automatic testing and debugging, namely fault localization.

Distributed Systems

Our work on Distributed Systems focuses on dependable data management for cloud computing and data science environments. In particular, we are interested in combining the scalability of NoSQL systems with the functionality of relational and transactional database management systems. Our contributions encompass the development of new techniques and mechanisms for data replication and distribution, including conflict-free approaches to eventual consistency with conflict-free replicated data types, query processing focused on analytic workloads, secure data processing in untrusted infrastructures, and operational management of performance and reliability. The main challenge is thus to make novel data management technologies as safe and usable as practice as the well-known and trusted SQL technologies.

The support of scalability is grounded on efficient dissemination protocols and data collection. This is based on topologies that are both resilient and effective in dissemination speed and load, and when appropriate, in stochastic data aggregation techniques that reduce the communication load while providing a global view of the system with controlled accuracy.

Cryptography and Information Security

Our work in Cryptography and Information security covers both fundamental and applied topics, and also the challenge of bridging theory and practice. At the theoretical level we conduct research in provable security and machine-assisted cryptography, where the goal is both to develop the theoretical foundations of rigorous security analysis of cryptographic protocols, and to design formal verification techniques that permit verifying security proofs. At the applied level we focus on high-efficiency and high-security implementations of cryptography, with an emphasis on providing high-assurance as to the functional and nonfunctional properties of cryptographic implementations. A major challenge that we address at this level is to provide domain-specific languages and tool support that guarantee the preservation of theoretically proven properties from high-level specifications to low-level implementations. Privacy enhancing technologies for securely storing data and computing in the Cloud are the most prominent application scenarios we have recently addressed.

5.13.3 Technology transfer

Requirement specification and validation

Early validation of requirements is key to ensure the success of a software project. We have members with a vast experience on using formal methods to specify and validate requirements (and on reliable system design methodologies in general) that can provide early feedback to all stakeholders about potential inconsistencies and critical scenarios. We can also provide consultancy in the process of developing domain specific languages and tools for requirement elicitation and validation. Finally, one important technology transfer area is the analysis of security requirements in software applications, namely those involving complex trust models, such as those arising in the Cloud, and the use of cryptography for more than securing communications and data at rest.

Algorithm design and implementation

We can provide consultancy in the design of algorithms for several complex and critical domains, for example, distributed data synchronization and aggregation, secure implementations of high-speed cryptographic modules for embedded devices, and complex implementations of advanced privacy enhancing protocols for the Cloud. We can also provide implementations of such algorithms with high correctness and efficiency guarantees, and, when applicable, implementations that are correct-by-construction obtained by refinement of formal specifications.

Evaluation of critical software components

We have expertise on evaluating the implementation of critical software components in order to check their conformance to functional and nonfunctional requirements, for example, security, execution safety, energy consumption, scalability or usability. We can also provide consultancy in the process of software certification required in several critical domains, for example, medical devices or aerospace. In the area of cryptographic software development we can provide independent validation of correctness and nonfunctional properties such as the deployment of side-channel countermeasures.

Polyglot data management

The use of multiple data management technologies side-by-side is increasingly common in practice. Besides the traditional SQL database management systems, applications rely on novel systems such as MongoDB or HBase for storage, and on Hadoop or Spark for query processing. In particular, the technologies based on the Hadoop stack have been proven useful in a variety of application domains. We have experience in deploying and operating these systems and can provide support in their implementation in new scenarios and the optimization of existing applications. Moreover, we have experience in integrating and combining multiple technologies in the scope of the same application.

Cloudification services

The deployment of applications on today's technological landscape is moving towards the cloud. The industry largest companies have started to migrate their infrastructure to a cloud environment, seeking to reduce the operational costs and reaping the benefits of resource allocation on demand. Whether the transitions is made to a public service provider, a private cloud or a hybrid-model there is always the problem of integrating an application on the cloud environment. It is not simply a matter of deploying an application on a virtualized environment, there are always concerns regarding the application’s configuration, components interaction, resource monitoring and automatic resource allocation. From years of research and by collaborating with the industry, we gathered the experience required to accelerate the transition of applications to the cloud.

5.13.4 Knowledge valorisation chain

The following table presents the contribution of the “Research and Technology” areas to the “Technology Transfer” areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-HASLab – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)					
	Status (2)	Requirement specification and validation	Algorithm design & implementation	Evaluation of critical software components	Polyglot data management	Cloudification services
Software Engineering	I	H	M	H	L	L
Distributed Systems	I	L	H	M	H	H
Cryptography and Information security	I	M	H	M	L	M

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.13.5 Main objectives and actions planned for 2018

- Increase the income from consultancy and R&D services, by actively searching for new contracts and partnerships. The goal is to increase the income from this category to 20% of the global budget of the centre;
- Move from prototype-level high-assurance software development tools to production-level open-source tools with a significant user-base and high-profile real-world applications;
- Reinforce the stability of the research team by hiring 30% of the current postdocs with regular medium term contracts instead of yearly grants;
- To consolidate stable long-term technology transfer collaborations with international giants in ICT such as Amazon, Google, IBM, etc. that guarantee high-impact in real-world applications for mature research contributions.

5.13.6 Centre Organizational Structure and Research Team

The HASLab is coordinated by Alcino Cunha and Manuel Barbosa and is organized in the following Areas:

- Software Engineering - Responsible: Alcino Cunha
- Distributed Systems - Responsible: José Orlando Pereira
- Cryptography and Information Systems - Responsible: Manuel Barbosa

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

Table 5.2-HASLab – Research team composition

Type of Human Resources			2016	2017	2018	Δ 2017-2018
Integrated HR	Core Research Team	Employees	0	3	3	0
		Academic Staff	21	21	21	0
		Grant Holders and Trainees	46	35	34	-1
		Total Core Researchers	**67**	**59**	**58**	**-1**
	Affiliated Researchers		1	0	0	0
	Administrative and Technical	Employees	0	0	0	0
		Grant Holders and Trainees	1	1	1	0
		Total Admin and Tech	**1**	**1**	**1**	**0**
	Total Integrated HR		**69**	**60**	**59**	**-1**
	Total Integrated PhD		**69**	**60**	**59**	**-1**

5.13.7 Activity indicators for 2018

The following tables present the main indicators of the activity planned for 2018 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination.

The income from projects presented in Table 5.3 includes signed contracts listed in Table 5.7 and new projects to be signed during the year.

Table 5.3-HASLab – Project funding

Funding Source	Total Funding (K€)			
	2016	2017 (Forecast)	2018 (Plan)	Δ 2017 - 2018
National R&D Programmes - FCT		19	23	4
National R&D Programmes - S&T Integrated Projects	157	199	176	-23
National Cooperation Programmes with Industry		20	24	4
EU Framework Programmes	369	637	611	-26
EU Cooperation Programmes - Other				
National R&D Services and Consulting	69	80	60	-20
International R&D Services and Consulting			5	5
Other Funding Programmes		14	139	125
Uncertain Projects	20	88	25	-63
Total Funding	**615**	**1 057**	**1 063**	**6**

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

Type of Publication	2016	2017 (Forecast)	2018
Papers in international journals indexed by ISI, Scopus or DBLP	43	15	20
International conference proceedings indexed by ISI, Scopus or DBLP	55	57	60
Books (author)	0	0	0
Chapter/paper in books	2	1	0
Total	**100**	**76**	**80**

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

Type of Result	No.
Invention disclosures	2
Software copyright registrations	0
Patent applications	1
Licence agreements	0
Spin-offs	0

Table 5.6-HASLab – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	10
Participation in events such as fairs, exhibitions or similar	2
Advanced training courses	1

Table 5.7-HASLab – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	GSL	Rui Maranhão	01/07/2016	30/06/2019
PN-PICT	CORAL-TOOLS-7	Alcino cunha	01/01/2016	31/12/2018
PN-PICT	NanoStima-RL1-4	José Creissac Campos	01/07/2015	31/12/2018
PN-PICT	NanoStima-RL3-4	Manuel Barbosa	01/07/2015	31/12/2018
PN-PICT	SMILES	Carlos Baquero	01/07/2015	31/12/2018
PN-COOP	Cloud-Setup-1	Manuel Barbosa	01/07/2016	31/12/2018
PUE-FP	CloudDBAppliance	Rui Carlos Oliveira	01/12/2016	30/11/2019
PUE-FP	InteGrid-1	Manuel Barbosa	01/01/2017	30/06/2020
PUE-FP	Lightkone	Carlos Baquero	01/01/2017	31/12/2019
PUE-FP	SafeCloud	Rui Carlos Oliveira	01/09/2015	31/08/2018
PUE-FP	UPGRID-2	Rui Carlos Oliveira	01/02/2015	31/01/2018
SERV-NAC	Consultoria	Rui Carlos Oliveira	01/01/2014	
SERV-NAC	DSGrid	Vitor Fonte	01/06/2016	31/12/2018
SERV-INT	CRDB	Carlos Baquero	21/01/2018	20/01/2020
SERV-INT	EMRPrototype	Paolo Masci	20/12/2017	19/02/2018
OP	EUROSYS'2018	Rui Carlos Oliveira	01/10/2017	31/12/2018
OP	PTCRIS	Alcino cunha	01/07/2016	30/06/2019

Type of Project:

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

6 TEC4 INITIATIVES

6.1 Overview

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

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

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

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

- A concrete market domain, represented by businesses and associations;
- A multidisciplinary scientific community dedicated to the challenges of that market domain;
- A technological R&D infrastructure that supports the scientific and innovation activities and is able to offer high added value services to businesses that cannot be found in the market.

Each TEC4 must have its own strategic agenda, according to their market domain, addressing three pillars: the stakeholders and partnerships perspective, the scientific roadmap and the technological R&D infrastructure evolution - to keep up with the state-of-the-art and support the roadmap.

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

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

6.1.1 Current Initiatives

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

- TEC4Sea – solutions for the Blue Economy
- TEC4Media – solutions for the Creative Industries Economy
- TEC4Agro – solutions for the Agro-Industrial, Forest and Green Economy
- TEC4Industry – solutions for the Retail and Manufacturing Economy
- TEC4Energy – solutions for the Energy Economy
- TEC4Health – solutions for the Health Economy

The application domains addressed by the TEC4 have the advantage of mapping directly in regional and national priority domains, aligning and consolidating internal R&D competencies around economic pillars, well understood by businesses. Furthermore, attracting international partners to the TEC4 initiatives, supports the INESC TEC internationalization strategy, facilitates the national companies an easy access to international partners and enables the attraction of foreign direct investment into the Region and the country.

6.1.2 Methodology

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

- Identification of market segments where INESC TEC competencies can create value;
- Identification of internal research lines with highest potential impact in businesses – based on the assessment of market needs;
- Identification of the R&D infrastructure (i.e., laboratories, equipment, demonstration facilities and other technical means) supporting the offer of high added value services to businesses;
- Identification of new potential partners and stakeholders that can bring added value to the TEC and support its innovation cycle;
- Definition/alignment of the strategic agenda of each TEC and the creation of its advisory board;
- Establishment of collaboration plans with other institutions and running of the projects.

6.2 TEC4SEA - Scope and objectives

TEC4SEA is the INESC TEC initiative to induce a market pull drive into R&D and generate a convergence of knowledge and competences into producing solutions for the Blue Economy.

The articulation with stakeholders operating at Sea has been established through strong networking activities, in main national events (Business2Sea) and in strategic international fora - e.g. EIT Raw Materials (Teaming) or IEEE/MTS OCEANS.

TEC4SEA monitors research results in the range TRL 1-9 and focuses on applied research leading to products, processes and services (TRL 5-9) that can be transferred, combining several INESC TEC cross-Cluster competences, in a process where TEC4SEA structures opportunities and the Research Centres undertake the necessary R&D.

The TEC4SEA effort joins shorter term objectives, addressing traditional industries, with longer term visions addressing emerging activities. For traditional industries, projects will be pushed to improve efficiency, resource and cost optimization. Areas such as robotics and autonomous systems, sensors, information systems and communications have been contributing to coastal tourism, intensive aquaculture, port management, shipbuilding and repair industries.

Emerging activities are associated to safety and border surveillance, offshore wind energy, deep sea exploration, mining and deep-sea mining, deep- and ultra-deep-water O&G industries. Partnerships with companies and public sector have already been established and a number of projects developed, supporting the growth of new competencies to address foreseen business challenges.

A TEC4SEA Research Infrastructure (RI) is under implementation, with national support. It brings together a set of partners and laboratories, testbeds, equipment and support facilities, for testing and validating solutions in controlled and real environments. Its support to multidisciplinary research enables a full validation and evaluation of solutions, from simulation/lab experiment to field trials.

For the coming years (2022), TEC4SEA aims to:

- promote the use of the TEC4SEA RI by national and international stakeholders;
- increase the knowledge/technology transfer to industrial ecosystems and the impact in the sea economy and employment in the region;
- contribute for a long term presence on the surface and in the deep and ultra-deep waters;
- consolidate knowledge about resources, biodiversity and human pressures on the sea, empowering decision support.
- align action with the new AIR - Atlantic International Research Centre, where INESC TEC plays a supporting role.

The activity of TEC4SEA will address also visibility, dissemination and interaction. Leveraged by the presence in national and international forums and the STRONGMAR initiative, meetings with decision makers will be conducted as well as thematic seminars and open days.

6.3 TEC4MEDIA - Scope and objectives

TEC4MEDIA is the INESC TEC initiative to induce a market pull drive into R&D and generate a convergence of knowledge and competences into producing solutions for the Content and Creative Industries Economy, increasing digital content market offer and improving end-user experiences. Being INESC TEC a high producer of research targeting this sector, technology transfer to companies and public sector must be ramped up.

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

TEC$MEDIA is being targeted to: production and reuse of content for multiple platforms, second screen, virtual and augmented reality; digitization, restoration and preservation of contents (video, photography); access and navigation in large repositories, customizing and adapting content, gamification strategies; digital economy and digital marketing.

Future work in TEC4MEDIA will cover topics combining several INESC TEC cross-Cluster competences, such as:

- content management, distribution and interaction
- multimodal media user interaction
- multimodal content analysis
- user modeling and personalization
- cross-media information extraction and retrieval
- augmented reality
- multisensory immersive interaction with virtual reality
- digital games and serious games
- context aware multimedia services and applications
- personalised multimedia environments
- sound and music computing: generation, perception, description, interaction
- machine learning for multimedia environments
- data analysis and digital marketing
- long term consumer preferences
- digital tools integration and management
- automatic content generation
- digital content business models

INESC TEC had a major role in the creation and is a major actor in NEM Portugal, a mirror platform of the European platform NEM (New European Media). It gathers hundreds of European key players in media industries (content producers, technology providers). NEM Portugal working together with the supporting clusters (TICE.PT; ADDICT) fosters the interaction of creative and technological companies with the academia in the preparation of new services and products. TEC4MEDIA will allow INESC TEC to fully profit from this platform.

Leveraged by the presence in national and international forums, meetings with decision makers will continue as well as thematic seminars and open days.

6.4 TEC4INDUSTRY - Scope and objectives

TEC4INDUSTRY is the INESC TEC initiative to induce a market pull drive into R&D and generate a convergence of knowledge and competences into producing solutions for the Retail and Manufacturing Industry, covering all supply chain actors, anchored in a history of successes and impact in technology transfer to companies.

TEC4INDUSTRY monitors results in the range TRL 1-9 and focuses on applied research leading to products, processes and services (TRL 5-9) that can be transferred to companies.

It aims at providing high impact services and foster partnerships, supported by applied research, resulting in systems, tools, techniques, models, and methods for decision making, design of operations and services, intelligent automation, robotics, strategy development, networks and chains governance and performance management. The purpose is to address the complex challenges of today's industry, in terms of digitalisation, sustainability and circular economy, human-centredness, innovation, and changeability and flexibility.

This process works by gathering several scientific competences from all INESC TEC Clusters, benefiting from their multidisciplinary scope, in a process where TEC4INDUSTRY structures opportunities and the Research Centres perform the R&D. The innovation sought includes areas such as: operations, logistics and processes, business intelligence and analytics, networks and supply chains, robotics and intelligent systems, innovation and technology management, business information systems and customer interaction and co-creation.

INESC TEC has a unique experience of decades in working together with the manufacturing industry and TEC4INDUSTRY gives structure and strategy to this know-how. In the European context, INESC TEC participates in many HORIZON2020 projects (BEinCPPS , ScalABLE4.0, FASTEN, MANU-SQUARE, NEXT-NET, ColRobot), addressing subjects in the industry 4.0 context such as: business experiments in cyber physical production systems, flexible and autonomous manufacturing systems, collaborative robotics for smart manufacturing, and technology roadmapping for the future supply chains.

Aligned with the TEC4INDUSTRY roadmap, INESC TEC is member of the European Technology Platform Manufuture, the European Factories of the Future Research Association and euRobotics AISBL. In Portugal, INESC TEC is associate of PRODUTECH, TICE.PT and several sectorial industrial associations. Also, INESC TEC is currently actively involved in the creation of the Digital Innovation Hub - iMan Norte Hub, to foster the digital transformation of manufacturing companies of the Northern Region of Portugal and to nurture the respective innovation ecosystem.

The activity of TEC4INDUSTRY will address also visibility, dissemination and interaction. Leveraged by the presence in national and international forums, meetings with decision makers and prescribers will be conducted as well as thematic seminars and open days.

6.5 TEC4AGRO - Scope and objectives

TEC4AGRO is INESC TEC initiative to induce a market pull drive into RTD and generate a convergence of knowledge and competences into producing solutions for the Agricultural, Agrofood and Forestry Economy. INESC TEC is a high producer of research targeting these sectors. It has competencies in the main technologies involved in the digital (r)evolution of agriculture and forestry and digitization of agrofood industry, i.e. IoT, artificial intelligence, robotics and big data. However, its image as a technological partner must be further promoted.

TEC4AGRO strategy is driven by societal challenges, like food security, sustainable agriculture, forestry and bio-economy, and a will to contribute to the European goal of achieving leadership in enabling technologies, such as in biotechnology and ICT.

The Clusters participate in this effort by forming internal consortia of Research Centres, establishing ad-hoc coordination for each action. The TEC4AGRO Agent acts often as an opportunity detector or as a broker. Internal and external events (such as thematic market-focused workshops) are organised under the TEC4AGRO umbrella to foster cooperation between Research Centres and external visibility and cooperation.

The effort will build up on two pillars: experience and resources. As for experience, INESC TEC already has a history of R&D and contracts, such as the development of machinery equipped with variable-rate technology VRT, or projects such as eFoodChain, Smart Farming, BIOTECFOR, Water4Ever and Agrinupes. INESC TEC may and will act in all phases of the precision agriculture/forestry cycle, from variability measurement to action with VRT, encompassing data analysis and decision and prescription.

Regarding the agro-food industry, the activity is already related with all Industry 4.0/digitization issues, i.e. digitalization, robotisation, automation and artificial intelligence. TEC4AGRO follows-up results in the range TRL 1-9 and focuses on applied research leading to products and services (TRL 5-9).

INESC TEC is associate of TICE.PT (ICT companies) and AIFF (forestry companies), a member of the Technical Council of ADVID (wine producers) and a member of AEF (Agricultural Industry Electronics Foundation) and euRobotics. INESC TEC is currently involved in the Digital Innovation Hub "iMan Norte Hub". An active international cooperation with Brazil is foreseen (EMBRAPA).

As for resources, INESC TEC has available several laboratories, such as Robotics for Agriculture and Forestry, Optical and Electronic Technologies, Computer Graphics and Virtual Environments, Optoelectronics for Sensing Technologies and Smart Grids and Electric Vehicles.

The activity of TEC4AGRO will address also visibility, dissemination and interaction. Leveraged by the presence in national (e.g. Agroglobal) and international forums (e.g. Agri Innovation Summit), meetings with decision makers and prescribers will be conducted as well as thematic seminars and open days.

6.6 TEC4ENERGY - Scope and objectives

TEC4ENERGY is INESC TEC initiative to induce a market pull drive into R&D and generate a convergence of knowledge and competences into producing solutions in the Energy Sector. INESC TEC is a high producer of research and technology transfer targeting this sector, allowing companies to be internationally competitive with innovative products.

The main drivers are the Societal Challenges and Innovation Strategies for Smart Specialisation defined by EU policies: the energy sector will be heavily digitalized, under user centric and market based approach, requiring the conceptualization and development of disruptive solutions.

The TEC4ENERGY benefits from a strong, recognized INESC TEC expertise in Power Systems, with more than 20 years transferring research results to manufacturers, utilities and large energy users in Portugal, in Europe and Brazil (e.g. EFACEC, ENERCON, EDP, TBE Brazil, etc). This adds credibility to a broader effort, extended to the fossil fuel sector, and encompassing from industry to transportation, buildings and energy efficiency.

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

TEC4ENERGY will support the establishment of pluri-annual contract-research programmes with companies - one already up with EDP since 2016 and others under way. It will also support the activity extension to other countries, such as Brazil (using INESC P&D Brasil) and Morocco (Government Agencies IRESEN and MASEN). The structuring of TEC4ENERGY obeys to a planetary vision: energy concerns extend beyond borders and INESC TEC already has international penetration in this area. Building up on on-going activities, TEC4ENERGY will also help to consolidate an international advanced consultancy capacity, already translated into international contracts in underwater HVDC interconnections.

TEC4ENERGY monitors results in the range TRL 1-9 and focuses on applied research leading to products, processes and services (TRL 6-9) that can be transferred from all INESC TEC clusters. A Smart Grid and Electric Vehicle Research Infrastructure (RI) provides interaction and services to industry.

The activity of TEC4ENERGY will also include a strong communication activity, combining classical presence in international fora (industry associations, standards bodies) with open day events, research think-tank and viral communication using worldwide-adopted social media.

6.7 TEC4HEALTH - Scope and objectives

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

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

The focus is in human-centered technology, combining INESC TEC cross- Cluster competences: signal and imaging processing, pattern recognition; data mining (image, voice, text); intelligent systems (prediction and decision support), deep learning; robotics and man-machine interfacing. It runs across several areas, such as physics; microelectronics; computing; neurology, neuro-surgery, -physiology, -radiology and biology; systems architecture and interoperability; serious games and optimization. To produce solutions, scientific competences from all INESC TEC Clusters are made to converge, in a process where TEC4HEALTH structures opportunities and the Research Centres perform the R&D.

TEC4HEALTH is being targeted to: chronic diseases (cardiovascular; diabetes); neurological diseases; cancer (breast, lung); disease management; ambient assisted living; sports and wellness; active and healthy ageing and quantified self (personalized medicine & healthy life style).

This strategy is aligned with the EU research agendas. INESC TEC has been involved in H2020 projects, mainly in Societal Challenge 1 Health, Demographic Change and Wellbeing. Also, relevant is the involved in EIP on AHA with submitted commitments in C.2 group as member of the consortium of the reference site PORTO4AGEING, for the Silver Economy.

TEC4HEALTH is already supporting the interaction of INESC TEC with the Health Cluster Portugal (association of companies) to further promote the interaction with technological companies.

INESC TEC work in 2018-22 will cover: Medical Cyber-Physical Systems, Quantified self, Digital transformation, Photonic solutions for point of care diagnostics, Photonic solutions for genomics and proteomics and Photonic solutions for single cell diagnostics. This research will be supported by Biomedical Imaging, Bioinstrumentation and Neuroengineering Labs.

Impact will be maximized through active engagement with world-leading regulatory authorities. On-going collaboration with US FDA aims at a new international standard (AAMI/UL-2800) for interoperable medical systems (to be extended to European and Portuguese safety bodies).

TEC4HEALTH will address also visibility, dissemination and interaction. Leveraged by the presence in national and international fora, meetings with decision makers and prescribers will be conducted as well as thematic seminars and open days.

7 SPECIAL PROJECTS

7.1 UT Austin

Coordinator: Rui Oliveira

Coordinator: José Manuel Mendonça and Rui Oliveira

The UT Austin Portugal Program is a partnership program in Science and Technology between the Portuguese Foundation for Science and Technology and the University of Texas at Austin, duly authorized by the Ministry of Science, Technology, and Higher Education in close collaboration with the Council of Rectors of the Portuguese Universities.

Launched in 2007 the partnership is renewed in 2018, towards a new decade until 2030. The UT Austin Portugal Program addresses a number of knowledge areas where scientists and companies in Portugal will engage with the University and other institutions in Texas in multidisciplinary research and technology transfer. The vision is to develop and foster science-based innovation in companies and in society to help Portugal face the challenges of the future. The basis of the Program focuses on enabling technologies: **nano-technologies**, which bring a revolution to products and systems through novel advanced materials, and **advanced computing** technologies and services which, together with emerging data science approaches, allow us to make intelligent and valuable use of the massive amounts of data we have access to today. Additionally, two big challenges will be tackled with collaborative research in **medical physics**, impacting on health and quality of life, and in areas related to the new Atlantic International Research (AIR) Center - **space, sea, climate and energy** - which will be looking at some of the country's most valuable assets. Finally, UTEN (**University Technology Enterprise Network**) will leverage previous high-impact work in transforming science into valuable technologies for businesses and helping Portuguese start-ups to be successful globals.

Currently the Program is hosted at INESC TEC. Based out of INESC TEC, the Programs' Directors, Prof. José Manuel Mendonça and Prof. Rui Oliveira, and executive team carry out the planning, management and coordination of the activities of the partnership in Portugal, including the promotion of the cooperation between UT Austin and the Portuguese institutions. The executive team also works in close integration with INESC TEC's support services and staff on the Program's administrative, legal, and financial management.

After ten years of joint collaboration, it is proposed that UT Austin and Portuguese universities develop a joint effort to promote an internationally new research agenda in areas of emerging international attention and relevance. The following lines of action are foreseen:

- **Competitive funding for medium to large-scale collaborative research projects** involving researchers at UT Austin and Portuguese researchers, in close association with other institutions, researchers and companies worldwide;
- **Advanced training programs** in topics on the forefront of knowledge, within the research areas of the UT Austin Portugal Program;
- **Research exchanges** of Portuguese and UT Austin faculty, researchers, and graduate students, to explore relevant research collaboration within the Program areas;
- **Joint-appointment programs** maybe implemented as a platform for identification, joint recruitment and empowerment of high potential junior faculty that could benefit from the exchanges and affiliation with the program to effectively become agents of changes in Portuguese institutions.
- **New entrepreneurial initiatives,** through UTEN, to prepare Portuguese researchers and innovators for scientific readiness for commercialization success.

The collaboration should be oriented towards the development of a sound and scientifically relevant research-based agenda at an international level, in close association with the opening-up of new networks of opportunity far beyond the boundaries of UT Austin and Portugal.

7.2 DIGITAL COMPETENCE INITIATIVE

Coordinator: Pedro Guedes de Oliveira

In 2016, the Ministry of Science Technology and Higher Education (MSTHE) created a taskforce the goal of which is to conceive and promote a national programme to increase the number of graduates in ICT at the higher education level lead by Pedro Guedes de Oliveira. Its work was concluded in October 2017 but, earlier that year, the MSTHE decided to expand the purpose of this program, through an integrated public policy initiative with a much broader scope, organised in five different axes:

Axis 1, INCLUSION: ensuring that the whole population has equal access to digital technologies to obtain information, communicate, and interact with others;

Axis 2, EDUCATION: Ensuring the education of the younger population by stimulating and reinforcing digital literacy and digital competences at all levels of schooling and as part of lifelong learning;

Axis 3, QUALIFICATION: Qualifying the working population by providing them with the knowledge they need to become a part of a labour market that relies heavily on digital skills;

Axis 4, SPECIALISATION: Promoting specialisation in digital technologies and applications to improve employability and create higher added value in the economy;

Axis 5, RESEARCH: Ensuring conditions are in place for the production of new knowledge and active participation in international R&D networks and programmes.

Pedro Guedes de Oliveira was appointed to be the global coordinator of the initiative, where Francisco Vaz and José Maria Azevedo will still be involved, and Sofia Marques da Silva will be the Coordinator of Axis 1. At the same time Sofia together with Nuno Feixa Rodrigues, Prof. at IPCA, will be Assisting Coordinators for the initiative and Lucília Fernandes will continue to assure the secretarial and administrative support. Finally, João Neves will also be involved in a special group dedicated to planning an Integrated Network for Public Communication Services.

In order to support the coordinating activities, a contract will be signed between FCT and INESC TEC.

In 2018 a set of flagship projects will be launched:

- Development of an Integrated Network for Public Communication Services that will enable the access of Internet for everyone.
- Development of a Network of Creative Communities for Digital Inclusion in order to bring digital competences to less favoured groups.
- Qualification and re-qualification of Teachers in ICT, to expand the teaching of Computing to students at all levels.
- Qualification and Digital Specialisation of employed or unemployed population for the private sector, in services, commerce, industry and agriculture, creating the necessary competence to leverage the digital transformation of companies.
- Qualification and Digital Specialisation of workers in the Public Administration.
- Increase the offer of studies in ICT in universities and polytechnic institutes, both for continuing education and lifelong learning.
- Promote the use of Data Science in Public Administration in order to improve the decision procedures and the effectiveness of public policies.
- Development of a National Network for Advanced Computing, to enable R&D in cutting edge disciplines in Computer Science.

8 SUPPORT SERVICES

8.1 LEGAL SUPPORT SERVICE

Manager: Maria da Graça Barbosa

Table 8.1-AJ – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	1	3	2	-1
	Academic Staff				
	Grant Holders and Trainees	2			
	Affiliated Researchers				
	Total Integrated HR	**3**	**3**	**2**	-1
	Total Integrated PhD				

8.1.1 Presentation of the Service

The Legal Support service provides legal advice and appropriate action on most of the legal matters emerging within the INESC TEC universe, namely in the areas of human resources, institutional relations, project contracts and public procurement of goods, services and works. The service is committed to always defend the institution's best interests, not only preventively, ensuring that the institution is compliant with national, European or other applicable legal frameworks, but also in order to repair any damage or minimize costs.

8.1.2 Main actions planned for 2018

- Participation in the Multidisciplinary Team nominated for accompanying the implementation of and monitoring the compliance with the European General Data Protection Regulation (Regulation EU 2016/679) and any complementary national legislation;
- Contribute to the Preparation and design of Data Protection Management Plans and Contracts and Data protection Policies
- Implement and adapt internal procedures to the revision of Public Procurement Code and launching of open tenders for acquisition of critical services and goods.
- Proposal of a Confidentiality Guarantee Policy ("Chinese walls");
- Promotion of awareness and information internal sessions, addressed to different attendees, on legal subjects with relevant or high impact to INESC TEC, namely:
    - Scientific Employment;
    - State Aid and related rules for participation in R&D consortia, especially in the ambit of the Programme Portugal 2020;
    - Revision of the Public Procurement Code;
    - Personal Data Protection;
    - Bullying and harassment at work.
- Conception and availability in the intranet of templates for the most frequent types of contracts;
- Revision of rules and templates for R&D Services and Consulting contract proposals, in line with the Proposals submission business process;
- Participation in the conclusion and implementation of the IP Regulation, namely ensuring the appropriate provisions in contracts with collaborators and with entities.

8.2 FINANCE AND ACCOUNTING SERVICE

Manager: Paula Faria

Table 8.1-CF – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	4	4	9	5
	Academic Staff				
	Grant Holders and Trainees	3	4		-4
	Affiliated Researchers				
	Total Integrated HR	**7**	**8**	**9**	1
	Total Integrated PhD	1	1	1	

8.2.1 Presentation of the Service

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

8.2.2 Main actions planned for 2018

The main actions planned for 2018 pertain the improvement of services provided to internal stakeholders, namely Research Centres, Administration and other Services.

During 2018, both travel and purchasing processes will continue under analysis. In collaboration with the Management Information Systems Service several improvements are expected to be implemented in order to enhance systems integration at INESC TEC.

Maintain the focus on continuous improvement bringing collaboration with INESC TEC Research Centres coordinators and researchers to the forefront and promoting a dialogue to get a clearer identification of their needs and projects requirements.

8.3 MANAGEMENT CONTROL SERVICE

Manager: Marta Barbas
Assistant Manager: Vanda Ferreira

Table 8.1-CG – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	8	7	9	2
	Academic Staff				
	Grant Holders and Trainees	1	1	1	
	Affiliated Researchers				
	Total Integrated HR	**9**	**8**	**10**	2
	Total Integrated PhD				

8.3.1 Presentation of the Service

The Management Control service is responsible for coordinating and executing the activities inherent to budgetary planning and control, and also to produce, coordinate and disseminate management information in order to ensure that all resources are obtained and used effectively and efficiently so as to fulfil the purposes of the institution. The service is also responsible for continuous reporting to funding agencies of financial reports and the reimbursement of expenses, monitoring funded projects for compliance with funding agencies terms and conditions by working closely with researchers and providing training whenever necessary.

8.3.2 Main actions planned for 2018

- Conception, development and Implementation of new tools for monitoring Human Resources projects' allocation.
- Organisation of meetings with projects' Principal Investigators.
- Organisation of periodical meetings with the Centres secretaries and organization and management services.
- Workshops' organisation for Centres' managers about projects financial control.
- Enrich intranet by sharing contents for common usage.
- Monthly budget control.

8.4 HUMAN RESOURCES SERVICE

Manager: Maria da Graça Barbosa
Assistant Manager: Margarida Gonçalves

Table 8.1-RH – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	3	4	4	
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	**3**	**4**	**4**	
	Total Integrated PhD				

8.4.1 Presentation of the Service

The Human Resources service coordinates and executes all activities pertaining to human resources administrative management and to the implementation of HR related policies, according to the applicable law, internal regulations and guidelines provided by the Board.

Specific duties include follow-up and management of INESC TEC's insurances related to people, namely Health Insurance, Personal Accidents and Work Accidents, as well as the follow-up and control of the services rendered by the hired company in the area of Safety and Health at Work.

8.4.2 Main actions planned for 2018

- Continuous updating and improvement of the intranet HR processes, in order to reduce workload, time of processing and error occurrences;
- Based on the historical record implementation, generation of the most frequently needed reports and lists, as versatile as possible, in order to help HR management at global and centre levels;
- Generate strategic HR indicators, organised by function besides legal status of the collaborators;
- Promote the clear definition of rights and duties of each kind of liaison of INESC TEC collaborators, as well as clarification and updating of the set of agreements or individual terms and commitments applied to each one;
- Job descriptions updating, so as to reflect the organization evolution;
- Recruitment improvement process: review the effectiveness of our dissemination sources and participate in job fairs;
- Database of spontaneous applications improvement: giving access permissions to all centres and enable queries by areas, qualifications, key words;
- Promotion of information internal sessions, addressed to the Secretariat or other attendees, on changes in HR processes and new requirements;
- Revision of all processes involving personal data treatment, in order to comply to the requirements of the General Data Protection Regulation, to be applied from May 2018;
- Revision of all HR documents available on INESC TEC's intranet.

8.5 MANAGEMENT SUPPORT

Manager: Maria da Graça Barbosa
Assistant Manager: Isabel Macedo

Table 8.1-AG – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	1	1	2	1
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	**1**	**1**	**2**	1
	Total Integrated PhD				

8.5.1 Presentation of the Service

The Management Support service promotes the coordination between the Board, R&D centres and support services, guaranteeing process integration so that the institution provides a coordinated, coherent response. The service also prepares and assures the operationalization of the decision-making process at several levels, from the Board of INESC TEC to other empowered bodies at the institution.

8.5.2 Main actions planned for 2018

- Support the final implementation of INESC TEC's management model in the intranet (implementation of electronic approval workflows at all management levels, including the Board and sub-delegations);
- Contribute to the preparation and design of Data Protection Management Plans and Data protection Policies, in particular concerning the impact on the several business processes management;
- Start periodical business processes management analysis routines for continuous improvement;
- Make electronically available contracts/protocols signed by INESC TEC to designated groups and the lists of Non-Disclosure Agreements;
- Collaboration in the reorganization of internal business processes, namely Proposals Submission and HR processes, and in the automation of other projects, such as the gathering of INESC TEC Strategic Indicators;
- Follow-up and proposal of improvements to the new website of INESC TEC and the intranet.

8.6 SECRETARIAL COORDINATION

Manager: Grasiela Almeida

8.6.1 Presentation of the Service

The Secretarial Coordination is responsible for managing the group of secretaries of Centres and Services at INESC TEC in order to guarantee that all typical procedures are coherent, and to make sure that all internal rules and procedures are followed in close collaboration with the different organization and management services.

The Coordinator provides feedback to the Board on performance and also supervises the group, anticipating the institutions needs and scheduling secretaries to accommodate absence periods.

This service also verifies the constant update of the existing protocols necessary for the current activity of the secretariat group (hotels, renting and travel agencies, among others) and the creation of new protocols, if necessary.

8.6.2 Main actions planned for 2018

Continuous improvement of applications such as PLONE and others used by the secretaries, suggesting changes and improvements, such as:

- Creation of new fields that isolate the supplier for travel, hotel and rent-a-car agent. This will allow us to gather new useful data for activity reports such as “suppliers per user/centre”, “hotel occupancy rate per year”, etc;
- Integration in PLONE of forms used in paper support (“Prestação de serviços”, “Pedido de Emissão de Fatura”, “Pedido de Adiantamento”, “Abertura OI”.
- Help creating a new PLONE area to register indicators related to the secretariat work (conference organization, agenda management as well as other defined indicators)*.

These would be important in order to allow us to evolve gradually towards a paper free environment, to have workflows that are more fluent and also to provide us with additional administrative indicators, other than admissions, purchase and travel processes.

Implement Periodic Report produced by CG regarding Travel and Purchase processes in PLONE to give each centre feedback regarding the approval or rejection of expenses, within the rules of eligibility and according to the feedback from Funding Agencies. This report should be issued with the necessary frequency that would allow us to learn from our work pattern and correct it, improving our Quality Indicators and, ultimately, obtain a budget optimization by increasing the rate of approval of expenses.

Maintenance of the Directory of Useful Information (residences or renting agencies for scholars or visiting fellows, bus companies or other transports, venues for events, catering companies, IT suppliers, and many others);

Training/Coaching actions: evaluate possible training opportunities for the Secretaries and providing frequent coaching sessions with our services.

8.7 FUNDING OPPORTUNITIES OFFICE

Manager: Marta Barbas

Table 8.1-SAAF – Service team composition

Type of Human Resources		2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees			1	1
	Academic Staff				
	Grant Holders and Trainees	1	1		-1
	Affiliated Researchers				
	Total Integrated HR	**1**	**1**	**1**	
	Total Integrated PhD				

8.7.1 Presentation of the Service

The Funding Opportunities Office aims at identifying the relevant funding opportunities to support INESC TEC Research, Development and Innovation activities, always aligned with the mission and objectives of the Institute. This service will also support and supervise the development and submission of proposals to different funding programmes, always in collaboration with the R&D Centres and with the other Business Development Services.

8.7.2 Main actions planned for 2018

Organization of workshops to explain the procedures for preparing and submitting proposals to particular calls for proposals.

Monthly presentation (@ CCI and Intranet) of open calls and submission.

Dissemination of “proposals workflow” in order to better coordinate tasks between the different services involved in the process.

8.8 INDUSTRIAL PARTNERSHIPS SERVICE

Manager: Augustin Olivier

Table 8.1-SAPE – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	4	4	2	-2
	Academic Staff				
	Grant Holders and Trainees	1	1	1	
	Affiliated Researchers				
	Total Integrated HR	**5**	**5**	**3**	-2
	Total Integrated PhD	2	2	1	-1

8.8.1 Presentation of the Service

The Industry Partnership Service aims at strengthening INESC TEC's approach to the market and achieve higher revenues from industry contracts.

The service is responsible for building strong relationships with partners, identifying business opportunities, negotiate and close industry contracts for innovative projects based on INESC TEC R&D competencies and maintain an extensive knowledge of market trends and conditions. Furthermore, SAPE should plan different strategies and marketing contents highlighting INESC TEC added value and differentiation, prospect for new industry partners, organize and set up business meetings and increase INESC TEC business network.

The main actions will be divided in four activities described below.

8.8.2 Main actions planned for 2018

8.8.2.1 Activity 1: Organization based on a multidisciplinary approach

INESC TEC will continue to present its competencies on the market based on its multidisciplinary approach organized in innovation areas, called TEC4 ("TEChnology FOR …").

Each TEC4 has its own strategic agenda, according to their market domain, addressing three pillars: i) the stakeholders and long-term partnership perspective, ii) the technological roadmap and iii) the R&D infrastructure evolution - to keep up with the state-of-the-art and support the roadmap.

INESC TEC is leading six TEC4 areas, in different stages of maturity and devoted to the following domains:

- TEC4Sea – sea activities and economy
- TEC4Media – content, creative industries and tourism
- TEC4AGRO-FOOD – agricultural, agrofood and forestry sectors
- TEC4Industry – production technologies, manufacturing, distribution, logistics and retail
- TEC4Energy – energy related activities and economy
- TEC4Health – health and well-being related activities and economy

TEC4s are dynamic organization models that need to be periodically evaluated and adapted to the economic structure. From time to time, these TEC4 can be reformulated in order to get a new positioning.

During 2017, all enumerated TEC4 areas were pushed forward in terms of structuring their activities and establishment of stronger relations with their stakeholders. Namely, TEC4SEA and TEC4Energy focused their efforts in the implementation of their R&D infrastructure; TEC4Media was reformulated under the umbrella of TICE.PT, accessing a broader scope of sectors; TEC4Industry is strengthening its relations with the main stakeholders and companies; TEC4AGRO-FOOD asserted as a preferential partner for the national agricultural and forestry sectors' digital (r)evolution. These activities will have further impacts in the years of 2018 and 2019.

8.8.2.2 Activity 2: Networking and promotion activities for knowledge transfer

The main objectives of this activity are:

- to increase the networking activities with national and international partners as well as the efficiency of these networking activities;
- to extract more knowledge and value from the regular interactions with partners, supporting better targeting and, if possible, anticipating needs;
- to strengthen the INESC TEC positioning as an RTD partner of businesses, by increasing the number of national and international projects;

Those global objectives are supported by the following tasks:

- Networking and promotion activities - participation in exhibition fairs/events. Aligned with the TEC4, INESC TEC considers the participation in Business2Sea (Ocean Forum), EMAF (manufacturing and logistics sector), FIMA 2018 (agricultural machinery), Agroglobal 2018 (agriculture), TechDays (ICT);
- National networking and promotion activities – Seminars organization, aligned with the smart specialization thematic areas and/or societal challenges identified in Horizon 2020;
- International networking and promotion activities: events such as infodays, international fairs, participation in interest groups, reference site member of the EIP on Active & Healthy Ageing as Porto4Ageing), to enable the identification of high level challenges that remain to be solved and facilitate the entrance in international consortiums;
- Networking and promotion activities by through Business Clusters. The establishment of strong links with the Business Clusters, strategic aligned with the TEC4, is a means to access people with power to decide, influence and/or provide valuable feedbacks. The National Business Clusters aligned with the previously presented TEC4, are: Forum Oceano, Portugal Mineral Resources, Produtech, Smartwaste, Mobinov, NEM Portugal, Porto4Ageing, HEALTH CLUSTER Portugal, ADVID, aiff, Portuguese AgroFood Cluster and TICE.PT.

8.8.2.3 Activity 3: New technologies and knowledge dissemination for business

Communicating and disseminating the new thematic organization, supported by the TEC4, must also take place in the Internet. This activity aims at creating a web site for each TEC4, publicizing the corresponding Research Lines addressed by the institution concerning that domain, the main businesses and academic partners, the R&D infrastructure capabilities and corresponding available services. Dedicated web sites also serve as a space for rapid dissemination of technological results and achievements.

8.10 TECHNOLOGY LICENSING OFFICE

Manager: Catarina Maia

Table 8.1-SAL – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	1	2	2	
	Academic Staff				
	Grant Holders and Trainees	1		1	1
	Affiliated Researchers				
	Total Integrated HR	**2**	**2**	**3**	1
	Total Integrated PhD		1	1	

8.10.1 Presentation of the Service

The mission of the Technology Licensing Office is to protect and license technology developed at INESC TEC. To carry out its mission, the office works in close collaboration with the Legal Support Service and the Industrial Partnerships Service. The office's responsibilities consist of establishing and managing INESC TEC's processes related to: internal scouting and dissemination of research results that can be protected by Intellectual Property (IP) rights; market and state of the art assessment; definition of IP strategy; technology licensing; negotiation and monitoring of licensing contracts.

8.10.2 Main actions planned for 2018

The office's main activities planned for 2018 include:

- technology scouting;
- market research and business development for licensing opportunities, namely through finding a suitable broker and presence in trade fairs;
- increase the amount of funding for patent applications, namely through proposals to Compete 2020, and manage the current projects;
- increase INESC TEC's readiness for the open science challenge, namely through open source licensing guidelines and adoption of open data licenses;
- develop technology offers as flyers and web-based presence (both in INESC TEC's website and innovation marketplaces);
- actively monitor open innovation platforms for technology calls that can be met by INESC TEC's technologies;
- create a societal impact case for one of INESC TEC's licensed technology;
- the adoption and implementation of a software for IP management.

The service will continue to provide support on IP matters to INESC TEC researchers through:

- meetings and workshops for IP knowledge dissemination;
- support in contracts negotiation and background identification;
- patent landscapes searches;
- support to patent drafting;
- the preparation of applications for public funding of patent processes.

The service will continue to provide support on IP matters to INESC TEC's Board of Directors, namely:

- evaluation of invention disclosures;
- INESC TEC's Intellectual Property Guidelines and Regulation;
- draft and implementation of spin-off policies;
- licensing to spin-offs;
- report on IP key performance indicators for stakeholders.

8.11 INTERNATIONAL RELATIONS OFFICE

Manager: Vladimiro Miranda

Table 8.1-GRI – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees				
	Academic Staff				
	Grant Holders and Trainees	1			
	Affiliated Researchers				
	Total Integrated HR	**1**			
	Total Integrated PhD				

8.11.1 Presentation of the Service

The International Relations Office (IRO) is established under the dependency of the Board to systematically and regularly organise the internationalisation of activities in selected countries. The Office focus specifically on identifying opportunities, concentrating knowledge on research and industrial foreign markets, promoting the attraction of foreign researchers to INESC TEC and acting in general as a facilitator of contacts and relations between research groups in INESC TEC and foreign.

The IRO is a structure constituted presently by two Offices: the Brazil Office and the India Office. These Offices should act as mediators, facilitators or cooperation brokers. The human resources acting in this framework are recruited among the diverse structures of INESC TEC to give specific contributions and do not constitute a full-time dedicated resource.

8.11.2 Brazil Office: main actions planned for 2018

The Brazil Office, acting as a broker or facilitator and as an aid to the Board in Latin America matters, will not have the responsibility over projects or contracts. The main activities of the Brazil Office will be the following:

- follow up the activity in INESC P&D Brazil (IB) and keep regular meetings with the IB secretariat and administration;
- track the direct relation of INESC TEC with Brazilian partners and assist the Board in these contacts;
- assist the INESC TEC Centres in the contact with IB and in proposing/implementing R&D contracts;
- assist Brazilian visitors to INESC TEC;
- provide assistance to the relations of INESC TEC with other Latin American countries;
- provide a sense of community and attachment to INESC TEC of the Brazilian researchers in the institution.

This activity, in 2018, will be instrumental in consolidating relations with Brazil, given that INESC P&D Brazil enters in a new stage of development - new associates are joining this institute, in a juridical association and not only as members of a cooperation network.

8.11.3 India Office: main actions planned for 2018

The India Office, acting as a broker or facilitator and as an aid to the Board in affairs with India and Indian parters, will not have the responsibility over projects or contracts. Its main activities in 2018 will be the following:

- Continue the study of the India system of research and education and reinforce the knowledge on key partners and actors, legislation and opportunities;
- Build bridges with important actors in India and the India industry and act as a facilitator between such partners and INESC TEC Centres, to the point of achieving the signature of MoUs and other agreement instruments formalizing a cooperation framework.

Structure, negotiate and launch a program of post-graduation training, aimed at attracting valuable Indian students to Portugal and INESC TEC.

8.12 COMMUNICATION SERVICE

Manager: Sandra Pinto

Table 8.1-SCOM – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	3	5	5	
	Academic Staff				
	Grant Holders and Trainees	3	2	2	
	Affiliated Researchers				
	Total Integrated HR	**6**	**7**	**7**	
	Total Integrated PhD				

8.12.1 Presentation of the Service

The Communication Service collaborates with the Board in order to define the institution's communication strategies and image. Its main activities are planning, implementing, organising and coordinating both internal and external communication in accordance with the regulations and procedures established, promoting the image and prestige of the institution.

8.12.2 Main actions planned for 2018

The Communication Service has been defining its strategies in accordance with the principles of integrated marketing communication, which involves a number of tools, such as Public Relations (events, media advisory), digital marketing (social media management), sponsorships, exhibitions and fairs. The goal is that these tools can complement each other in a coordinated way in order to bring more notoriety to the INESC TEC brand.

8.12.2.1 New actions planned

- The Communication Service along with the Industry Partnership Service (SAPE) is developing a communication strategy, which is more focused on the market. This strategy intends to highlight the important role of INESC TEC in the ecosystem of companies and industry. Communication is oriented towards a logic that presents the Clusters behind science push, but especially stresses the TEC4 behind the market pull. Its main purpose is to highlight that INESC TEC addresses real world challenges. Institutional presentation will be the first communication support that will follow this strategy, but then all communication support will focus on the premise “turning science into economic value”.
- With respect to media advisory, the Communication Service will start to communicate in international media. In 2018, a newsworthy theme will be selected as the target of an international dissemination action. The idea is that this international mediation serves as pilot experience for future disclosures. With the aim of broadening more visibility, the less active R&D Centres in the media will be encouraged to communicate more.
- The presence of INESC TEC in social media has made progress, however measures will be taken to increase the community of social media and the awareness of INESC TEC collaborators during this year. In order to increase the number of followers in social networks, a "Brand Advocate Program" will be created to use as a guideline. Thereby the Communication Service will promote the sharing of INESC TEC content by selected collaborators. Moreover, the Board and Coordinators will be encouraged to play an active role in social media. Our resources will also be dedicated on editing video content and direct events on social networks as well as developing training sessions for collaborators on "why" and "how" to communicate science in social media.
- Regarding the corporate image of INESC TEC, and following the approval of the new institutional identity, which highlights the multidisciplinary nature of INESC TEC, new communication supports will

be created, such as an exterior textile to the building façade, pop-ups for events, basic stationary, folders, flyers or business cards. “Connect INESC TEC” website and INESC TEC Bulletin (BIP) are other platforms for the new redesign identity foreseen for 2018. BIP will also have a monthly bilingual edition, with weekly updates.

- Regarding internal communication, the 1st “INESC TEC walk” will be organised, which intends to be a social moment of sharing of all genders and ages. It is also planned the 1st edition of a training session “Improve your public speaking skills” for researchers with the aim of preparing them to present their projects in a more appealing and engaging way.

8.12.2.2 Standard and enhanced actions planned

- Concerning Public Relations, it is worth mentioning the events organised by INESC TEC, such as Fórum INESC TEC do Outono and the role of INESC TEC in other renowned events. These initiatives allow INESC TEC to attract public and media attention and to *increase* brand *awareness.*
- It is also important to stress the support that the Service provides to INESC TEC’s R&D Centres with dissemination work packages, such as European projects like UPGRID, GReSBAS, InteGrid, FEEdBACK and StrongMar, integrated projects like NanoStima and TEC4Growth, and the EEN network. The Service will also prepare the visit of the FCT evaluation committee, which will entail a significant effort in terms of the image INESC TEC wants to present.
- The regular communication activities are also worth mentioning, namely: national media advisory, promotional project videos, organising Science Communication initiatives, producing the institution’s monthly newsletter (BIP), overseeing visits to INESC TEC, photo and video coverage of events.
- Regarding internal communication, the 2nd edition of the “Strategic Meeting for senior researchers” and the 2nd edition of the “INESC TEC on the move” (a Team Building initiative for all collaborators) will be organised.
- Finally, usual internal events will be organised, such as photo competitions, “Magusto” and the multicultural party, as well as monthly welcome sessions for new collaborators and media training sessions.

8.13 NETWORKS AND INFORMATICS SERVICE

Manager: Gil Coutinho

Table 8.1-SCI – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	2	2	2	
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	**2**	**2**	**2**	
	Total Integrated PhD				

8.13.1 Presentation of the Service

The Networks and Informatics Service manages INESC TEC's voice and data communication infrastructures and is responsible for the implementation and maintenance of network services.

8.13.2 Main actions planned for 2018

- Reorganize the network's routing topology and configuration, including the acquisition of redundant firewall appliances and core forwarding equipment and the deployment of IPv6.
- Upgrade the switching infrastructure, namely to improve its redundancy and reliability and also to provide access speeds of at least 1 Gigabit/s for every workstation and 10 Gigabit/s for every server;
- Upgrade the Wi-Fi infrastructure, regarding coverage, access speed and delivered services for INESC TEC, eduroam and other visiting users;
- Upgrade the videoconferencing infrastructure, including the integration of new solutions (e.g. Cisco WebEx) with the existing terminals and services;
- Refit the voice communication system (VoIP), including the necessary modifications to put the legacy PABX out of service;
- Improve the e-mail system, revising software packages and versions, clustering architectures, management tools and SPAM filtering techniques;
- Upgrade the network-based multifunction printing equipment (software and hardware), including the implementation of a per-user authentication mechanism;
- Simplify and further automate the network's access granting procedures to new devices and users;
- Foster and implement high-speed interconnections (e.g. 10 Gigabit/s) between INESC TEC's network and relevant external networks like the national research and education network (RCTS) and the city of Porto's metropolitan network (Porto Digital);
- Implement and deploy an authentication infrastructure which integrates both the Portuguese federation (RCTSaai) and the global confederation (eduGAIN), fostering the delivery of federated services (e.g. Colibri, Digicert);

8.14 MANAGEMENT INFORMATION SYSTEMS SERVICE

Manager: José Carlos Sousa

Table 8.1-SIG – Service team composition

Type of Human Resources		2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	3	3	4	1
	Academic Staff				
	Grant Holders and Trainees	2	2		-2
	Affiliated Researchers				
	Total Integrated HR	**5**	**5**	**4**	-1
	Total Integrated PhD				

8.14.1 Presentation of the Service

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

8.14.2 Main actions planned for 2018

- Continuous improvement of INESC TEC Website;
- Continuous improvement of processes;
- Reorganization of the Intranet and significant improvement of its performance;
- Increase SAP integration with the Intranet;
- Implementation of the Projects Database and interconnection with the uONE project management tool;
- Inventory validation for CF with online listings for SCI;
- Improvement of the publications data retrieval from Authenticus; allow ad hoc changes indicated by the monitoring committee; verify that the information in the researchers' ORCID is up to date;
- In evaluation process, continue to take steps to make it fully automated;
- Complete the systematic collection of all institutional indicators and improvement of its visualization;
- System for reporting research results to the Associates and FCT;
- Establishment of a CRM system, interoperable with the INESC TEC information system.

8.15 SYSTEMS ADMINISTRATION SERVICE

Manager: Jaime Dias

8.15.1 Presentation of the Service

The Systems Administration Service is responsible for managing servers, computer systems and collaborative applications, for providing support to end-users and for Research and Development. This Service is also responsible for managing the INESC TEC Living Lab, in collaboration with Centres and other Services, to enable INESC TEC's building and infrastructures as real life testbeds while promoting R&D results.

8.15.2 Main actions planned for 2018

The computing cluster will be expanded with more nodes and with GPU High-Performance Computing.

A new email service will be installed, configured and integrated with the INESC TEC Directory (LDAP service). It will support new functionalities, including calendaring and invites, and will be mobile-device aware.

The collaborative services, including Gitlab and Chat, will integrate with new services to enable the full DevOps production chain – from Development to Production.

The INESC TEC Identity Provider (IdP) will be installed and configured, enabling INESC TEC users to access the FCCN services with their INESC TEC Directory credentials.

The Knowledge Base (help.inesctec.pt) will be populated with new articles to help collaborators, especially the new ones.

The INESC TEC Living Lab initiative will be started. The INESC TEC Living Lab aims at promoting and enabling the exploitation of INESC TEC R&D results, and use the INESC TEC building and infrastructures as a laboratory testbed for experiments with real people and real scenarios. The promotion shall exploit the "WOW Effect", increase researcher's inspiration and creativity, and help attracting new customers and researchers. Centres will have a central role in the definition of the testbeds and on the selection of the R&D results to be promoted. Some of the planned equipment are Smart Displays, which include a Smart Glass and an Interactive Wall that will allow the presentation of news, promotion of INESC TEC R&D results, access to remote testbeds and equipment in real-time, and possibly to building telemetry.

8.16 INFRASTRUCTURE MANAGEMENT SERVICE

Manager: Jorge Couto

Table 8.1-SGI – Service team composition

	Type of Human Resources	2016	2017	2018 (Plan)	Δ 2017 - 2018
Integrated HR	Employees	5	5	4	-1
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	**5**	**5**	**4**	-1
	Total Integrated PhD				

8.16.1 Presentation of the Service

The Infrastructure Management Service ensures the support services necessary for adequate management, maintenance and use of INESC TEC's buildings and infrastructures.

8.16.2 Main actions planned for 2018

The main actions of the service planned for 2018 are the following:

- Improve the active and passive security of the INESC TEC building. Implement safety regulations and install video surveillance systems;
- Submit an application to the P2020 programme to support the installation of LED lighting in the building, and thus reduce electricity costs;
- Schedule and implement a set of maintenance actions in the buildings' electrical infrastructure (transformer substation, main and partial switchboards, water pumps, etc.);
- Rationalize and optimize the air conditioning infrastructure in order to improve comfort and reduce costs of operation;
- Development of safety prevention actions and firefighting procedures. A fire drill will take place to test the adequacy of these procedures;
- Schedule and register technical verifications of equipment installed at INESC TEC to detect and fight building fires;
- Continue the painting works which started on the 1st and 4th floor (offices and common areas) using internal resources;
- Use as frequently as possible internal resources in the different maintenance and support tasks;
- Improve the image and environment inside the buildings with natural plants;
- Improve the documentation of the service processes and equipment;
- Increase the level of usage of tickets for services to be provided;
- Promote recycling in INESC TEC buildings.