INESC BRUSSELS HUB

HEALTH TECHNOLOGIES CAPACITY CHARACTERISATION AND MATCHING WITH EU PROGRAMMES

INTERNAL DOCUMENT - DO NOT SHARE OUTSIDE INESC

VERSION DATED 16TH JUNE 2020

INESC Brussels HUB is a European representation of the 5 INESC institutes, located in the heart of the European district in Brussels.

This report was prepared by request of the INESC Brussels HUB Management Committee by the Work Group on Health Technologies (WGHT) by all the WG members and the Head of the INESC Brussels HUB office, Ricardo Migueis.

The INESC Brussels HUB WGHT is chaired by Susana Vinga (INESC-ID) and Co-Chaired by Verónica Romão (INESC MN). The full membership of the WGHT members is:

INESC Coimbra: Joana Matos Dias

INESC ID: Susana Vinga

INESC INOV: Gabriel Pestana and João Cordeiro

INESC MN: Verónica Romão

INESC TEC: Miguel Coimbra and Carlos Ferreira

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EXECUTIVE SUMMARY

This report results from a request by the Management Committee to the HUB, with the main goal of providing a clear perspective of what was the research and innovation (R&I) capacity in health technologies (HT) across the 5 INESC institutes and matching it with the prospective opportunities in Horizon Europe and other relevant European programmes and funds. This should allow to evaluate which activities are needed and relevant to be developed by the Work Group Health Technologies (WGHT) in its next phase of existence.

The WGHT came together and all its members equally contributed to the information gathering, writing, analysis of the Horizon Europe already known documents, presentations and all relevant information available at this point. It is worth noting that at the time of writing, there are only political guidelines and some draft general texts and not specific work programmes and topics to be analysed. This will be, therefore, dully accompanied by the WG and the document will be reviewed in due time.

The first phase of the work consisted in defining which information was needed, followed by an effort of information gathering about the R&I capacity in each institute. The challenges and outcomes of this first part of the work surpass the mere gathering of information, and were useful for each institute to understand how its data management methodology is adequate and can be relied upon for quickly answering the challenges posed by the new European funding programme for R&I, Horizon Europe. This work was done in close cooperation with the Task Force Funding.

The second phase was the definition of the universe of European programmes and instruments to be analysed by the WG, in order to proceed with the matching of the capacities. Once that universe was defined, different members from different INESC institutes were paired and chose which parts they would like to study, analyse and provide four outcomes:

1) A description of the specific part of the programme to be analysed, under the light of the HT area (i.e. Mission Cancer, Cluster Health, Research Infrastructures, Digital Europe, etc).
2) An initial matching of the existing R&I capacities of the 5 INESCs with the policy goals and R&I thematic areas and specific subject-matter expected to be covered by each part of each relevant funding programme.
3) A critical perspective about what should be expected from HT related topics for those parts of the programme, considering the state-of-art knowledge at INESC in the respective areas.
4) A set of suggested initiatives that should be developed by the WGHT in that particular area to better position INESC.

The WGHT considers that not only this document but the process that led to its elaboration, strongly contributes to:

- Provide a structured overview of the R&I capacity in all the 5 INESC institutes in the area of HT.
- Match the existing R&I capacity with the political orientations and information already known about the HT related opportunities in Horizon Europe.
- The training of the members of the WGHT (as crucial information multipliers in each organisation) as well as the broader INESC HT related researchers about Horizon Europe from an early stage.
- Have ready and objective information about our interests and be able to actively contribute to the European Commission agenda-setting process (building yearly work-programmes and respective topics).

- Serve as a living document of reference, available to everyone at INESC when developing research proposals.
- Serve as the basis for multiple and diverse presentations to potential partner institutes, companies and the European Commission, making them more easily aware of the existing capacity at INESC.
- Provide an overview of the INESC institutes response to the COVID19 pandemic.
- Increase multidisciplinary approaches by consciously reflecting upon the need for interaction with other thematic areas at INESC.
- Increase mutual knowledge about each other (between different INESC institutes).
- Increase the likelihood of synergistic and complementary approached by 2 or more INESC institutes, making full use of the INESC capacity, when developing R&I proposals.
- Serve as the basis for the definition of a workplan for the WGHT for the next 24 months.

The first section of this report is dedicated to capacity characterisation in each of the INESC institutes. Each chapter presents a description of the research capacity in the corresponding institute, which is then associated to the application or market areas (innovation). In order to facilitate the perception of the capacity and application areas, a visual representation of capacity and application for each institute was developed (as well as an overall HT capacity and application visual representation for the 5 INESCs – see Figure 1, below). Moreover, each chapter in this section includes a list of selected projects and papers in HT, as well as the published and active patents and the list of main collaborations with external national and international entities (an aggregated view for of the collaboration patterns for the 5 INESCs is also available in Table 1, below).

All the information was collected and presented in an objective way with the goal of serving as an updated and structured reference document, that can also be easily used as a reliable source of information to build presentations when needed.

The second section is a first step towards matching the capacity existing in the 5 INESC institutes with the European programmes in the next programming period. So far, it was possible to initiate this exercise for the following programmes and instruments:

- Mission Cancer
- Cluster Health
- Health -related Public-Private Partnerships
- EIT Health
- Digital Europe

The third section is a specific section on COVID19, elaborated upon the request of the INESC Holding President. It was elaborated in a very short time-span and, as the rest of the document, will be updated in the future. This section presents a summary of the European and national R&I related measures to support the fight against the Coronavirus and the goal was to also establish a concrete match between the different research capacities at INESC and the application areas pertinent to the fight against the virus. It also includes a summary of the measures already implemented and/or in preparation across the 5 INESCs.

Finally, we present the plan of activities of the WG HT for the remaining of 2020 and first semester of 2021. This plan is fully focused on the matching, deepening of network, creation of visibility and opportunities, mobilisation of INESC HT community, as well as the continuous information gathering, revision and planning work for the future.

OVERVIEW OF CAPACITY CHARACTERISATION

INESC capacity in Health Technologies covers a broad spectrum of applications and methodologies, covering the most significant areas in R&I, ranging from theoretical and computational topics to experimental laboratory applications.

The 5 INESCs gather exceptional expertise on theoretical and computational methods with strong application in health, such as optimization, artificial intelligence and machine learning, operational research, dynamic systems and control. The institutions also have a strong capacity on communication systems and security, iterative intelligent systems for visualization and multimodal interfaces, and human language technologies for health. The area of sensors, micro- and nano-devices, and microelectronic systems, including lab-on-a-chip further complement the full range of fundamental pillars in health research.

These built competences have comprehensive areas of applications, that include medical decision support systems, namely for treatment planning and optimization in radiotherapy, anesthesia, and rehabilitation, image analysis and classification for enhanced diagnosis, biomedical data analysis and health analytics, microelectronics for healthcare, micro and nanotechnologies for biosensing, identification of biomarkers and micro-organisms in point-of-care, robotic systems for critical handling and social care.

It is noteworthy the collaborative network of all the five INESCs, covering the majority of the hospitals in Portugal (IPO, Lisbon: Hosp Santa Maria, Hosp Beatriz Angelo, Hosp Luz; Center: Hosp Coimbra, North: Hosp Pedro Hispano, Hosp Santo António, Hosp São João); life-sciences research institutions (IMM, Champalimaud, IGC, ITQB, INSA, i3S, among others) and SMEs. The international collaboration includes many universities and research centers (Heidelberg, Cambridge, ETH Zurich, Texas MD Anderson, Karolinska, Munich, CMU, INRIA, EMBL, among others).

Besides this significant network, the impact of INESC activities is testified by the numerous projects, patents, and papers, specifically in the Health Technology macro-area.

	Successful projects	Published and active patents	Peer reviewed papers
INESC Coimbra	5	0	40
INESC ID	20	0	153
INESC INOV	4	0	7
INESC MN	16	3	29
INESC TEC	42	13	544

TABLE 1: INESC OVERALL INDICATORS IN HT

Overall, it is envisaged that the existing synergy and complementarity between the 5 INESC can be further exploited, expanded and strengthened for the support of medical diagnosis, treatment and monitoring, in the scope of chronic, infectious, neurological and oncological diseases, and also for active and healthy aging, towards a personalized, predictive and participatory medicine.

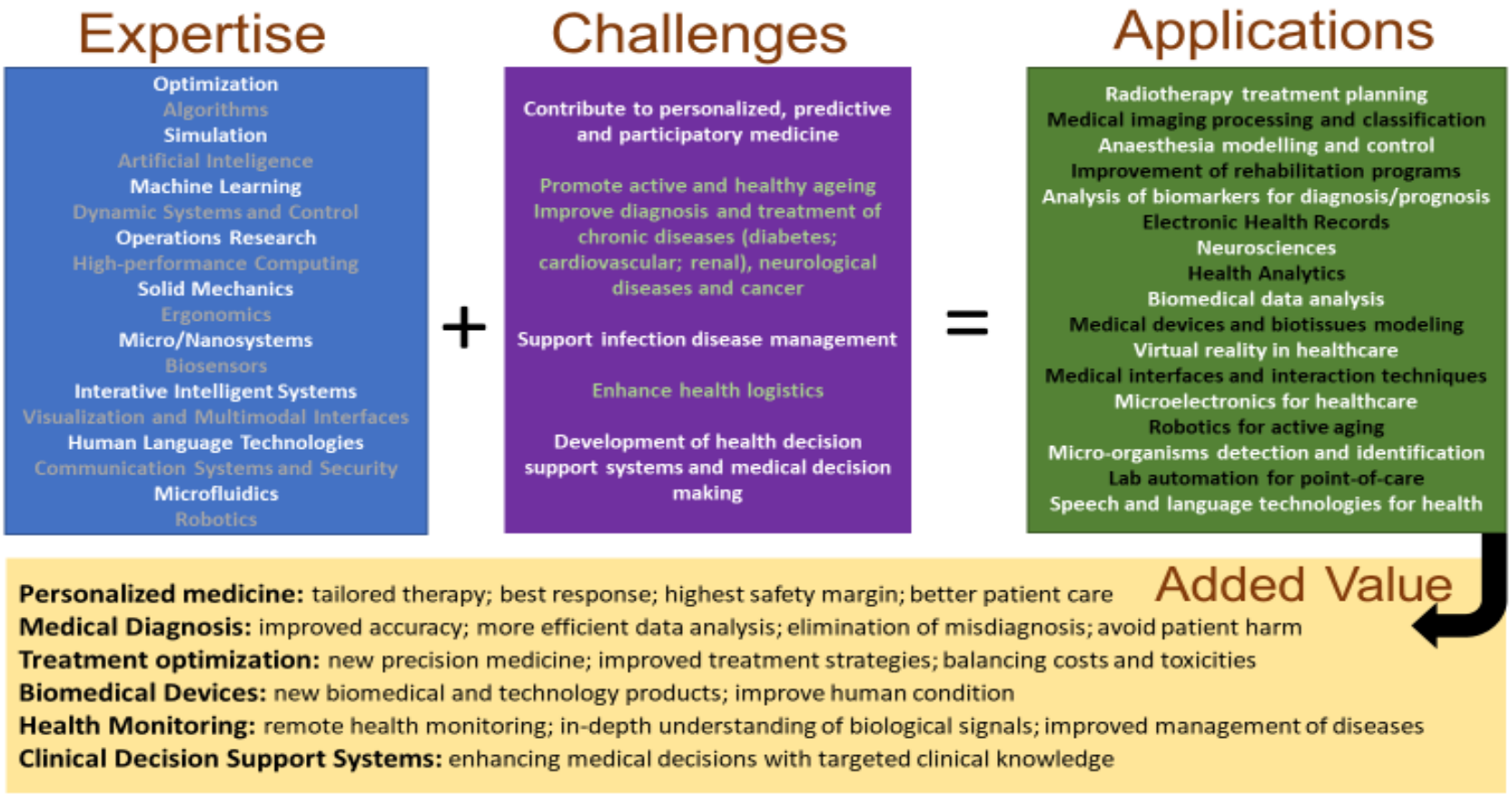


FIGURE 1: HT OVERVIEW OF DOMAINS OF RESEARCH EXPERTISE AND APPLICATIONS AREAS IN THE 5 INESCS

	INESC Coimbra	INESC ID	INESC INOV	INESC MN	INESC TEC
Adapttech, Porto					1
ANOVA-PLUS, France				1	
Biodevices/WeSenss, Porto					1
Biosense Institute, Serbia				1	
CardioID , Lisbon					1
Carnegie Mellon University, USA					1
CCG – Grupo de Computação Gráfica			1		
Centro Hospitalar de Lisboa Central, Serviço de Neurorradiologia, E.P.E.		1			
Champalimaud Foundation, Lisboa		1			1
CiiEM, Centro de Investigação Interdisciplinar Egas Moniz, Monte da Caparica		1			
CINAMIL, Military Academy Research Center, Portuguese Army				1	
Cintesis, Porto					1
Consiglio Nazionale delle Ricerche, Ist. di Tecnologie Biomediche, Segrate, Italy	1				
DPDP - Associação Protectora dos Diabéticos de Portugal			1		
Erasmus MC Cancer Institute, The Netherlands	1				
First Solutions, Porto					1
Fraunhofer AICOS (Porto, RTO, R&D);					1
Glintt, saúde			1		1
HCP - Health Cluster Portugal			1		
HopeCare, SA			1		
Hospital Beatriz Ângelo				1	
Hospital Beatriz Ângelo, Serviço de Ortopedia, Loures		1			
Hospital Prof. Dr. Fernando Fonseca, E.P.E., Amadora;		1			
Hospital Santo António, Porto					1
Hospital São João, Porto					1
I3S, Porto					1
IBB, ULisboa, Portugal				1	
iLof, Porto					1
iMed.Ulisboa, Faculdade Farmácia, Portugal				1	
IMG-Pharma, Spain				1	
IMM – Instituto de Medicina Molecular		1		1	
INL - International Nanomaterial Laboratory, Braga				1	
INSA – Instituto Nacional de Saúde Doutor Ricardo Jorge				1	
Instituto de Telecomunicações, Aveiro					1
Instituto Politénico de Leiria			1		
Instituto Português de Oncologia de Coimbra Francisco Gentil, E.P.E. (IPOCFG, E.P.E.)	1				
International Atomic Energy Agency (IAEA)	1				
IPO, Porto					1
ISPUP, Porto					1
Labiomep, Porto					1
Massachusetts General Hospital	1				
Probranca, serviços sociais na área idoso e crianças			1		
Science for Life Laboratory, KTH, Stockholm, Sweden				1	
Sociedade Portuguesa de Física (SPF)	1				
STABVIDA				1	
Stanford University, Department of Pathology	1				
Technophage, Portugal				1	
The Institute of Cancer Research, London	1				
Universidade Minho, escola de saúde			1		
Universitá degli Studi di Milano Bicocco	1				
University of Cambridge	1				
University of Heidelberg	1				
University of Munich, Germany					1
University of Nottingham	1				
University of Texas MD Anderson Cancer Center	1				
University of Toronto, Canada	1				

TABLE 2: MAIN COLLABORATIONS OF INESC INSTITUTES IN HT

CAPACITY CHARACTERISATION

INESC COIMBRA

INESCC is an interdisciplinary research institute, counting with the collaboration of researchers from different scientific backgrounds. INESCC has scientific capacity in different domains that make the institute capable of pursuing research and achieving advances beyond the state of the art in several challenges related with HT.

INESCC has the only research team in the Iberian Peninsula working, for several years now, in the automation and optimization of radiotherapy treatment planning.

INESCC has the only research team in the Iberian Peninsula working, for several years now, in the automation and optimization of radiotherapy treatment planning. Radiotherapy is the most technologically demanding cancer treatment approach, requiring cutting edge high cost technological equipment and trained personnel. However, nowadays, the treatment planning still relies heavily on manual tasks carried out by human planners. Being able to automate this procedure can have important social, economic and scientific impacts. The associated challenges require the combined work of researchers from computer science, operational research, medical physics, etc. The experience of INESCC can be assessed by the two funded FCT research projects (www.uc.pt/go/bao and www.uc.pt/go/rtcare, the latter still ongoing), and by the vast number of publications in high level quality scientific journals.

INESCC has researchers developing machine learning methods for classification based on medical images (MRI, for instance).

INESCC has researchers developing machine learning methods for classification based on medical images (MRI, for instance). The most recent approaches consider the detection of prostate cancer. Researchers were able to achieve better results than using conventional Deep Learning (Convolution neural networks trained backpropagation).

INESCC has researchers that have been doing research in Ergonomics (example: studying the use of anthropometric and ergonomic evaluation tools for pregnant women).

INESCC has researchers working on Solid Mechanics, namely structural dynamics, multibody dynamics and deployable structures. This scientific field has many applications in medicine and biomedicine. Examples are the modelling of medical prosthesis, bio-tissues, devices for unblocking blood vessels, for instance. Moreover, INESCC participates on a project on active and healthy ageing, funded by Portugal 2020.

INESCC has an internationally recognized expertise in decision support systems, multi-attribute decision making, multi-objective optimization, bi-level programming, location decision, that can be applied to health decision

related problems (medical decision making, health policy, cost-benefit analysis and systems design (health supply chain management, scheduling, layout optimization and so on).

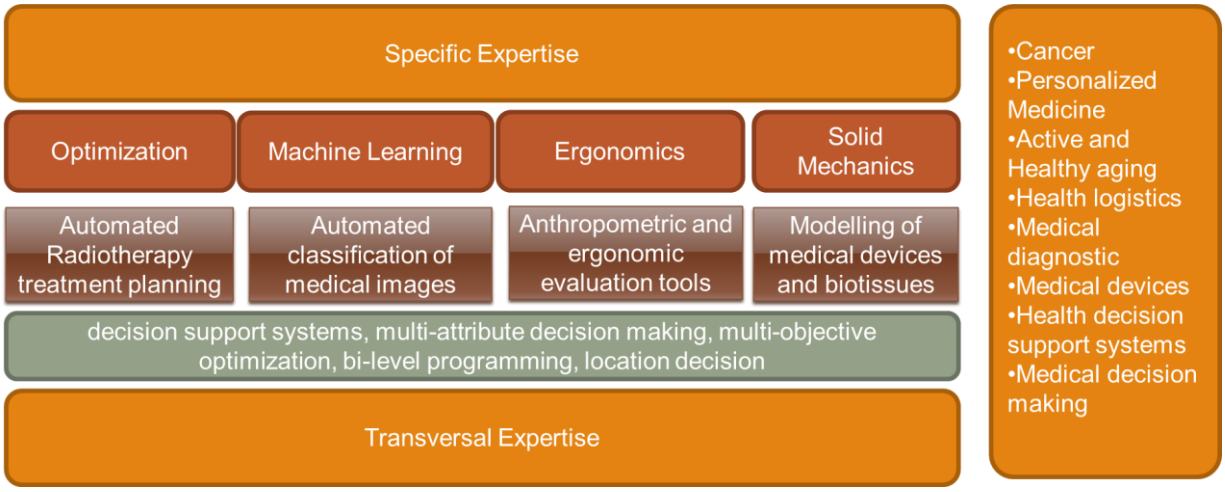


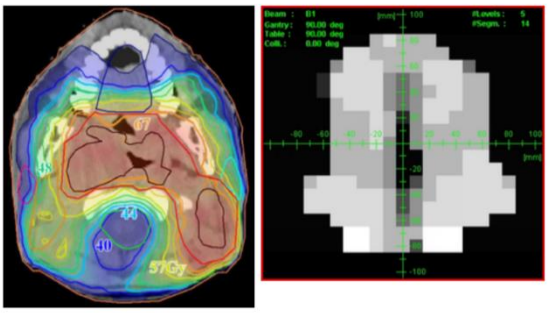
FIGURE 2: VISUAL REPRESENTATION OF INESCC CAPACITY IN HT

MAIN PARTNERS/COLLABORATIONS IN HT

- Instituto Português de Oncologia de Coimbra Francisco Gentil, E.P.E. (IPOCFG, E.P.E.)
- The Institute of Cancer Research, London
- Sociedade Portuguesa de Física (SPF)
- University of Toronto, Canada
- International Atomic Energy Agency (IAEA)
- Massachusetts General Hospital
- Erasmus MC Cancer Institute, The Netherlands
- University of Nottingham
- University of Heidelberg
- University of Cambridge
- University of Texas MD Anderson Cancer Center
- Ist. di Tecnologie Biomediche, Consiglio Nazionale delle Ricerche, Segrate, Italy
- Department of Pathology, Stanford University
- Universitá degli Studi di Milano Bicocco

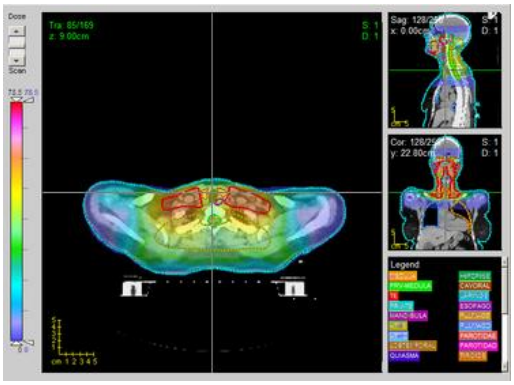
SELECTED PROJECTS IN HT

- Beam Angle Optimisation in Intensity Modulated Radiation Therapy (IMRT), Portuguese Science Foundation, 2012-2015.



In this project we intend to focus our attention in the resolution of the Beam Angle Optimization problem for radiotherapy treatment planning. This problem is important due to two main reasons. First, the choice of adequate directions may be decisive for the quality of the treatment. Second, changing beam directions during treatment is time consuming, and short treatments are desirable because the probability of the patient altering his position on the couch increases with the duration of the treatment. It is a challenging global non-convex optimization problem with many local minima yet to be solved satisfactorily. Not only good quality solutions have to be found, but also they have to be found within a reasonable time window (due to clinical practice requirements). Our objective is to introduce new approaches for the resolution of the BAO problem, using direct search methods and evolutionary algorithms. We also intend to investigate the use of non-coplanar beam directions and to determine the minimum number of incidence directions to be used.

- RT-CARE - Computational Approaches for Radiotherapy Planning of Excellence, Portuguese Science Foundation, 2018-2021[1]



In this project we will address the problem of radiotherapy treatment planning optimization, for Intensity Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT). In clinical practice, most of the time, treatment planning is still a manual, trial-and-error procedure. In this project we will work on computer-aided inverse planning applied to radiation therapy treatments, contributing to the automation of this process. We propose to improve treatment quality and reducing planning time by developing new automated global optimization strategies for IMRT (non-coplanar) and VMAT (coplanar and non-coplanar); to incorporating multiple objectives in the optimization procedures; to create and compare optimized plans for different treatment modalities considering quality assessment metrics and making use of multicriteria analysis methodologies.

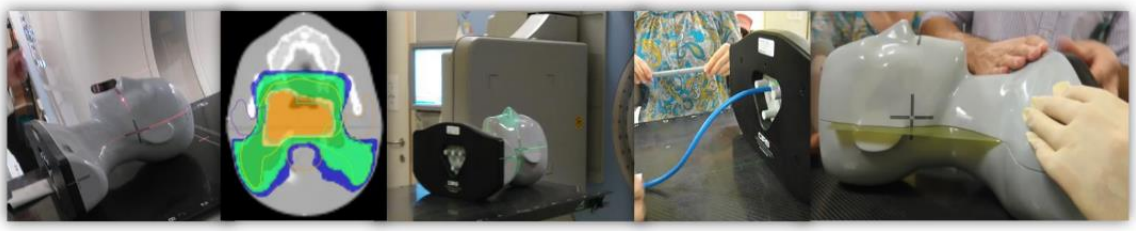
[1] (Image obtained using Software CERR)

Improving Radiotherapy Practices for Advanced Radiotherapy Technologies Including Quality Assurance and Quality Control, IAEA

The objective of this project is to improve the quality of radiation therapy practices for effective treatment of cancer patients through the use of advanced radiotherapy techniques in the region.

- National Project in Dosimetric Auditing in IMRT (2018-2019), IAEA, SPF

To ensure the optimal and safe usage of the complex IMRT procedures, the IAEA has developed an IMRT audit programme to review physical aspects of IMRT treatments through on-site visits. To be as close as possible to a patient treatment, the audit methodology simulates with a specially designed anthropomorphic head and neck (H&N)phantom –the CIRS Shoulder Head and Neck End-to-End(SHANE) –and a set of contours representing target volumes and organs-at-risk(OARs), all steps of an IMRT treatment, in an 'end-to-end' approach. A multicentre pilot study was conducted to test the audit methodology.



- Aga@4Life, Portugal 2020, CENTRO-01-0145-FEDER-023369, 2017-2019

This project aims at valuing the elderly, by promoting health and well-being, independence and autonomy, mobility and the opportunity to be active participants in the community.

SELECTED PAPERS IN HT

- Diaby, V., L. Dias, "Beyond Value Function Methods in MCDA for Health Care", in: K. Marsh, M. Goetghebeur, P. Thokala, R. Baltussen(Eds), "Multi-Criteria Decision Analysis to Support Healthcare Decisions", 299-310, Springer International Publishing, 2017. DOI:10.1007/978-3-319-47540-0_15.
- Beretta, S., Castelli, M., Gonçalves, I., Merelli, I., & Ramazzotti, D. (2017). Combining Bayesian approaches and evolutionary techniques for the inference of breast cancer networks. arXiv preprint arXiv:1703.03041.
- Vanneschi, L., Castelli, M., Gonçalves, I., Manzoni, L., & Silva, S. (2017, June). Geometric semantic genetic programming for biomedical applications: A state of the art upgrade. In 2017 IEEE Congress on Evolutionary Computation (CEC) (pp. 177-184). IEEE.
- Ventura, Tiago, H. Rocha, B. C. Ferreira, L. Khouri, Joana Dias, M. C. Lopes (2019) "Comparison of two beam angular optimization algorithms guided by automated multicriterial IMRT", Physica Medica: European Journal of Medical Physics, vol 64, pp 210-221.
- Almeida, H.A., Ascenso, R.M.T., Oliveira, E. "Anthropometrics and Ergonomics in Pregnant Women". In: Women's Health and Biomechanics. Lecture Notes in Computational Vision and Biomechanics. Brandão S., Da Roza T., Ramos I., Mascarenhas T. (Ed). Vol 29. Springer, Cham (2018). DOI: https://doi.org/10.1007/978-3-319-71574-2_8

INESC ID

INESC ID is an R&D institute dedicated to advanced research and development in the fields of Information Technologies, Electronics, Communications, and Energy.

INESC-ID is a non-profit institution, privately owned by Instituto Superior Técnico (IST) and INESC, officially declared of public interest. It was created in 2000, as a result of a reorganization of its parent institution. Since December 2004, the institution has the status of "*Laboratório Associado*" from the National Science Foundation (FCT).

INESC ID has more than one hundred PhD researchers and two hundred postgraduate students divided between nineteen research groups, organized in five main research lines. Participated in more than 50 research projects funded by the European Union and more than 190 funded by national entities. Until today, our researchers have published more than 700 papers in international journal papers, more than 3000 papers in international conferences, and have registered 15 patents and/or brands.

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INESC-ID is the leader of Biodata.pt, the 12 institutions consortium of the Portuguese node of ELIXIR (in total, ELIXIR counts with 23 Nodes+1 Hub organization, totalling 220 Institutes). BioData.pt supports the national scientific system through best practices in data management and state of the art data analysis. It interfaces with both academia and industry, making research available for innovation, namely in sectors such as agro-food and forestry, sea, and health. BioData.pt services such include a training programme and computing facilities, as well as consulting services in data analysis and management, and a number of community services.

INESC-ID is the leader of Biodata.pt, the 12 institutions consortium of the Portuguese node of ELIXIR

The table below presents a correspondence between the research groups at INESC ID with the respective research expertise areas:

Dept./Group	Area/topics
ES - Sustainable Energy Systems / Control of Dynamical Systems (CSD)	Anaesthesia modeling and control
IDSS - Information and Decision Support Systems	Patient-centered multimorbidity management solution
	Biomedical Informatics; information retrieval
	Artificial intelligence and neurosciences
	Next generation sequencing technologies; networks and algorithms
	Machine Learning and Biostatistics for high-dimensional data
	Biomedical data analysis
	Software tools for Electronical Medical Records
IIS - Interactive Intelligent Systems / Visualization and Intelligent Multimodal Interfaces (VIMMI)	Virtual reality in healthcare; Medical Interfaces and Interaction Techniques
	Context aware digital tech improvement of rehabilitation programs
EES - Embedded Electronic Systems / Algorithms for Optimization and Simulation (ALGOS)	Algorithms for simulation of biological neural networks
NECS - Nano-Electronic Circuits & Systems	Microelectronics for Healthcare
HPCAS - High Performance Computing Architectures & Systems	Embedded systems design and implementation for biomedical applications; next generation sequencing
HLT - Human Language Technologies	Speech and Language Technologies for Health

TABLE 3: INESC ID RESEARCH GROUPS CORRESPONDANCE WITH AREAS OF EXPERTISE IN HT

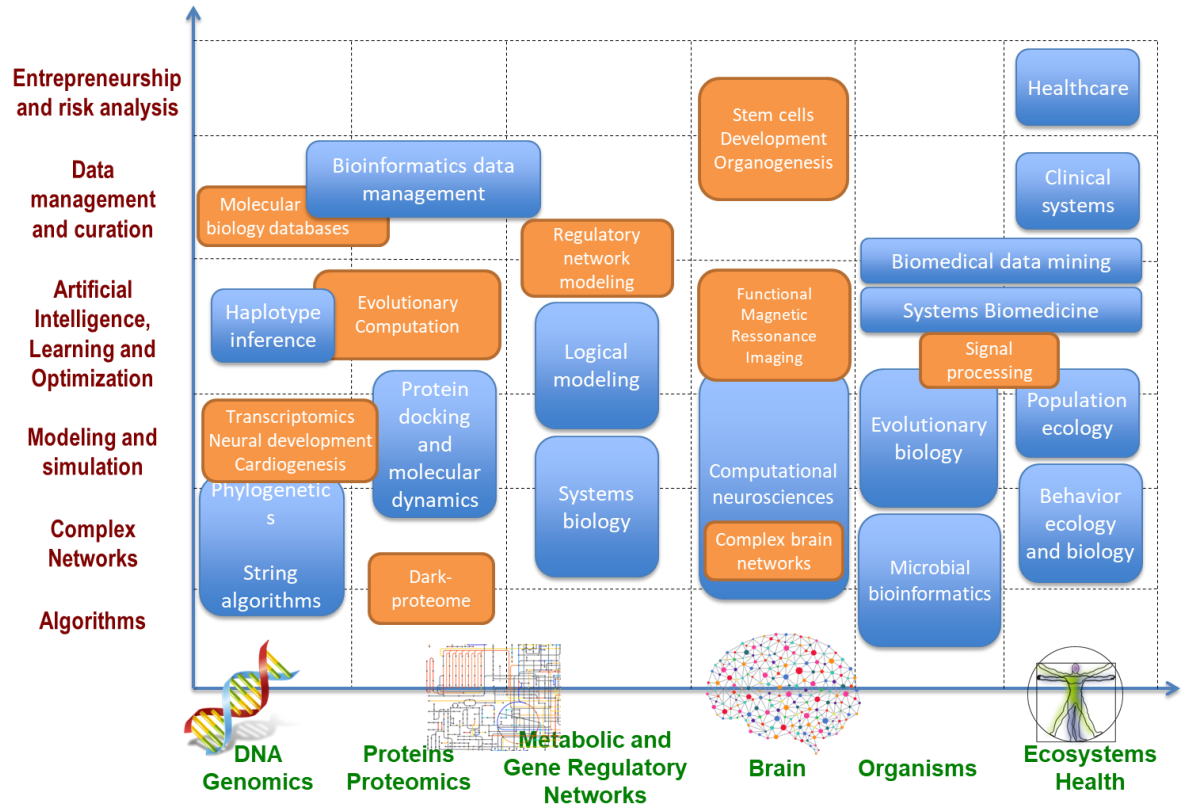

FIGURE 3: VISUAL REPRESENTATION OF INESC ID CAPACITY IN HT

MAIN PARTNERS/COLLABORATIONS IN HT

- IMM – Instituto de Medicina Molecular
- Champalimaud Foundation, Lisboa
- Hospital Prof. Dr. Fernando Fonseca, E.P.E., Amadora;
- CiiEM, Centro de Investigação Interdisciplinar Egas Moniz, Monte da Caparica
- Serviço de Neurorradiologia - Centro Hospitalar de Lisboa Central, E.P.E.
- Serviço de Ortopedia, Hospital Beatriz Ângelo, Loures
- Hospital da Luz
- iBEB
- IPO-Porto
- i3S
- INSA
- IGC
- ITQB
- Hospital de Santa Maria, Lisboa
- Hospital Pedro Hispano, Matosinhos
- Centro Hospitalar do Porto (Hospital Geral de Santo António), Porto

- Faculdade de Ciências da Universidade do Porto
- Karolinska Institute
- Fundación Progreso y Salud
- National Institute for Health Research (King's College London)
- ETH Zurich, Switzerland
- EMBL, Germany
- INRIA, France

SELECTED PROJECTS IN HT

- IntelligentCare Project AAC 04/SI/2019
- Learning Health - Simulation Center
- Nationally with INESC-MN:
  - UNSEEN: UWB Non-Invasive Screening for Breast Cancer LISBOA-01-0145-FEDER-031416
  - MagScopy4IHC: High-resolution Magnetic Scanner for Immunohistochemistry LISBOA-01-0145-FEDER-031200
  - STARCHIP: Smart TubulAR sensing and actuation devices for lab-on-CHIP platforms FP7-AAT-2012-RTD-LO
- Internationally with Philips as coordinator:
  - POSITION II Ecsel-783132-Position-II-2017-Ia
  - Moore4Medical (starts June 1st, 2020)
- OLISSIPO - Fostering Computational Biology Research and Innovation in Lisbon (nr. 951970). Funding EU (Horizon 2020 call WIDESPREAD-05-2020 – Twinning). Starting in Jan 2021.

SELECTED PAPERS IN HT

PHYLOViZ 2.0: providing scalable data integration and visualization for multiple phylogenetic inference methods By: Nascimento, Marta; Sousa, Adriano; Ramirez, Mario; et al. BIOINFORMATICS Volume: 33 Issue: 1 Pages: 128-129 Published: JAN 1 2017 DOI: 10.1093/bioinformatics/btw582

The YEASTRACT database: an upgraded information system for the analysis of gene and genomic transcription regulation in Saccharomyces cerevisiae By: Teixeira, Miguel Cacho; Monteiro, Pedro Tiago; Guerreiro, Joana Fernandes; et al. NUCLEIC ACIDS RESEARCH Volume: 42 Issue: D1 Pages: D161-D166 Published: JAN 2014 DOI: 10.1093/nar/gkt1015

The influence of empathy in human-robot relations By: Leite, Iolanda; Pereira, Andre; Mascarenhas, Samuel; et al. INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES Volume: 71 Issue: 3 Pages: 250-260 Published: MAR 2013 DOI: 10.1016/j.ijhcs.2012.09.005

The ecology of cancer from an evolutionary game theory perspective By: Pacheco, Jorge M.; Santos, Francisco C.; Dingli, David INTERFACE FOCUS Volume: 4 Issue: 4 Special Issue: SI Article Number: 20140019 Published: AUG 6 2014 DOI: 10.1098/rsfs.2014.0019

Tracking intratumoral heterogeneity in glioblastoma via regularized classification of single-cell RNA-Seq data By: Lopes, Marta B.; Vinga, Susana BMC BIOINFORMATICS Volume: 21 Issue: 1 Article Number: 59 Published: FEB 18 2020 DOI: 10.1186/s12859-020-3390-4

INESC INOV INOVAÇÃO

INOV INESC Inovação is a leading private non-profit R&D organization in Portugal. INOV's main purpose is the participation in technological development and innovation processes in close cooperation with governments, enterprises and universities.

INOV has accumulated strong technical expertise in:

- Artificial Intelligence
- Cybersecurity
- Speech Technologies and Systems
- Telecommunication Equipment and Services
- Access Networks, Mobile Communication Systems
- Sensor Networks, Network Architectures and Protocols
- Navigation Systems and Fleet Management
- Remote Monitoring and Surveillance Systems
- Security and Defense Systems
- Control and Electronics Development
- New Technologies for Aeronautics & Aerospace
- Organizational Engineering

INOV has consolidated knowledge and proven installed solutions with clients and partners in Portugal, EUA, Angola, Turkey, Brazil, Greece, Italy, among other countries.

INOV has extensive experience in large National and European R&D projects (FP6, FP7, H2020) with over 70 participations in the last 10 years.

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In the table 4, we present the areas of expertise at INOV and corresponding application areas, with direct relevance for HT.

Area of expertise at INOV	Applications
Sensors and Communication Systems	Low-cost textile sensors for motion detection
	Carpet pressure sensors for patient tracking
	Precision indoor location to predict the spread of infectious diseases
Decision Support Systems for Seniors	Platform for collecting and storing biometric parameters
	Generation of alarms based on rules engines
Cybersecurity applied to health, in particular medical devices	
Artificial Intelligence & Data Analysis	Detection of patterns and anomalies; predictive models; complementary means of diagnosis; text analysis and features extraction, …
	Expertise knowledge on NLP - Natural Language Processing, CV – Computer Vision, Data and Text mining, …
Hyper-spectral analysis	Useful for measure blood glucose levels, identify skin changes, or applied to fungi and bacteria identification
Ultra Wide Band (UWB) used, for instance, for body sensors	

TABLE 4: AREAS OF EXPERTISE AT INOV AND CORRESPONDING APPLICATIONS IN HT

MAIN PARTNERS/COLLABORATIONS IN HT

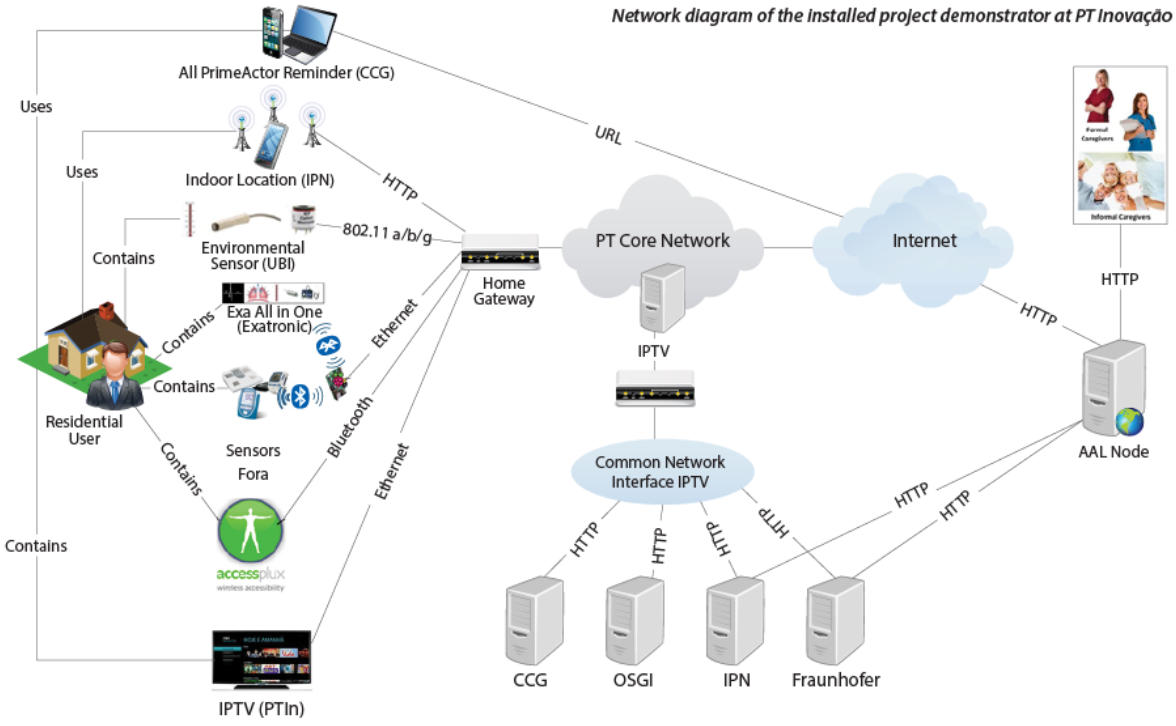
- HopeCare, SA
- HCP - Health Cluster Portugal
- Probranca, serviços sociais na área idoso e crianças
- Politénico de Leiria
- CCG – Grupo de Computação Gráfica
- Glintt, saúde
- Universidade Minho, escola de saúde
- DPDP - Associação Protectora dos Diabéticos de Portugal
- Médico especialista na área de diabetes

SELECTED PROJECTS IN HT

- AAL4ALL - Industrial ecosystem of products and services within Ambient Assisted Living.Ambient Assisted Living (AAL) is a new approach to the challenges related with population aging and has as its main goals applying ambient intelligent technologies in supporting and training people with specific requirements (such as giving to elderly with memory loss products/services that help them reminding events or paths), and in developing safe environments to the maintenance of an independent life, promoting the active aging. http://www.aal4all.org/

AAL4ALL
Ambient Assisted Living for All

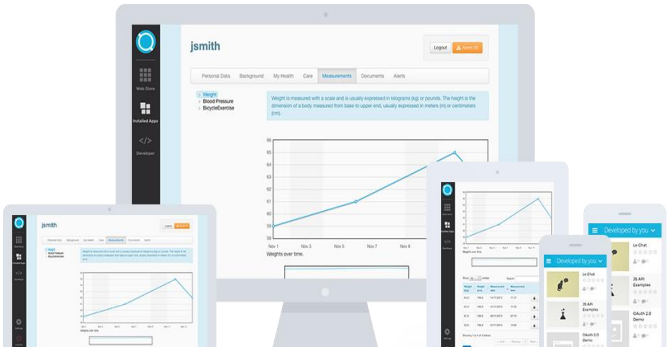
Network diagram of the installed project demonstrator at PT Inovação

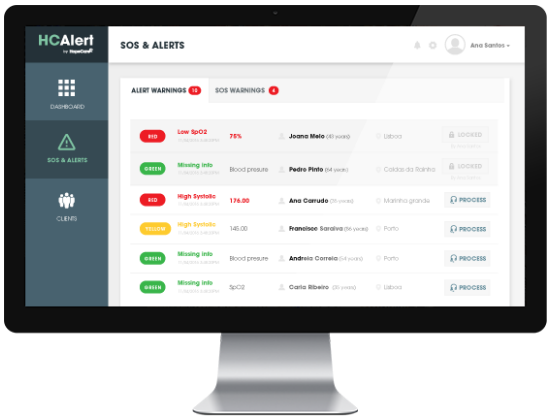


- Active@Work – Virtual Assistant to help workers near retirement age, to continue to perform their daily work or remain active.

The Active@Work project addresses the development and deployment of a web based solution, centred at helping senior workers in their roles within the organisation, providing services to streamline their integration and responsibilities .Advanced wearable multi-sensors will be provided to monitor each individual health status, the project will study how the compliance of monitoring with (advanced) wearable devices can be improved in order to generate value information about the health status of the user in the working environment. To assure that the Active@Work prototype addresses market needs, end-users will be involved since an early stage of the project execution, overcoming some of the limitations of existing market solution. The two pilots to be deployed will cover heterogeneous organisational processes on various working environments (local and mobile). To achieve that, an extensive and diverse range of users will be included in order to approach the solution to the end-users real needs. http://www.activeatwork.eu/

- TICE.Healthy - Healthcare market products and services with internet support. Systems of Health and Quality of Life project seeks to develop, integrate and test innovative technological approaches that will serve as a basis for new products and services for markets linked to the aspect of "Health and Quality of Life." http://tice.healthy.ipn.pt/





- HC Alert - Analytical system applied to health data telemonitoring HCAlert is an analytical system applied to the Telemonitoring of health data, it is based on the cloud service and receives health data and emergency alarms from different providers. This creates alerts to the user, in the HCAlert, in order to draw attention to the critical situations according to the health program and/or rules previously defined in the system. https://hope-care.pt/en/hc-alert/

SELECTED PAPERS IN HT

- Helgheim, B. I., Maia, R., Ferreira, J. C. & Martins, A. L. (2019). Merging data diversity of clinical medical records to improve effectiveness. International Journal of Environmental Research and Public Health. 16 . DOI: 10.3390/ijerph16050769
- Gonçalves, F & Pereira, R & Ferreira, João & Vasconcelos, J.B. & Melo, F & Velez, I. (2018). Emergency waiting times data analysis. IAENG International Journal of Computer Science. 45. 494-499. DOI: 10.1007/978-3-030-01746-0_16
- Lamy, M & Pereira, R & Ferreira, João & Melo, F & Velez, I. (2018). Extracting clinical knowledge from electronic medical records. IAENG International Journal of Computer Science. 45. 488-493. DOI: 10.1007/978-3-030-01746-0_13
- Gonçalves, Filipe & Pereira, Ruben & Ferreira, João & Braga Vasconcelos, José & Melo, Fernando & Velez, Iria. (2019). Predictive Analysis in Healthcare: Emergency Wait Time Prediction. 10.1007/978-3-030-01746-0_16. DOI: 10.1007/978-3-030-01746-0_16
- Rala Cordeiro, João; Postolache, Octavian. & Ferreira, João, “Child’s Target Height Prediction Evolution”, Applied Sciences Journal. 2019, 9, 5447. DOI 10.3390/app9245447

INESC MN

INESC Microsistemas e Nanotecnologias is a private, non-profit Research and Development Institute created in January 2002 from the former Solid-State Technology group of INESC, operating a 250 m^2 cleanroom (class 100 and class 10 areas) and adjoining 250 m^2 grey area (nominally class 10,000).

INESC MN is dedicated to leading edge research and development in strategic technological areas of micro- and nanotechnologies, whose core research activities are in the areas of nanoelectronics, magnetic thin films and nanostructures, thin film MEMS biochips/biosensors and biomedical devices.

The group's mission is to provide advanced training in micro and nanofabrication, nanotechnologies and nanoelectronics courses (Master level) with 100 students/year. Over the past five years, INESC MN researchers have published an average of 35 research articles/year on multidisciplinary journals, ranging from applied physics to nanomedicine. INESC MN has an extensive involvement in projects at both National and European level and maintains a solid relationship with international companies and research institutions, in a wide geographic area (Portugal, Europe, Asia, Australia, Africa, US).

For the last 7 years, INESC-MN had running about 35 projects in total including European and National, from which about half (16 projects) were in the Health Tech area.

At the national level, INESC MN is member of the INTERFACE (Portuguese Technological Interface Centers) and the National Roadmap for the research infrastructures MicroNanoFabs@PT. Finally, INESC MN, is an active member of various international networks including the SpinTronicFactory, KET tools and the European Technology Platform of Nanomedicine.

There are 5 research groups at INESC-MN:

- Spintronics and Magnetic Biosensors;
- Thin Film MEMS and BioMEMs
- Simulation of Materials
- Wide Bandgap Semiconductors
- Bioanalytical Engineering Group - BIONEER

INESC-MN team is composed by 8 Principal investigators, 8 senior researchers, about 40 students of PhD and MSc level, 5 process engineers and 2 administrative assistants.

In the table 5 we present the research areas of expertise of INESC MN in HT and the corresponding application areas.

Research areas of expertise	Application areas
Spintronics and Magnetic Biosensors Group	Magnetoresistive sensors and applications: Integrated MR sensors within silicon needle probes with local electrical sensing ability for the detection of magnetic fields generated by neurons. Tactile sensors for robotics - extremely sensitive and fast magnetoresistive sensors to detect the magnetic field generated by elastic polymers with embedded magnetic materials with application in soft tissues and organs handling, and social care activities.
	Biological and biomedical platforms: Portable electronic reader for bioanalysis, compatible with sensor arrays to multiplexable detection of biomarkers. Microcytometer with integrated magnetic sensors to count magnetically labelled entities flowing inside microfluidic channels above the sensors.
Thin Film MEMS and BioMEMs Group	Label-free detection of biomolecules in microfluidic systems using on-chip UV and Impedimetric Sensors.
	Capillary-driven microfluidic device with integrated nanoporous microbeads for ultra rapid biosensing assays.
	High-throughput nanoliter-scale analysis and optimization of multimodal chromatography for the capture of monoclonal antibodies.
	The application of microbeads to microfluidic systems for enhanced detection and purification of biomolecules.
	A novel microfluidic cell co-culture platform for the study of the molecular mechanisms of Parkinson's disease.
Bioanalytical Engineering Group – BIONEER	Multiplexed detection of pathogenic bacteria research

	Engineering of novel affinity ligands
	Detection of viral infections in dual-assays

TABLE 5: RESEARCH AREAS OF EXPERTISE AT INESC MN AND CORRESPONDING AREAS OF APPLICATION

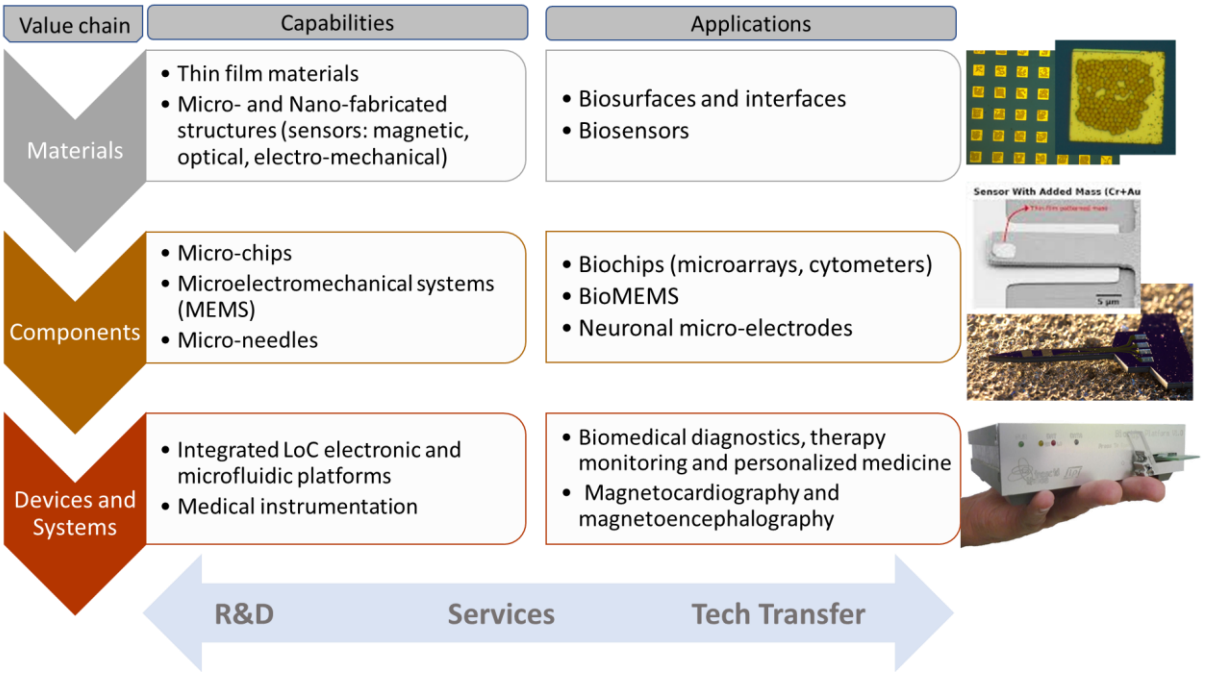


FIGURE 4: VISUAL REPRESENTATION OF INESC MN CAPACITY IN HT

SELECTED PROJECTS IN HT

MAGNAMED - Novel magnetic nanostructures for medical applications MSCA-RISE

(Lab-On-Chip-Magnetic platform/HealthTech) 2017-2021

MAGNAMED designs, fabricates, and assesses novel magnetic nanostructures (MNS) with unique spin configurations for innovative diagnostics and therapy techniques. MNS (e.g. nanodisks) present a planar shape with novel properties for diagnosis and for therapy. The efficiency of MNS in these two medical applications has not been investigated yet for MNS at the nanometer scale. The challenge of this project is to produce MNS with nanometer dimensions suitable for medical applications. MAGNAMED is a cross-sectoral and interdisciplinary project involving Physics, Chemistry and Medicine. Findings will have a medium-term impact on the European strategy for early stage detection of cancer and a long-term impact on the development of novel and ground-breaking therapeutics techniques.

(https://cordis.europa.eu/project/id/734801)

IPANEMA- Integration of PAper-based Nucleic acid testing mEthods into Microfluidic devices for improved biosensing Applications MSCA-RISE

(Lab-On-Chip-Magnetic platform/Agri-food/Healthtech) 2020-2023

IPANEMA has formed a large network of multidisciplinary expertise to rapidly realise the potential of paper-based microfluidic platforms. With partners in Europe, the US, and third countries that includes SMEs and academics, IPANEMA is working on several different technologies that can be integrated with smart phones for sophisticated yet cost-effective and easy-to-use POC diagnostics.

(https://cordis.europa.eu/project/id/872662)

Moore4Medical- Towards open technology platforms for medical devices ECSEL-2019-IA

(Integration of magnetic sensors in microfluidics for Organ-on-Chip devices /HealthTech) 2020-2023

Accelerating Innovation in Microfabricated Medical Devices. It is the overarching objective of Moore4Medical to accelerate innovation in electronic medical devices. The project addresses emerging medical applications and technologies that offer significant new opportunities for the Electronic Components and Systems industry including: bioelectronic medicines, organ-on-chip, drug adherence monitoring, smart ultrasound, radiation free interventions and continuous monitoring. Moore4Medical will bring together 59 specialists from 12 countries who will develop open technology platforms for these emerging fields to help them bridge “the Valley of Death” in shorter time and at lower cost.

(https://www.ehu.eus/es/web/europeanprojects/-/project_moore4medical_ecsel)

MagScopy - Imagiologia magnética de ultra-alta resolução para detecção imuno-histoquímica (Magnetic sensors/HealthTech) 2018-2021

The technology behind MagScopy for Health takes advantage of the consolidated experience of INESC MN on the fabrication of MR sensors for biomedical applications and aims to develop a magnetic camera for a 3D imaging of biological tissues specifically labelled with magnetic nanoparticles for the identification of disease states.

Phage4bacID- Bacteriophages for the diagnosis of multi-resistant bacteria in Portugal and the in the world (Lab-on-chip-magnetic/HealthTech) 2018-2020

Phage4BacID aims to revolutionize the diagnosis and treatment of infections caused by multiresistant bacteria of high risk for the Portuguese and World population, thus reducing the number of hospital infections. The project joins the knowledge of three internationally renowned entities - Technophage, INESC MN and IST.

SELECTED PAPERS IN HT

1. Soares, R. R. G. et al. Silica bead-based microfluidic device with integrated photodiodes for the rapid capture and detection of rolling circle amplification products in the femtomolar range. Biosens. Bioelectron. 128, 68–75 (2019). (https://doi.org/10.1016/j.bios.2018.12.004)
2. Soares, R. et al. Go with the flow: advances and trends in magnetic flow cytometry. Anal. Bioanal. Chem. 411, 1839–1862 (2019). (https://doi.org/10.1007/s00216-019-01593-9)
3. S.A.M.Martins, V.C.Martins, F.Cardoso, J.Germano, M.Rodrigues, C.Duarte, R.Bexiga, S.Cardoso, P.P.Freitas, "Biosensors for on-farm diagnosis of mastitis", Front. Bioeng. Biotechnol. Vol 7, 186 (2019). https://doi.org/10.3389/fbioe.2019.00186
4. Romao, V. C. et al. Lab-on-Chip Devices: Gaining Ground Losing Size. ACS Nano 11, 10659–10664 (2017). (https://doi.org/10.1021/acsnano.7b06703)
5. Cardoso, S. et al. Challenges and trends in magnetic sensor integration with microfluidics for biomedical applications. J. Phys. D. Appl. Phys. 50, 213001 (2017). (https://iopscience.iop.org/article/10.1088/1361-6463/aa66ec)

ACTIVE PATENTS RELEVANT FOR HT

- (PCT/IB2013/000397) - Monolithic device combining cmos with magnetoresistive sensors (2013-04-01) (https://patents.google.com/patent/WO2013102850A1/fr?oq=PCT%2fIB2013%2f000397)
- (PCT/IB2005/052702) - A bio-electronic device (https://patents.google.com/patent/EP1781820A1/en)
- (US14/405,659) - Autonomous and programmable sequential flow of solutions in capillary microfluidics (https://patents.google.com/patent/US9931630B2/en?oq=US14%2f405%2c659)

MAIN PARTNERS/COLLABORATIONS IN HT

- Hospital Beatriz Ângelo – project Phage4BacID, clinical samples of bacterial infections
- INSA – Instituto Nacional de Saúde Doutor Ricardo Jorge, Centro de Estudos de Vetores e Doenças Infeciosas (CEVDI) Doutor Francisco Cambournac, Águas de Moura, Portugal
- Technophage, Portugal, project Phage4BacID
- STABVIDA, Portugal, service contract
- IMG-Pharma, Spain, project MAGNAMED
- ANOVA-PLUS, France, project IPANEMA
- Science for Life Laboratory, KTH, Stockholm, Sweden
- Biosense Institute, Serbia, project IPANEMA
- iMed.Ulisboa, Faculdade Farmácia, Portugal, project POINT4PAC
- IST- IBB, ULisboa, Portugal, project Phage4BacID
- IMM – Instituto de Medicina Molecular, Lisboa, Portugal
- INESC ID, Lisboa, Portugal
- I3S – Univ. Porto, Portugal, project MiNerv
- Universidade da Beira Interior (CICS), project Biodevices
- LAIST (Laboratório de Análises, Instituto Superior Técnico), Lisboa, Portugal
- CINAMIL (Centro de Investigação da Academia Militar), Lisboa, Portugal

INESC TEC

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

The University of Porto, INESC, the Polytechnic Institute of Porto, the University of Minho and the University of Trás-os-Montes e Alto Douro are INESC TEC's associates. Presently, INESC TEC's main sites are located in the cities of Porto, Braga and Vila Real. By the end of September 2019, INESC TEC's 13 R&D Centres hosted 720 integrated researchers (329 PhDs), including R&D employees, academic staff, grant holders and affiliated researchers. INESC TEC's team also includes trainees and technical and administrative support staff.

INESC TEC's vision is to be a relevant international player in Science and Technology in the domains of Computer Science, Industrial and Systems Engineering, Networked Intelligent Systems, and Power and Energy.

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

INESC TEC leverages the knowledge and results generated as part of its research, in technology transfer projects, seeking impact both through value creation and social relevance.

The dual mission of INESC TEC is to excel in research, seeking social relevance and international influence, and to foster pervasive intelligence, contributing to the competitiveness and internationalisation of Portuguese companies and institutions.

The merit of INESC TEC in the accomplishment of its dual mission has been formally acknowledged by the Foundation for Science and Technology, with the institute's recognition as Associate Laboratory, and the Portuguese Ministry of Economy, with its recognition as Technology Interface Centre.

TEC4HEALTH

The TEC4 initiatives articulate INESC TEC's activity towards the market, defining market strategies and planning the interaction with the main market application areas. A TEC4 initiative establishes a network of external contacts and dialogue with industrial partners and brings back major challenges and the identification of opportunities.

The Mission of TEC4HEALTH is to contribute to the improvement of the health of all individuals in the future by researching and developing technology. For accomplishing this, TEC4HEALTH aims to explore the activities within the health sector where technology needs and roadmaps indicate a high potential for applying INESC TEC's skills and research lines, resulting into successful projects, contracts and technology transfers.

INESC TEC already has several examples of research, development and technology transfer of HT, in clinically relevant areas such as cancer, neuroscience or disease screening systems. TEC4HEALTH aims to:

- Create internal and external visibility of the profile and activities of INESC TEC in the area of HT.
- Promote the growth of the area of HT within INESC TEC, namely research, services and technology transfer activities.

INESC TEC aims to position itself as a disruptive research and development partner of HT, in which the excellence of its fundamental research associated with the intense collaboration with clinical partners creates new opportunities for products and services for companies operating in the health sector market.

TEC4HEALTH aims to address all the value chain actors and processes in the health sector, and is currently very committed to bringing unique knowledge and technologies to solve challenges in mainly cancer, neurological diseases and disease screening.

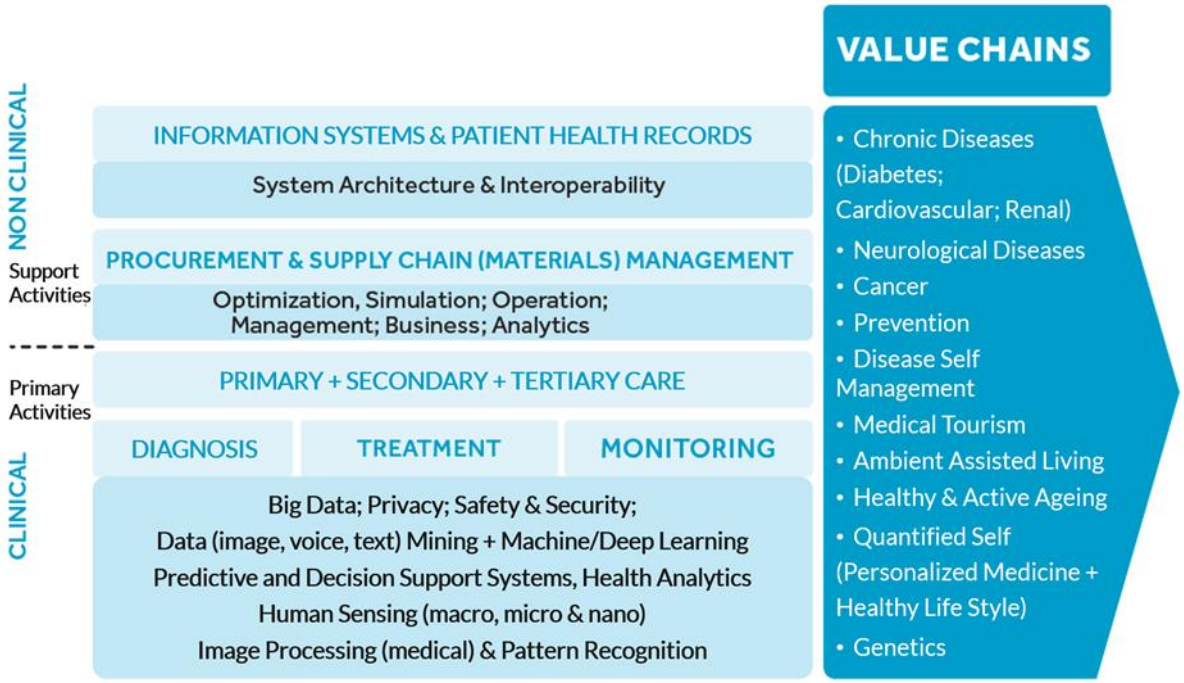


FIGURE 5: AREAS OF EXPERTISE AT INESC TEC AND CORRESPONDING APPLICATION AREAS (IN MARKET CONTEXT)

INESC TEC already produces relevant research and development for some of these value chains, with a stronger emphasis on three: cancer (lung, breast, colorectal, stomach, esophagus, thyroid, cervix uteri), neurological diseases (epilepsy, Parkinson, Alzheimer) and disease screening (retinal disease, heart disease). The later involves a variety of different diseases such as retinopathy or cardiovascular, but is unified by the concept of technologies for mass cost-effective screening the global population. All three are strongly aligned with current health challenges identified in the strategic agendas of H2020, WHO and FCT.

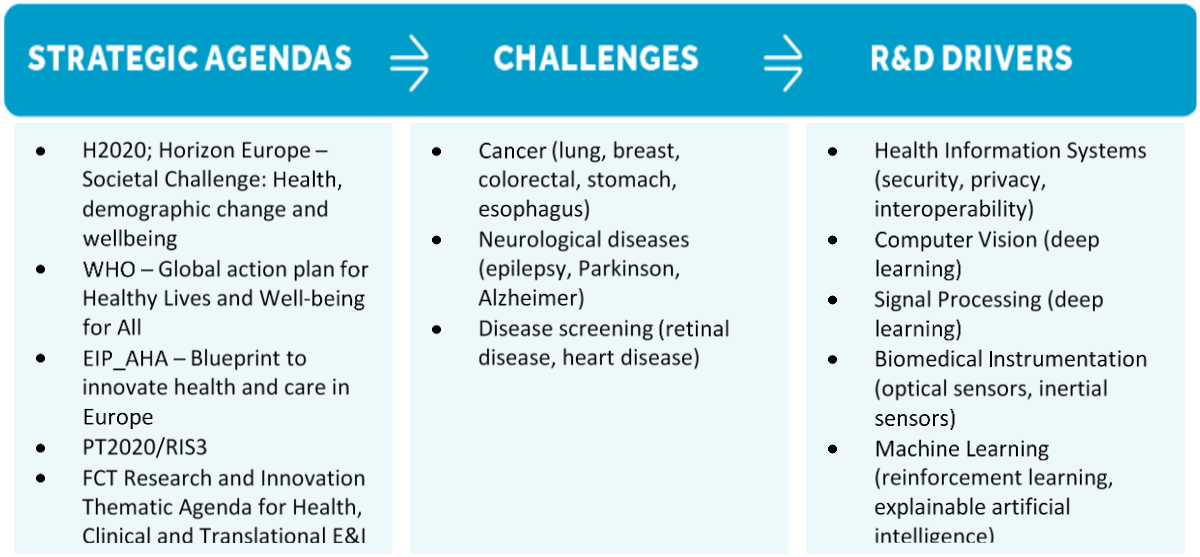


FIGURE 6: STRATEGIC OVERVIEW OF R&I PROCESS AT INESC TEC IN THE HT AREA

A stronger external image of INESC TEC as a highly competent innovator in the area of HT is needed in order to fully explore the potential of providing these services. Four core competences have already been identified, which will form more solid structured offers in the future:

- Artificial intelligence for healthcare studies
- Artificial intelligence for computer-aided screening and diagnosis
- Information systems for healthcare
- Novel sensor-based devices for healthcare

SELECTED PROJECTS IN HT

- SCREEN-DR

The North of Portugal Health Administration is implementing a mass screening for diabetic retinopathy (DR). The goal is to perform an eye exam on about 75% of identified diabetics. The goal of the SCREEN-DR consortium is to create a distributed and automatic screening platform for DR, based on PACS management, Machine Learning and Image Analysis, enabling an immediate response from health careers, allowing accurate follow-up strategies, and fostering technological innovation. The main objectives are: automatically assessing image quality, automatically detecting and grading diabetic retinopathy, which can be mild non-proliferative, moderate/severe non-proliferative and proliferative.

- EUCAN-CONECT

EUCAN-Connect aims to promote collaborative and multidisciplinary research in high-value cohort and molecular data on a large scale in order to improve statistical power with the aims of making new discoveries about the factors that impact human life course and facilitating their translation into personalized diagnostics, treatment and prevention policies.

- RECAP

The overall aim of the RECAP preterm Project is to improve the health, development and quality of life of these children and adults by developing the RECAP preterm Cohort Platform, a sustainable, geographically diverse and multidisciplinary database of national and European cohorts of babies born very preterm or with very low birth weight (VPT/ VLBW cohorts). This network contains cohorts constituted over a 30 year time span and is designed to optimize the use of population data for research and innovation in healthcare, social and education policy. This will be complemented by the development of novel methodologies and tools for data management and analysis to strengthen research on current and future VPT/VLBW cohorts.

- LUCAS

Lung cancer screening - A non-invasive methodology for early diagnosis. Through non-clinical data (age, smoker, emphysema and features of CT), the idea is to predict the presence of the gene mutated for lung cancer through artificial intelligence and image analysis methods.

- Mine4Health

Due to the existence of many clinical records in free text, an application is being built with a series of text mining techniques so that the information can be displayed in an attractive and useful way and be used for clinical decision making.

Check more at: https://www.inesctec.pt/pt/inovacao/tec4health#projects

SELECTED PAPERS IN HT

- Paiva, J. S., Jorge, P. A., Ribeiro, R. S., Balmaña, M., Campos, D., Mereiter, S., ... & Cunha, J. P. (2020). i LoF: An intelligent Lab on Fiber Approach for Human Cancer Single-Cell Type Identification. *Scientific reports*, *10*(1), 1-16.;
- Costa, P., Galdran, A., Meyer, M. I., Niemeijer, M., Abràmoff, M., Mendonça, A. M., & Campilho, A. (2017). End-to-end adversarial retinal image synthesis. *IEEE transactions on medical imaging*, *37*(3), 781-791.;
- Pinheiro, G., Pereira, T., Dias, C., Freitas, C., Hespanhol, V., Costa, J. L., ... & Oliveira, H. P. (2020). Identifying relationships between imaging phenotypes and lung cancer-related mutation status: EGFR and KRAS. Scientific reports, 10(1), 1-9.
- Lopes, M. A., Almeida, Á. S., & Almada-Lobo, B. (2015). Handling healthcare workforce planning with care: where do we stand?. Human resources for health, 13(1), 38.
- Renna, F., Oliveira, J., & Coimbra, M. T. (2019). Deep convolutional neural networks for heart sound segmentation. IEEE journal of biomedical and health informatics, 23(6), 2435-2445.

ACTIVE PATENTS RELEVANT FOR HT

- Accurate-BV
- iHandU
- Vital-Sticker
- BB-Spectral
- NeuroKinect

Check more at: https://www.inesctec.pt/en/technologies

MAIN PARTNERS/COLLABORATIONS IN HT

- Fraunhofer AICOS (Porto, RTO, R&D);
- I3S (Porto, RTO, R&D);
- Hospital São João (Porto, Hospital, R&D + Sub-contracts);
- IPO (Porto, Hospital, R&D + Sub-contracts);
- Hospital Santo António (Porto, Hospital, R&D + Sub-contracts);
- Champalimaud (Lisbon, RTO, R&D);
- CMU (USA, Univ, R&D);
- University of Munich (Munich - Germany, Univ, R&D);
- Glintt (Lisbon, Company, R&D + Sub-contracts);
- IT (Portugal, RTO, R&D);
- Labiomep (Porto, RTO, R&D);
- Cintesis (Porto, RTO, R&D);
- ISPUP (Porto, RTO, R&D);
- First Solutions (Porto, Company, R&D);
- CardioID (Lisbon, Company, , R&D);
- Adapttech (Porto, Company, R&D);
- Biodevices/WeSenss (Porto, Company, R&D);
- iLof (Porto, Company, R&D).

CAPACITY MATCHING WITH EUROPEAN PROGRAMMES AND FUNDS

OVERVIEW

The mapping and positioning of INESC in relation to European Commission guidelines is achieved through the matching of INESC expertise and application areas with key policy objectives and impacts of the different programs on Health, namely Mission Cancer, Partnership on Health INNOVATION and Transforming Health and Care Systems, Cluster Health and Digital Europe, among others.

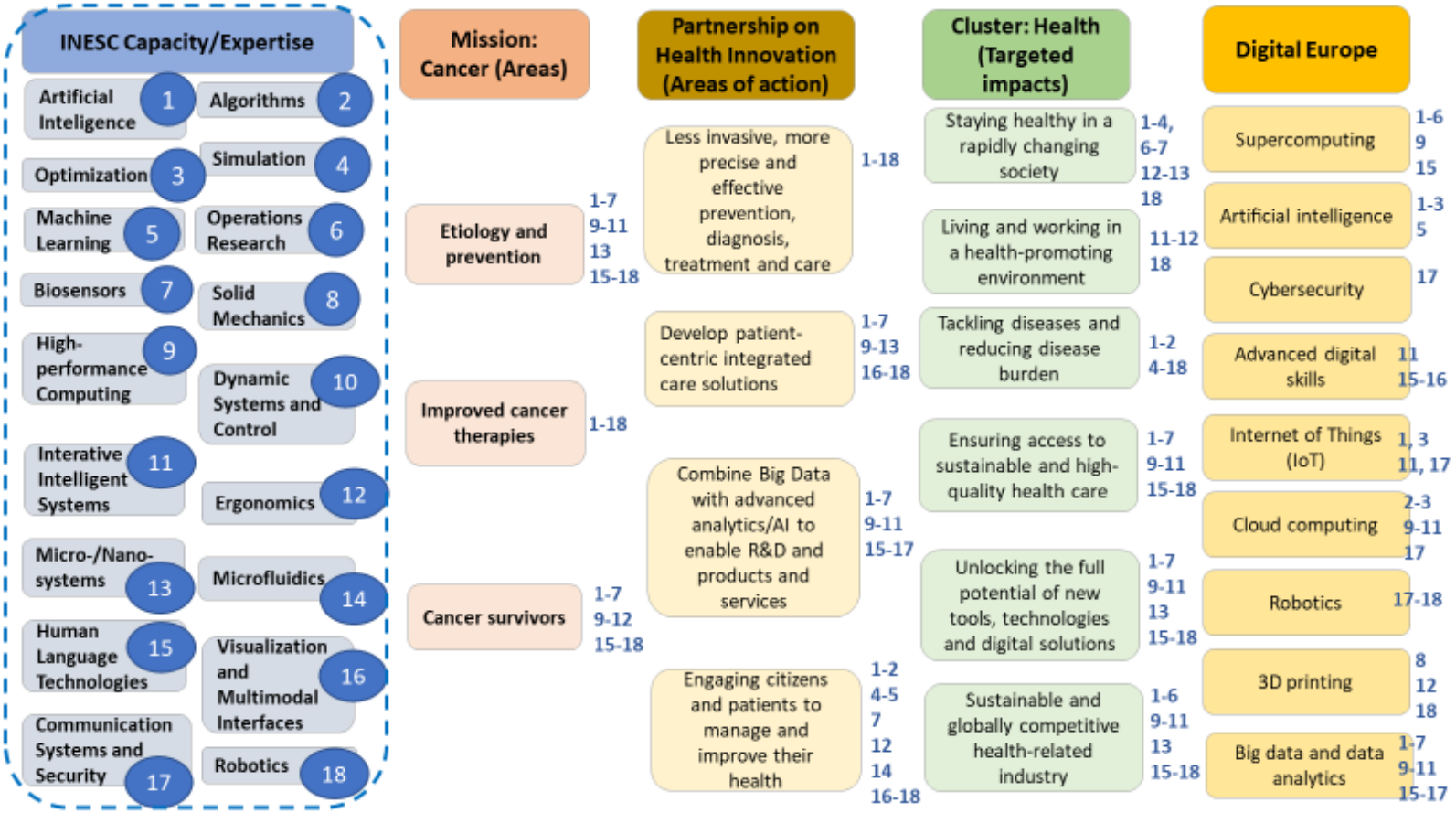
Figure 7 represents that matching capacity making the correspondence of each expertise with the objectives, areas of action and targeted impacts drafted and defined for the next European programmes. As unveiled by the number of correspondences it is clear the strong matching of most of the R&D areas gathered at INESC with the presented guidelines. In fact, one could argue that a strong multidisciplinary approach could almost link all expertise to tall priorities and rend these type of exercises obsolete or too general.

The three major areas referred by the Mission Cancer include the following several specific topics, such as, “Addressing inequities (gender and childhood cancer)”, “Assess data considering privacy issues” and “Precision medicine”, which practically fully matches with INESC’s expertise subjects. The same considerable level of correspondence applies to the other highlighted programmes.

The Partnership on Health INNOVATION is represented on the diagram (Figure 7) but it is also worth to mention the existence of other relevant health partnerships namely the Transforming Health and Care Systems, which aims to tackle:

- Gaps in health and care systems in Europe;
- Need for identification of existing, development, validation of new organizational, technical and digital innovations.
- Development and implementation of evidence-based results and innovations.
- Knowledge and research on factors are lacking that contribute to the successful transfer, implementation and scale up of innovative health services and policies in different settings.
- Insufficient research results on innovation’s effectiveness and efficiency that could be able to be used across European countries.

These challenges are again easily in line with many of the capacities presented by INESC. Also, Digital Health major focus are directly matching with many of the subjects investigated at INESC, namely Supercomputing, Artificial Intelligence, Internet of Things, Robotics, Big Data and data Analytics.



Based on the information already known for the non-bottom up parts of the framework programme for Horizon Europe and Digital Europe, we have developed a series of matching diagrams between the R&I expertise existing at INESC in health technologies and the specific R&I goals and areas of Cluster 1 (Health), Mission Cancer, Partnerships and Research Infrastructures.

FIGURE 7: MATCHING CAPACITY/EXPERTISE AT INESC WITH HORIZON EUROPE AND DIGITAL EUROPE

There are two main macro-policy priorities and objectives informing most of the strategic planning taking place at the moment, which will be the basis for the Horizon Europe and Digital Europe work programmes being developed. These are the Green Deal and the Europe fit for the Digital Age priorities. The two are heavily intertwined. In fact, the main tenet of the digital policy package is "to make this transformation work for people and businesses, while helping to achieve its target of a climate-neutral Europe by 2050.". The priority "An economy that works for the people" also has clear direct impacts in the Horizon Europe agenda-setting. We developed short sub-chapters that summarise the relation between policy priorities and the definition of goals, impacts and eventually calls and topics of the next framework programme for research and innovation.

GREEN DEAL

The European Green Deal provides a roadmap with actions to boost the efficient use of resources by moving to a clean, circular economy and restore biodiversity and cut pollution.

It outlines investments needed and financing tools available, and explains how to ensure a just and inclusive transition. The EU aims to be climate neutral in 2050. To do this, the EC proposed a European Climate Law. Reaching this target, according to the EC, will require action by all sectors of our economy, including:

- investing in environmentally-friendly technologies;
- supporting industry to innovate;
- rolling out cleaner, cheaper and healthier forms of private and public transport;
- decarbonising the energy sector;
- ensuring buildings are more energy efficient;
- working with international partners to improve global environmental standards;

HEALTH IN THE GREEN DEAL

Health, in general, is widely referenced in the European Green Deal legal text. In fact, it is very clear in saying that "all EU actions and policies will have to contribute to the European Green Deal objectives". Namely, it states among its overall goals to "protect the health and well-being of citizens from environment-related risks". Generally, the Green Deal refers to health in the context of other priorities, such as:

- the need of promoting sustainable use of resources and improving human health;

- healthier and cleaner mobility alternatives;

- a fair, healthier and environmentally-friendly food system, namely, affordable healthy food for all and healthy and sustainable diets;

- the impact of forested areas and deforestation on health as well as the same for clean/unclean oceans;

- air quality, toxicity and use of chemicals in industry.

Europe fit for the Digital Age

This priority includes three main policy areas:

- Excellence and Trust in Artificial Intelligence
- European Data Strategy
- European Industrial Strategy

These are transversal areas and all are relevant to health in general and health is relevant to all of these areas in many ways. A more details overview of this linkage should be explored in the intersection between the work developed by the WG HT and other HUB Work Groups.

Investment in research and innovation regarding health (Cluster 1) will support the following targeted impacts:

- Unlocking the full ***potential of new tools, technologies and digital solutions for a healthy society: new tools, technologies and digital solutions*** provide significant gains in health outcomes, address unmet medical needs and inform regulatory standards and requirements; (also contributing to an economy that works for the people);
- A sustainable and globally competitive health-related industry in the EU: health industries, including SMEs, increase their productivity and sustainability in developing relevant health innovation due to the potential of data-enabled research and development, the related convergence of pharmaceutical, digital and medical technologies, and the prospect of the digital transformation of health and care supported by data-driven manufacturing of tailor-made products and the delivery of personalised services.

OTHER EUROPEAN COMMISSION POLICY PRIORITIES

The European Commission policy priorities are 6 in total. Besides the European Green Deal, which should be seen as the core priority of the von der Leyen Commission, towards which all others converge, there is the Europe Fit for the Digital Age, which is particularly relevant for INESC, as it addresses technological development that is at the heart of INESC's R&I activity, as well as:

- An economy that works for the people - Investments in research and innovation, in particular concerning health (Cluster 1) will target and contribute to the following impacts:
    - Healthy citizens in a rapidly changing society: citizens stay healthier throughout the life course due to improved health promotion and disease prevention, and supported by healthier behaviours and lifestyles;
    - Effective health services to tackle diseases and reduce the burden of diseases: patients can rely on effective health services to tackle their diseases, as well as to reduce the burden of diseases on them, their families and communities;
    - Improved access to innovative, sustainable and high-quality health care: health systems are able to provide timely access to affordable health care services of high-quality to everybody while being environmentally and fiscally sustainable.

And three others that are important in specific but more indirect ways, such as reinforcing our position internationally (outside Europe – related to the goal "A stronger Europe in the world").

- Promoting our European way of life
- A stronger Europe in the world
- A new push for European democracy

Figure 8 clearly demonstrates the relative importance of each of the European Commission policy priorities and how they will be translated into budgetary choices, and ultimately, into calls and topics.

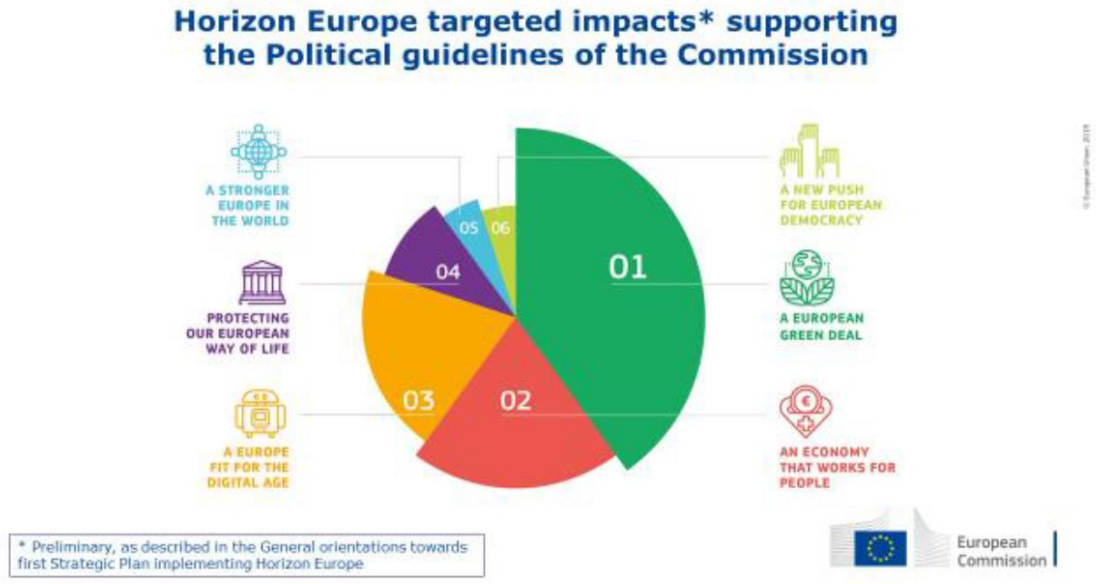


FIGURE 8: RELATIVE WEIGHT OF EC POLICY PRIORITIES AND HOW THEY TRANSLATE INTO THE HE BUDGET, CALLS AND TOPICS

CROSSCUTTING ISSUES AND IMPACT

As always there are a number of crosscutting issues that remain important and, in fact, are emphasised, in particular, in direct relation to impact assessment of the effectiveness of the policies and the project outcomes. It is important to remember at all times that all projects in Horizon Europe will be assessed against impact achieved (or potential impact, in case of a proposal).

Impact here should be understood much more broadly than scientific impact *per se*. Impact should always be read as the capacity of the project to contribute to the goals stated in the policy that justifies the creation of the specific call you are answering too and, in ultimately, to the specific goals and impacts listed in the topic text. The highest percentage of which will not be scientific. Research and technology development are means to a higher end and not an end in itself. That is how policy makers justify investment of public money in research.

The orientations document from December 2019 refers to the following cross-cutting issues:

- The ***inclusion of gender perspectives*** will enable better quality and higher societal relevance of research and innovation activities.
- ***Interdisciplinarity and inclusion of Social Sciences and Humanities (SSH) aspects*** is a prerequisite for addressing a number of societal challenges, which are cross-cutting by nature and should be actively implemented throughout the whole research programme.
- The mainstreaming of ***open science*** across activities will increase efficiency, quality, reliability and creativity of research and innovation, enhance transparency and relevance and enable dissemination of results.
- Dissemination and exploitation of results will be supported through ***targeted support actions to reach relevant stakeholders.***
- ***Circulation of knowledge between research, industry, education and training***, and the balance between research and innovation, is ensured throughout the design of Horizon Europe activities.
- Key enabling technologies will be supported to enhance Europe's competitiveness in ***strategic value chains***.

Along the time, the HUB (through its thematic and transversal workgroups) will work on each of these specific issues and attempt to contribute to a better understanding of each of them.

HORIZON EUROPE

STRATEGIC PLAN FOR HORIZON EUROPE

The European Commission is preparing a strategic plan for Horizon Europe, where it will present in detail what are the Key Strategic Orientations (KSOs) that will underpin the definition of calls, topics and their specific goals. The Strategic Plan focus in particular on Pillar II of Horizon Europe "Global Challenges and European Industrial Competitiveness" (see Figure 4, below), and seek to establish relation with other parts of the framework programme. The Strategic Plan will contain a description of impacts to be targeted from 2030 onwards, although in some cases, they might be achieved earlier, cross-cluster issues and intervention areas covered. It will also identify missions and European Partnerships. Overall, the Strategic Plan will describe, within the frame of the legal base, major policy drivers, strategic policy priorities, and the targeted impacts to be supported through Horizon Europe from 2021 to 2024.

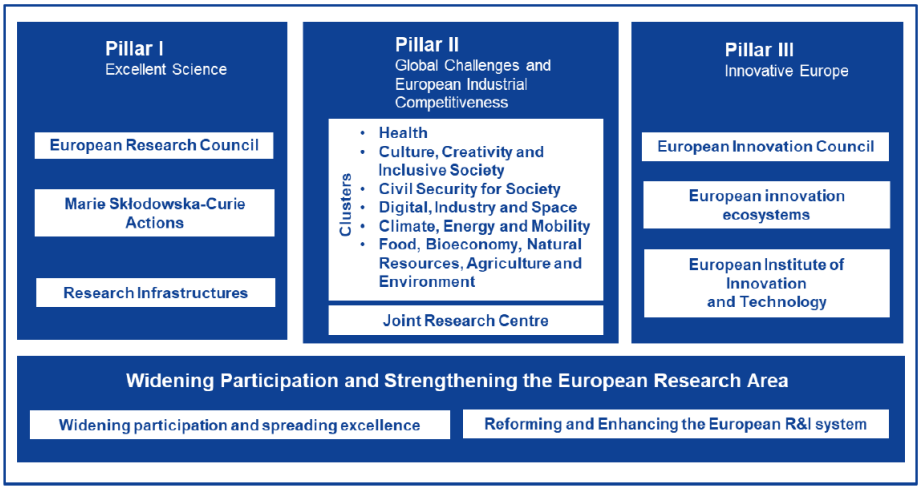


FIGURE 9: PRELIMINARY HORIZON EUROPE STRUCTURE (AS PRESENT IN THE ORIENTATIONS DOCUMENT FOR THE HE STRATEGIC PLAN, DATED DECEMBER 2019)

It is important to note that ***Horizon Europe specific objectives highlight the need to strengthen the impact of research and innovation in developing, supporting and implementing Union policies and addressing global challenges, with a particular emphasis on climate change and the Sustainable Development Goals. It is particularly important to keep this in mind when writing your project application.***

FIGURE 10: THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

As noted in the Orientations towards a Strategic Plan for Horizon Europe, "a main objective of Horizon Europe, and in particular its second Pillar is to generate knowledge, strengthen the impact of research and innovation in developing, supporting and implementing Union policies and support the access to and uptake of innovative solutions in European industry, notably in SMEs, and society to address global challenges, including climate change and the Sustainable Development Goals.". Moreover, ***Horizon Europe as all other framework programmes before, but now with an increased focus and clarity, is a policy support instrument, supporting the six priorities of the European Commission***, which were already listed above.

MISSIONS

What are the Missions included in Horizon Europe? Crazy bold ideas, inspired in the moonshot concept. In the words of Ursula von der Leyen, President of the EC, it's Europe's man on the moon shot (curing cancer, cleaning oceans, etc): "Partly inspired by the Apollo 11 mission to put a man on the moon, the European research and innovation missions aim to deliver solutions to some of the greatest challenges facing our world.". There are 5 different areas for missions, and very importantly the only topic explicitly associated with healthcare is **Cancer**. These areas are:

- cancer
- adaptation to climate change including societal transformation
- healthy oceans, seas coastal and inland waters
- climate-neutral and smart cities
- soil health and food

A set of various specific Missions are planned, which will fall into one of these 5 areas. The details of these missions are proposed and monitored by a mission board (15 experts from various areas) and an assembly (enlarged group for ideas and consulting) as well as a broad public engagement consultation.

MISSION: CANCER – BOARD AND ASSEMBLY

The Chair of the Board is Walter Ricciardi, Professor of Hygiene and Public Health at the Università Cattolica del Sacro Cuore in Rome.

There is one portuguese representative in the Cancer Mission Board:

- Prof. Pedro Pita Barros, from Univ. Nova de Lisboa, from the School of Economics: https://novaresearch.unl.pt/en/persons/pedro-p-barros

The Assembly includes two Portuguese members:

- Prof. Fatima Carneiro Medical Faculty of the University of Porto, https://noticias.up.pt/fatima-carneiro-eleita-a-patologista-mais-influente-do-mundo/
- Prof. Maria Ceu Machado Faculty of Medicine, Universidade de Lisboa, Lisbon, https://www.dn.pt/vida-e-futuro/a-ultima-licao-de-maria-do-ceu-machado-para-ser-chefe-a-mulher-tem-de-se-portar-como-uma-mulher-10975474.html

Looking at the profile of the chosen board members and mission assembly members, it is possible to conclude that most of them are medical doctors. There is not a significant presence of researchers/practitioners for more technological, engineering or ICT fields. Importance was given to the participation of patients' associations and public/economic health.

SUGGESTED ACTION:

- Meet with the three Portuguese members for advice and opinions and presentation of the INESC capacity and potential contributions.

MISSION: CANCER – AREAS ALREADY DEFINED BY THE MISSION BOARD

The Cancer Mission Board has produced a draft mission outline, which proposes one Mission: "Conquering cancer: Mission Possible – 3 million lives saved by 2030". The goal and the vision of the Mission on Cancer align with the UN Sustainable Development Goal (SDG) 3: Ensure healthy lives and promote well-being for all at all ages. The target of this SDG for non-communicable diseases is "to reduce premature mortality by one third, by 2030, through prevention and treatment and promote mental health and well-being.". As such, the ultimate goal of the Mission on Cancer has been formulated, in close collaboration with European experts, Member States and stakeholders, as "by 2030, 3 million lives saved, living longer and better".

For the time being, the proposed Mission on Cancer proposes 12 recommendations and addresses four major themes: Understanding, Prevention, Treatment and Survivorship. Across these, the Board identified five transversal areas of action (digital transformation; capacity and skills; European and international cooperation; cross-sector synergies; public engagement). Details of areas on the four themes addressed by the mission:

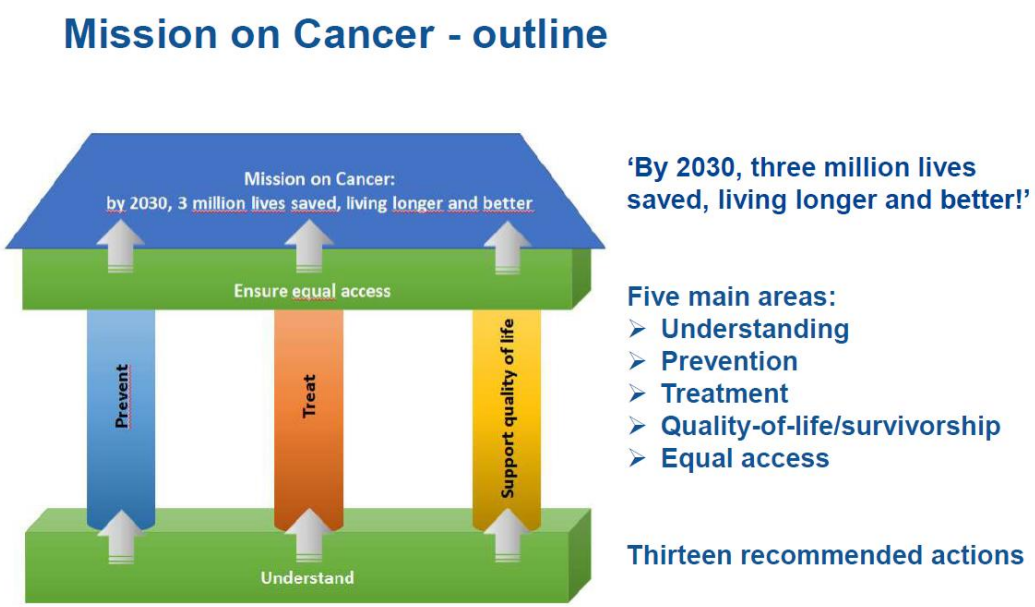


FIGURE 11: MISSION CANCER OVERVIEW

Below is a list of the known major themes and specific actions proposed per theme:

- Etiology and prevention:
  - Addressing inequities (gender and childhood cancer)
  - Cost-effectiveness evaluation of prevention measures
  - Comprehensive cancer centers, bio banks, data mining
  - Basic research dedicated to etiology

- Assess big data, small data, personalized data considering privacy issues
- Evaluation of different interventions

- Improved cancer therapies
  - Streamline the process of development, avoiding the duplication of efforts, sharing knowledge across Europe
  - Fighting inequalities within European countries, guaranteeing access to both innovative and standard treatments. Pediatric tumors and rare cancers should be considered. Comprehensive cancer centers working in a network (through an accreditation process).
  - Creating friendly ecosystems for innovation.
  - Trying to take the most of available data.
  - Multidisciplinary teams for treatment care (funding, treatment practice, legal issues, databases).
  - Precision medicine: the right treatment for the right patient at the right time.
- Cancer survivors
  - Research on quality of life (mental health, rights, stigma, impact on the family). Looking specially to children that survive cancer.
  - Health literacy.
  - Data collection from the survivors, to understand how the different treatments worked and to understand what is important for survivors (including palliative care).

The most recent version (May 2020) of the Mission Cancer High-Level Group report, sets ***out concrete recommendations with impact on the proposals to be expected in the first work programmes***:

> ***Create an EU platform for large-scale studies to understand tumours with an emphasis on poorly understood cancer, and use the platform to conduct large-scale studies***

Objectives:

- Connect current data silos to benchmark on-going EU projects, data repositories of established academic networks and highly profiled research institutions including contributions from industry, on the beneficial utilization of up-to-date interdisciplinary technologies
- Develop a "convergence science" dedicated to cancer research that integrates engineering, physics, chemistry, mathematics in search of completely novel insights into difficult to treat cancers

Type of action: support action (resources, infrastructure, collaboration), research & innovation action

Promote a large-scale research programme to identify genetic and polygenetic cancer risk factors

Objectives:

- To set up a large-scale population-screening programme to generate polygenic risk scores (PRS) providing information on cancer risk before the disease symptoms emerge.

Type of action:

- research & innovation action, policy action

Create an EU platform for studies and actions to support, monitor and evaluate EU policy and legislation on implementation of cancer prevention

Objectives:

- To be a source of knowledge to EU institutions and Member States. The platform will benchmark and advise on future cancer risk agents/behaviours.

Type of action:

- Support action (resources, infrastructure, collaboration), policy action

Facilitate optimisation of existing screening programmes and the development of new non-invasive and minimally invasive methods for screening and early detection

Objectives:

- To establish a EU platform that will facilitate the optimization of existing screening programmes and the development of new methods for screening/early detection taking into account the limitations of the current screening tests/programmes and reports (Cancon Joint Action) suggesting that additional cancers would benefit from early detection approaches.

Type of action:

- Support action (resources, infrastructure, collaboration), policy action, research & innovation action

Develop a coordinated European research programme on cancer-personalised medicine for optimized treatment in cancer patients

Objectives:

- Greater involvement of all stakeholders, including patients themselves and, when possible, the pharmaceutical industry
- Greater harmonization of national legislation and research programmes
- Up-front assessment of cost-effectiveness of treatments, based on data from the real-world setting
- Innovative research on personalised medicine

Type of action:

- Research & innovation action

Promote a research programme to advance knowledge on the quality of life of cancer patients, survivors and carers

Objectives:

- Improve the quality of life of cancer patients by providing high-quality follow-up care and/or palliative care
- Improve the quality of life of cancer survivors and carers by providing high-quality survivorship and carer support (aimed to strengthen their income and social participation)

Type of action:

- research & innovation action, support action (resources, infrastructure, collaboration)

Ensure equal access to cancer research, prevention, treatment and survivorship support in all EU Member States

Objectives:

- Ensuring that each EU citizen has the right to access quality cancer care (what is the measurable target: what should be achieved?)

Type of action:

- Policy, research and innovation, support action (resources, infrastructure, collaboration)

Support the creation of at least one accredited national comprehensive cancer infrastructure in all EU Member States to enable the delivery of the Mission's actions

Objectives:

- Achieving accreditation of at least one national comprehensive Cancer Infrastructure in all EU Member States to enable the delivery of the Mission Cancer's actions for cancer research, translation of innovation, optimized care for all patients and training for all care professionals, patient advocates and researchers across EU and to create a strong network of these Infrastructures on an EU-wide basis.

Type of action:

- Policy action, support action (resources, infrastructure, collaboration)

Ensure actions to understand, diagnose, treat and care for children, adolescents and young adults with and after (childhood) cancer

Objectives:

- To support actions to explicitly address challenges raised from childhood cancer (what is the measurable target: what should be achieved?)

Type of action:

- Research & innovation action, policy action, support action (resources, infrastructure, collaboration)

Support a European Cancer Patient Digital Centre

Objectives:

- Provide a pan-European centre of knowledge on cancer, cancer prevention, diagnosis, treatment and supportive care, including pain relief and psycho-social support.

Type of action:

- Support action (resources, infrastructure, collaboration), policy action

Continue innovation and implementation of new technologies in order to conquer cancer

Objectives:

- To establish an EU-level framework and a cross-sector research, innovation and knowledge-sharing platform to enable through supporting the creation, including through building understanding, of efficient and effective collaborative approaches to drive innovation, job creation and industrial competitiveness in healthcare and health-related industries as to fulfil Cancer Mission vision to conquer cancer.

Type of action:Policy action, support action (resources, infrastructure, collaboration)

MISSION: CANCER - INITIATIVES SO FAR

The Mission Board has so far met nine times to prepare a discussion paper, which is being expanded into a mission outline, divide tasks, discuss communication and citizen engagement strategies, interact with DGs on cancer policy activities, include foresight in its deliberations and engage with the Assembly. The next (virtual) Board meeting is planned for 29-30 June. A fruitful joint meeting with the Assembly on 14 February followed by a 2nd virtual consultation at the end of March, resulted in a revised discussion paper. The Board also met three times with the Member States subgroup. Moreover, Commissioners Gabriel (RTD) and Kyriakides (SANTE) met with the Chair and vice-Chair of the Mission Board, Walter Ricciardi and Christine Chomienne, on 12 December 2019. Finally, a first hearing at the European Parliament (ITRE Committee) on the Mission on Cancer took place on 23 January and the Board met with the co-Chair of the MEPs Against Cancer (MAC) group on 21 April.

Spain, Portugal and Austria hosted stakeholder events to present the Cancer Mission. An online citizen/stakeholder engagement event also took place between 4-23 February in Helsinki, with the participation of Mission Board member Prof. Tomi Mäkelä, a colleague from the RTD Cancer team and with a video message from Commissioner Gabriel. Planned for 31 March, but postponed due to SARS-COV-2, an interactive stakeholder/citizen engagement meeting was supposed to involve the Cancer Mission Board, Member States subgroup representatives and three national stakeholders from each Member State, chosen to represent wider health professions, patient/consumer organisations and youth. Due to the evolving situation with COVID-19, only two online citizen engagement events will be organised until May.

List of events that are being prepared: https://ec.europa.eu/info/files/horizon-europe-missions-related-events_en

POTENTIAL SYNERGIES WITH OTHER MISSIONS

Synergies will be established with the Mission on Soil Health and Food (prevention - e.g. exposure to nitrates, pesticides, endocrine disruptors), Climate Neutral and Smart Cities (prevention – e.g. air pollution, radon and asbestos; urban planning promoting physical activity, addressing socio-economic inequalities).

WHAT CAN INESC DO ABOUT MISSION CANCER?

- Besides engaging with Portuguese members of the HLG, build network and visibility about capacity through events and other meetings and communication tools.
- Monitor all other events.
- Meet with EC officials responsible for the development and implementation of Cancer Mission.

CLUSTERS

The Cluster 1 (Health), in Pillar 2 of Horizon Europe structure, is the one specifically and exclusively dedicated to health-related research and innovation. Below we provide what we believe is the most relevant information for all researchers to be informed about what is the genesis of Cluster 1 and what is the context of calls and topic texts that will be developed in the work programmes of Horizon Europe in this area. We also provide a guide for reading diverse work programmes across clusters, but mapping the potential synergies across clusters and in this way supporting a broader identification of potential topics to participate.

According to the orientations document from December 2019:

*Cluster 1, '**Health**', aims to promote and protect human health and well-being, prevent diseases and decrease the burden of diseases and disabilities on people and communities, support the transformation of health care systems in their efforts towards fair access to innovative, sustainable and high-quality health care for everyone, and foster an innovative, sustainable and globally competitive European health industry. Research and innovation actions under this cluster will be key to address the health-related challenges and drivers delivering new knowledge and capabilities, improving our understanding of health and diseases, developing innovative methodological and technological solutions to better manage health and diseases, and designing sustainable approaches for the digital transformation and delivery of integrated, person-centred and equitable health and care services with improved accessibility and health outcomes supported by needs-driven innovation and reliable supply chains in Europe.*

In a recent Strategic Programme Committee meeting (may 2020), the expected impacts for the Cluster Health were redefined in relation to the orientations document (December 2019), as detailed in Figure 7.

FIGURE 12: PRELIMINARY EXPECTED IMPACT STATEMENTS PER CLUSTER (AS OF MAY 2020 - STRATEGIC PROGRAMME COMMITTEE MEETING)

Health technologies are transversal to all targeted impacts, but there is one in particular (impact 3) that makes direct reference to health technologies. Even though it has been rewritten from *Unlocking the full potential of new tools, technologies and digital solutions for a healthy society*, its substance remains focused on supporting the integration and deployment of innovation in health care systems with the following specific impacts expected to be already "topic" ideas for the first work programes of Horizon Europe:

- Europe's scientific and technological expertise and know-how, its capabilities for innovation in new tools, technologies and digital solutions, and its ability to take-up, scale-up and integrate innovation in health and care is world-class.
- Researchers, innovators and health care providers use health data and Artificial Intelligence (AI) supported decision-making in a secure and ethical manner, respecting individual integrity and underpinned with public acceptance and trust.
- Better informed policies and tailored legal, regulatory and ethical frameworks for the development of innovative health technologies, and better understanding of the societal impacts and acceptance of innovative health technologies and the digital transformation of health and care.
- Citizens benefit from targeted and faster research resulting in safer, more efficient, cost-effective and affordable tools, technologies and digital solutions for improved (personalised) disease prevention, diagnosis, treatment and monitoring for better patient outcome and well-being, in particular through increasingly shared health resources (interoperable data, infrastructure, expertise, citizen/patient driven co-creation).
- Citizens trust and support the opportunities offered by innovation for health and care, are involved in their design and take part in informed decision-making, based on expected health outcomes and potential risks involved.

KEY RESEARCH AND INNOVATION ORIENTATIONS

Each cluster is supposed to achieve its targeted impacts (mentioned above) following some strategic orientations that will also influence the design of the calls and topics. In particular, in Cluster 1 – Health, synergies between the topics and other parts of the programme and other initiatives will be sought (***which reinforces the need to look cross-cutting at Horizon Europe and reinforce INESC's position in some of these initiatives to be able to be in the winning consortia more often***). Synergies will be sought with:

- EURATOM Research and Training Programme: innovation on medical applications of ionising radiation, including improvements in the quality and safety of such applications.
- Pan-European Research Infrastructures, namely those established within ESFRI and as ERICs[2] (see section below).
- European Partnerships (see section below).

[2] Such as : European Life-Science Infrastructure for Biological Information (ELIXIR) https://elixir-europe.org/, European Clinical Research Infrastructure Network (ECRIN) https://www.ecrin.org/; European infrastructure for translational medicine (EATRIS) https://eatris.eu/; Survey of Health, Ageing and Retirement in Europe (SHARE) http://www.share-project.org/; European research infrastructure for biobanking (BBMRI) http://www.bbmri-eric.eu/; European Social Survey (ESS) http://www.europeansocialsurvey.org/.

- International cooperation (with third countries when needing to tap into world-leading knowledge not available in the EU or in face of the need to tackle global challenges, such as Public Health Emergencies of International Concern i.e. COVID19).
- The answer to SDGs and particularly SDG 3: Healthy lives and well-being for all.

There are a number of other orientations detailed in the December 2019 document, that are directly relevant to health technologies and that will also inform directly the development of the concrete calls and topics:

- Development of digital tools applications and other solutions, including social innovation, fostering health literacy and empowering citizens to better manage their own health and well-being throughout their life course and to protect them from health threats, including for countering health-related misinformation, manipulation and fraudulent sales of substandard, falsified or inappropriate medicines and illicit drugs.
- Collection, combination and analysis of environmental, occupational and human health-related data, taking advantage of the exposome approach.
- Better understanding of diseases, their drivers and consequences, including pain and the causative links between health determinants and diseases.
- Better methodologies and diagnostics that allow timely and accurate diagnosis, identification of personalised treatment options and assessment of health outcomes, including for patients with a rare disease.
- Development and validation of effective intervention for better surveillance, prevention, detection, treatment and crisis management of infectious disease threats.
- Innovative health technologies developed and tested in clinical practice, including personalised medicine approaches and use of digital tools to optimise clinical workflows.
- Innovative solutions to support modernisation of health care systems (e.g. organisational models; innovative health service delivery models; integrated care models; long-term care; digitalised services; personalised approaches; financing models, including financing of health care systems; remuneration models; incentive mechanisms; new payment/ reimbursement models of health technologies; accelerated access models in case of health emergencies; human resources planning, education and training, incl. on digital skills and health data management).
- Methods, tools and demonstrated pilots for uptake and scale-up of innovation in health systems (e.g. technological and organisational innovation), as well as for their transferability/adaptation from one country/region to another.
- Simulation models to support policy-making, taking into account the complexity and specificities of health care systems and the need to protect access and pursue long-term fiscal sustainability.
- Innovative solutions to support people-centred health and care throughout the life course, and to improve citizen empowerment, access of citizens to their own health data, health literacy, self-care, informal care, and community care.
- Successful models, strategies and solutions increasing patient safety by preventing and reducing risks for patients during the delivery of health care services.
- Framework for better interoperability between data sources and infrastructures, for sharing, access, use and analysis of real-world data that will in turn improve the efficiency of health care systems by strengthening their governance, informing policy development and decision-making, facilitating monitoring and evaluation of health interventions with due attention to security, data protection, privacy, interoperability, standards, comparability and integrity.

- Innovative full health technology assessment methods (i.e. including all relevant aspects such as clinical effectiveness, cost-effectiveness, ethics, organisational aspects, etc.) to support better allocation of resources, including reinvestment from low to high value care for patients.
- Methods to assess performance and efficiency of healthcare organisations and health care systems based on outcomes that matter for patients and carers, aiming at reducing health inequality and allowing for international comparability.
- Identification of factors accounting for health care systems resilience in absorbing the impact of crises, such as the expected dementia raise, and accommodating disruptive innovation.
- New tools and technologies for biomedical research, prevention, diagnosis and therapy of diseases and tools for monitoring diseases as well as treatment progression are designed, developed, tested or validated for the benefit of patients and the health and care systems. These solutions can include a variety of technologies and approaches such as nano medicines, advanced therapies, biomaterials, medical devices, hybrid technologies, digital solutions, Artificial Intelligence applications, robotics, -omics and other data-driven interventions and procedures.
- Health data accessibility and interoperability across the EU, including the free flow and secure exchange of health data, leaning on existing research infrastructures as well as the creation of a European Health Data Space to promote health-data exchange and support research.
- Improved risk-benefit ratio of the developed innovative tools, technologies and approaches owing to powerful digital solutions using and processing big data for better detection, diagnosis and monitoring of disease, including real-world data, for efficient value assessment.
- Efficient up-scaling and production systems, including bioprinting, additive manufacturing and other advanced manufacturing techniques, enabling targeted and personalized health interventions.
- Improved health technologies and interventions based on digital solutions, which support timely health information and secure use of health data.
- New data-driven approaches, computer models and -simulations and other digital solutions are developed, translated and optimised for the prevention, health care and person-centred care, including smart data infrastructures and AI-based data analytics.
- Efficient innovation management strategies, including intellectual property, to translate breakthrough technologies into health care applications.
- Efficient collaboration with regulatory authorities and health care providers for an optimal time to patient access.
- Novel methodologies and metrics adapted to new tools, technologies, digital solutions and interventions for their assessment, validation and translation into health care practice, including ethical aspects, their societal impact and integration into regulatory frameworks, and for allowing swift access by health care providers, patients and healthy citizens.
- Regulatory authorities supported with better methodologies and interdisciplinary approaches to assess new health technologies and interventions.
- New European standards and quality assurance schemes developed for submission to standardisation bodies and implementation by stakeholders that, e.g., support a fast, reliable and secure handling of health data, health products or health services.
- Safe and clinically validated tools, technologies and services developed and delivered by European health industry that meet the needs of citizens, patients, health care providers and systems.
- Greener pharmaceuticals and health technologies.

SYNERGIES BETWEEN CLUSTERS

With cluster 3 "Civil security for society" on:

- health security/emergencies (preparedness and response, medical counter measures, epidemic outbreaks/pandemics, natural disasters and technological incidents, bioterrorism)
- security of health care infrastructures, incl. digital health infrastructures, or health systems preparedness and response to natural disasters and emergencies

With cluster 4 'Digital, Industry and Space' on:

- digital tools, telemedicine or smart homes
- health-related space research and innovation for location-based services, geo-observation and monitoring (e.g. of pollution)
- decision-support systems or on geo-observation and monitoring (e.g. of disease vectors, epidemics)
- cybersecurity of (public) health systems, products and infrastructures of digitalised health and care, or on health impact assessment (e.g. related to consumer products, working place innovation)
- industrial research and innovation infrastructures (pilot plants, testing and simulation facilities, open innovation hubs); additive manufacturing (3D/4D printing) and other production technologies (incl. bio manufacturing); safe, smart and sustainable materials

With cluster 5 'Climate, Energy and Mobility' on:

- the surveillance, prediction and mitigation of the health impact of climate change, on the health
- urban health or on mitigating the impact of road traffic accidents and related injuries

With cluster 6 'Food, Bioeconomy Natural Resources, Agriculture and Environment' on:

- the role of nutrition for health (incl. human microbiome, mal- and over-nutrition, safe food), personalised diets (incl. food habits in general and childhood obesity in particular) and the impact of food-related environmental stressors on human health (incl. marketing and consumer habits)
- healthy ecosystems and human habitats (incl. nature-based solutions for health and well-being), or on the sustainable management of clean water, soil and air

Moreover, research and innovation actions under cluster health may be inspired by research achievements under Pillar I (Open Science) or may benefit from follow-on support under Pillar III (Open Innovation).

SUGGESTED ACTION

Keep monitoring the development of the Strategic Programme and contribute through direct articulation with the European Commission.

Promote internal awareness of the information available and start with anticipation preparing for calls and topics through closer articulation with national and European stakeholders.

EUROPEAN PARTNERSHIPS

According to the Horizon Europe regulation Article 2, an 'European Partnership' means an initiative where the Union, prepared with early involvement of Member States and/or Associated Countries, together with private and/or public partners (such as industry, universities, research organisations, bodies with a public service mission at local, regional, national or international level or civil society organisations including foundations and NGOs), commit to jointly support the development and implementation of a programme of research and innovation activities, including those related to market, regulatory or policy uptake.

At the request of the European Council, the European Commission has reorganised the different types of European partnerships into three categories. The goal is to provide an umbrella overview of the types of partnerships and, in this way, be able to develop a common set of criteria for all partnerships and align them better with the political strategic orientations and goals defined by the Council.

In Horizon Europe there will be three forms of European Partnerships:

- Co-programmed European Partnerships: participation in partnerships set up on the basis of memoranda of understanding and/or contractual arrangements between the Commission and the partners, specifying the objectives of the partnership, related commitments for financial and/or inkind contributions of the partners, key performance and impact indicators, and outputs to be delivered. They include the identification of complementary research and innovation activities that are implemented by the partners and by the Programme;
- Co-funded European Partnerships: participation in and financial contribution to a programme of research and innovation activities, based on the commitment of the partners for financial and in-kind contributions and integration of their relevant activities using a Programme co-fund action (grant agreement);
- Institutionalised European Partnerships: participation in and financial contribution to research and innovation programmes undertaken by several Member States/ Associated Countries in accordance with Article 185 TFEU, or by bodies established pursuant to Article 187 TFEU, such as Joint Undertakings, or by the EIT Knowledge and Innovation Communities in compliance with the EIT Regulation, to be implemented only where other forms of European Partnerships would not achieve the objectives or would not generate the necessary expected impacts, and if justified by a long-term perspective and high degree of integration including central management of all financial contributions.

As partnerships are complex initiatives, based on the proven engagement of a wide range of stakeholders in the EU, the portfolio development of European partnerships will not likely change radically from that already identified by the European Commission, most of which stems from previous initiatives. Moreover, it must be aligned with the main political objectives of the EU such as the Green Deal, etc. Below, we present the portfolio of current candidates, including those for the Health area.

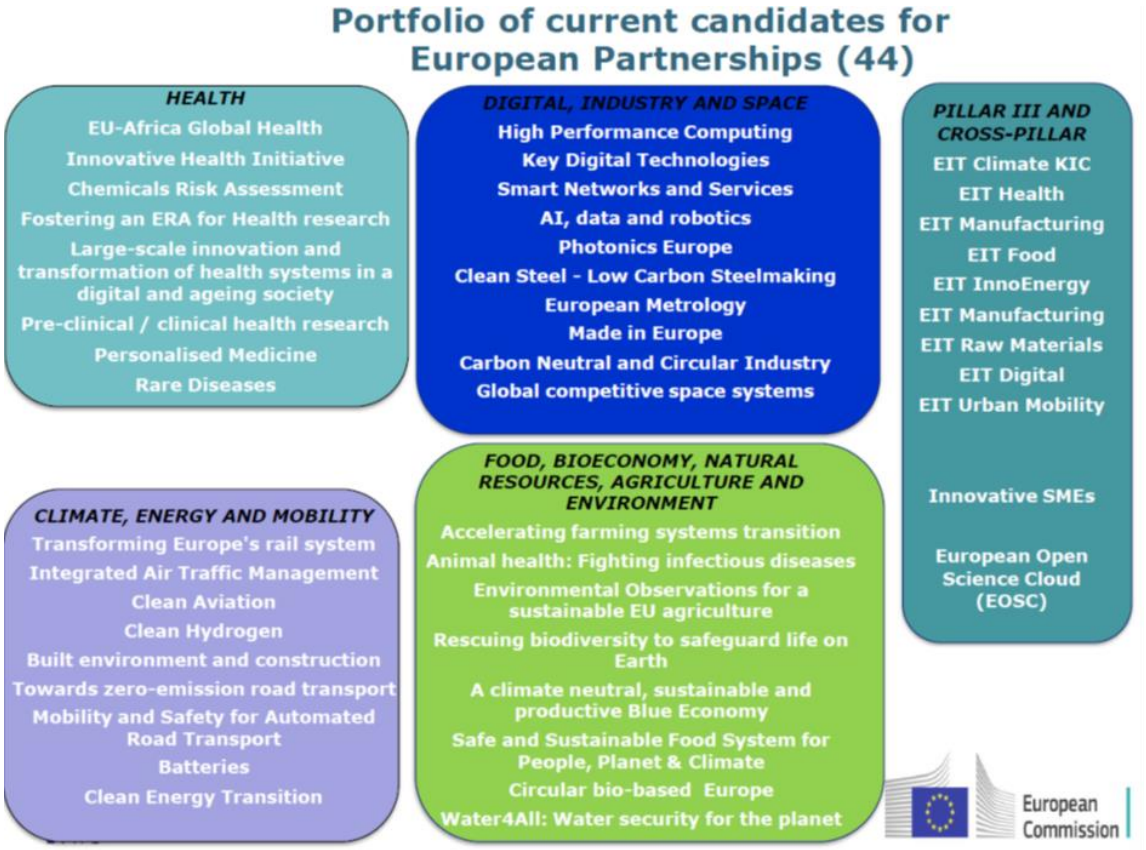


FIGURE 13: CURRENT CANDIDATE PARTNERSHIPS TO HORIZON EUROPE

State of play of European Partnerships (April 2020)

Currently, there are 30 candidate partnerships that are likely to be ready for the Work Programme 2021/22. This number does not include the 8 existing EIT-KICs whose activities are ongoing, and the launch of the new one on Cultural and Creative Industries that follows a separate preparation. For the remaining ones the current situation is the following:

- For three candidates (Transformation of health systems, ERA for health, Blue economy) it depends on how much they manage to accelerate the preparation process (notably in light of current situation);
- Four partnerships in the Cluster 6 are likely to be relevant only for the WP 2023/4, unless preparation advances and updates for the WP 2022 are considered;
- Three are planned for the WP 2023/24 (Personalised medicine, Rare diseases, One Health/AMR).

Any partnership that should be included in the WP 2021/2 needs to submit its elaborated draft proposal as soon as possible. Currently missing proposals: EuroHPC; Towards zero-emission road transport; Innovative SMEs. Any of the above-mentioned partnership that still want to accelerate their preparation and aim at the WP 2021/2 (transformation of health systems, ERA for health, Blue economy, possibly others from cluster 6).

Timeline for implementation of partnerships

For the time being the following scenario seems feasible:

- For the institutionalised European Partnerships (Article 185/7 initiatives the Impact Assessment work is ongoing, with a first hearing of the Regulatory Scrutiny Board having taken place on 25 March, and the remaining ones being scheduled for 13 May and 10 June.
- May 2020: Meetings per cluster to start discussions on budgetary aspects (overall investment envisaged, possible Union contribution needed) and governance. It will also take stock of progress on collaboration with other partnerships, and synergies.
- June 2020 (tbc): Commitments from partners will be requested, with the timing depending on impact of Covid-19 pandemic and the progress on MFF negotiations.
- September 2020: earliest possible adoption of Commission proposals for Article 185/7 initiatives, subject to e.g. political agreement of the MFF.
- September 2020: R&I Days (communication and discussion with stakeholders).
- At the time of adoption of the WP 2021/2: signature of MoUs for co-programmed partnerships, opening of calls for co-fund actions implementing co-funded partnerships.

Suggested action:

- Study the SRAs and composition of the Health-related partnerships and organise bilateral meetings with those of strategic interest to further understand in which could INESC further participate and what are the conditions and strategic interests.

- Invite the relevant Partnerships for the HT Presidency event.

EIT Health

Mission

EIT Health "European Institute of Innovation and Technology" launched by the European commission with a board of directors and KICs (knowledge and innovation communities). It works through pre-existing networks in universities and research institutes without the need of physical buildings.

Structure

It comprises approximately 140 partners from different European countries, with companies in the fields of information and communication technologies (ICT), or equipment suppliers, public and private health care providers, local authorities, universities and research centres.

Partners

EIT Health's headquarters are in Munich and the partners are divided into 6 Co-Location Centres (UK / Ireland; Scandinavia; Spain; France; Germany / Switzerland; Belgium / Netherlands) and the EIT Health Innostars ("not yet arrived to the desired point of innovation", this being a set of regional clusters that seeks to maximize the potential for the emergence of innovative clusters (Croatia, Hungary, Poland, Italy and Portugal).

Goals

Its strategy is based on the so-called knowledge triangle, integrating TRAINING with INNOVATION projects and the creation and ACCELERATION of companies. With a budget of approximately 2 billion in the coming years, EIT Health seeks to innovate in order to contribute with new products, concepts and services in a market-oriented strategy.

EIT Health Portugal

Portugal has 2 partners in the consortium (Coimbra and Lisbon) and 2 RIS HUBs, those that do not directly benefit from EIT Health activities and funding (Évora and Porto). Participating in the consortium has a fee associated with it, but it is possible to gather financing in calls destined directly to the members of the consortium. The financing opportunities for RIS HUBs are lesser, but they are willing to sooner become partners. The INESC TEC spin-off, ILOF, recently participated in a business call (startups), non-institutional and won the wildcard winner prize in the amount of 2 million €.

Suggested action

- Schedule a meeting with some of the main drivers of EIT Health in Portugal to allow the improvement of INESC activity: Jorge Figueira (University of Coimbra) and Nuno Viegas (Regional Manager of EIT Health Innostars Portugal);
- Find the EIT Health point of contact at the following partners: - Centro Hospitalar de Lisboa Norte, EPE; - Coimbra Hospital and University Center, EPE (CHU Coimbra); - Faculty of Pharmacy, University of Lisbon; - Faculty of Human Motricity; - Pedro Nunes Institute (IPN); - Higher Institute of Economics and Management; - Instituto Superior Técnico; - University of Coimbra; - University of Lisbon; - Glintt;
- Disseminate and further promote the participation of INESCs in EIT Health initiatives.

RESEARCH INFRASTRUCTURES

WHAT ARE RESEARCH INFRASTRUCTURES?

The European Strategy Forum on Research Infrastructures and the European Commission´s Framework Programme Horizon 2020 definition: research infrastructures are **facilities, resources and services** that are used by the research communities **to conduct research and foster innovation** in their fields. Where relevant, they may be used beyond research, e.g. for education or public services.

They include:

- major scientific equipment (or sets of instruments);
- knowledge-based resources such as collections, archives or scientific data;
- e-infrastructures, such as data and computing systems and communication networks;
- any other infrastructure of a unique nature essential to achieve excellence in research and innovation.

It is important to note that this definition can vary (depending on the EU Member State and even institution). In Portugal, for example, the definition of research infrastructure was equated with mere “equipment” until the late development of the National Roadmap of Research Infrastructures of Strategic Interest was developed in 2013.

In the Horizon Europe Regulation Article 2, there is a slightly adapted definition. Of particular importance is the fact that the definition includes “the associated human resources”.

'research infrastructures' mean facilities that provide resources and services for the research communities to conduct research and foster innovation in their fields. This definition includes the associated human resources, and it covers major equipment or sets of instruments; knowledge related facilities such as collections, archives or scientific data infrastructures; computing systems, communication networks, and any other infrastructure, of a unique nature and open to external users, essential to achieve excellence in research and innovation. Where relevant, they may be used beyond research, for example for education or public services and they may be 'single sited', 'virtual' or 'distributed';

WHAT THE COMMISSION IS DOING?

The Commission defines, evaluates and implements strategies and tools to provide Europe with world-class sustainable Research Infrastructures. It also ensures that these research infrastructures are open and accessible to all researchers in Europe and beyond.

Nevertheless, the focus of the European Commission is on Research Infrastructures of more than national interest, meaning that it applies the principle of subsidiarity, a core principle in European integration, and focus on those infrastructures that a country alone could not develop, i.e. ITER, CERN, etc or on integration of research infrastructures, i.e. the creation of networks of existing research infrastructures, with the goal to promote synergies in the research agenda setting, complementarity of scientific and technical capacity, visibility, training, capacity building. These integration efforts often lead, under ESFRI initiatives sponsored by the European Commission, to the so-called European Research Infrastructures Consortiums (ERIC).

KEY OBJECTIVES

- reduce fragmentation of the research and innovation ecosystem
- avoid duplication of effort
- better coordinate the development and use of Research Infrastructures
- establish strategies for new pan-European, well-established intergovernmental or national Research Infrastructures
- join forces internationally to construct and run large, complex or expensive infrastructures, respond to global challenges and/or foster combining skills, data and efforts of the world's best scientists
- foster the innovation potential of Research Infrastructures by making industry more aware of opportunities offered to improve their products and by the co-development of advanced technologies e.g. ATTRACT
- use Research Infrastructures for science diplomacy - using science collaboration to address common problems and build partnerships internationally e.g. SESAME in Jordan and EU-CELAC in Latin America

The Commission also provides the charter for access to research infrastructures which sets out principles and guidelines when defining access policies for Research Infrastructures.

https://ec.europa.eu/research/infrastructures/pdf/2016_charterforaccessto-ris.pdf

INITIATIVES, STRATEGIES AND NETWORKS

- European Strategy Forum on Research Infrastructures (ESFRI)

The ESFRI develops a strategic roadmap identifying investment priorities in European Research Infrastructures for the next 10-20 years.

One of the key ingredients of **ESFRI** rests in ensuring that excellent scientists have access to Europe´s best research infrastructures, irrespective of borders.

It is composed of national delegates nominated by research ministers of EU countries and countries associated with Horizon 2020. It also includes a Commission representative.

ESFRI is a self-regulated body, operating on a consensus basis and typically meets 4 times a year.

The ESFRI Roadmap is revised regularly. Currently, the goal is to revise it every 2 to 3 years. The ESFRI Roadmap works as an incubator of RI, providing excellent evaluation exercises, recognised by the European Commission and informing the EC about which RI initiatives deserve targeted funding develop their integration efforts. Most of the RI in the ESFRI Roadmap are distributed. An increasingly strong effort to integrate them with digital RI is being made. The 2018 Roadmap is now being revised and the call for integrating the ESFRI Roadmap 2021 is open: https://www.esfri.eu/esfri-roadmap-2021

The ESFRI Roadmap changed radically from 2012 to 2018. It passed from an average of 48 active research infrastructures initiatives (meaning under development) to an average of 20/25. All those RIs that did not

demonstrate capacity to achieve implementation phase (i.e. achieving ERIC status) in less than a maximum of 10 years and ideally in 3 to 4 years, were removed from the Roadmap. This means that an RI needs to undergo the first phases of its lifecycle in less than 10 years, i.e. going from

1. Concept development to
2. Design, including tested design studies to
3. Preparatory phase, i.e. mobilisation and commitment of the key EU RIs to integrate, scientific goals well defined, implementation plan finalised including political support and commitment to at least 5 year funding cycles

See this guide for further info.

The ESFRI Roadmap is organised in scientific domains: Physics and Engineering, Health and Food, Environment, Energy, Social Sciences and Humanities and counts with a cross-cutting priority "Digital".

Currently, in the Health and Food domain, in the ESFRI 2018 Roadmap there are 6 ESFRI RI projects, i.e. being incubated and supported to move from preparatory phase to implementation phase. Check the 2018 Roadmap for full info http://roadmap2018.esfri.eu/media/1066/esfri-roadmap-2018.pdf

10 other RIs are considered "Landmarks", i.e. they already achieved ERIC status and therefore have an European level coordination. Some of these RIs, ELIXIR is a good example, are not ERICs but established alternative legal status. An ERIC is considered an international organisation and has access to the respective legal and fiscal benefits generally attributed in Europe.

- National Roadmap of Research Infrastructures of Strategic Interest

https://www.fct.pt/apoios/equipamento/roteiro/2013/docs/RNIE_2019

Monitoring Committee Contacts:

Andreia Feijão: Executive Coordinator of the FCT Scientific Council for Life and Health Sciences

Tiago Saborida: FCT Research Infrastructures Unit

Celso Reis: IPATIMUP, Institute of Molecular Pathology and Imunology, University of Porto

Manuel Santos: CESAM, Centre for Environmental and Marine Studies, University of Aveiro

- European Research Infrastructure Consortium (ERIC)

A specific legal form that facilitates the establishment and operation of Research Infrastructures. The European Research Infrastructure Consortium (ERIC) is a specific legal form that facilitates the establishment and operation of Research Infrastructures with European interest. The ERIC allows the establishment and operation of new or existing Research Infrastructures on a non-economic basis. The Commission provides practical guidelines to help potential applicants. The ERIC becomes a legal entity from the date the Commission decision setting up the ERIC takes effect. An ERIC can carry out some limited economic activities related to this task.

- Group of Senior Officials (GSO)

Global group of experts that takes stock of the existing situation of global Research Infrastructures and explores new collaboration opportunities.

- European Open Science Cloud (EOSC)

Cloud database for research in Europe.

- EIROforum

Collaboration agreement to combine resources, facilities and expertise of its member organisations to support European science

- OECD Global Science Forum (GSF)

The European Commission is part of 2 working groups:

  - GSF working group on Research Infrastructure sustainability - to ensure coherence and complementarity with the long term sustainability effort conducted at European level
  - GSF working group on the socio-economic impact of Research Infrastructures which aims to reach an understanding at international level of the principles and processes to be followed when addressing the socioeconomic impact of any Research Infrastructure

Funding opportunities

Funding opportunities in Research Infrastructures, include EU funding from

- Horizon 2020 including the InnovFin funding scheme supported by the EIB group
- European Structural and Investment Funds (ESI Funds)
- the European Fund for strategic Investments (EFSI)

Examples of Research Infrastructure projects

- ELIXIR: A distributed infrastructure for Life science information
- SHARE: A survey on Health, ageing and retirement in Europe

Suggested Action

- Contact FCT representants for the ESFRI National Roadmap to understand when is the national roadmap being effectively revised and advice on how can INESC best position itself for the future regarding RI initiatives in Portugal.
- Study if there are funding opportunities where INESC can be present at European level. Examples of HT being mobilised and used in already implemented and RI projects under preparation.
- Study the RIs in Portugal in the areas of Biological and Medical Sciences and e-Infrastructures and see if it possible INESC to be involved.
- Analyse other Health and Food RI initiatives at European level and how can INESC be involved.Important to consider that INESC MN is already involved in the preparation of an ESFRI application in the Physics and Engineering domain.

DIGITAL EUROPE

The Digital Europe Programme focus on building the strategic digital capacities of the EU and on facilitating the wide deployment of digital technologies to be use by European citizens and businesses. It will shape and support the digital transformation of Europe's society and economy.

CONTEXT AND VISION

The vision for the policy direction in this respect was agreed by the Heads of State or Government during the Tallinn Digital Summit in 2017. Furthermore, the European Parliament has underline on numerous occasions the need to secure appropriate financing for digital policies, particularly for action to complete the digital single market. The Digital European Programme has been included under heading 1 "single market, innovation and digital", which constitutes almost 15% of the Multiannual Financial Framework (MFF). Other larger components of the heading are Horizon Europe, the Connecting Europe Facility, the European Space Programme and InvestEU.

THE COMMISSION ANALYSIS

The Commission considers that in order to benefit fully from the digital transformation, the EU needs to build cutting-edge digital capacity in critical area such as supercomputing and data, artificial intelligence and cybersecurity. In addition, these capacities need to be supported by advanced digital skills and made available and deployed by the private and public sectors, across societies and economies.

WHAT WILL THE DIGITAL EUROPE PROGRAMME FUND?

- Supercomputing:

  Develop and reinforce high-performance computing and data processing capabilities to achieve exascale capabilities by 2022-2023 and post-exascale facilities by 2026 or 2027

  Increase accessibility and broaden the use of supercomputing in areas of public interest such as: health, environment, security/cybersecurity and industry.

  The funding will ensure a more effective and wider use of supercomputing in public setor and SME or LE. The planned initiatives will build on the European strategy on supercomputers that will help the EU advance in many areas from health care and renewable energy to car safety and cybersecurity.

- Artificial Intelligence:
  The aim is to boost investments to make the most out AI, while considering the socio-economic changes brought about by AI and to ensure an appropriate ethical and legal framework.

  Give better access for public authorities and businesses, especially smallest ones, to AI testing and experimentation facilities in Member states, while increased investments in research and innovation under Horizon Europe.

  Develop common "European Libraries" to algorithms that would be accessible to all, to help the public and private sectors to identify and acquire whichever solution would work best for their needs.

Open platforms access to industrial data spaces for artificial intelligence, will be made available across Digital Innovation Hubs;

Providing testing facilities and knowledge to SME's and local innovator.

- Cybersecurity and trust:
  2€ billion will be invested into safeguarding the EU's digital economy, society and democracies through boosting cyber defence and the EU's cybersecurity equipment infrastructure as well as supporting the development of the necessary skills and knowledge.

- •Digital Skills:
  €700 million to ensure that the current and future workforce will have the opportunity to easily acquire advanced digital skills through long-and short-term training courses and on-the-job traineeships. The Digital Innovation Hub will carry out targeted programmes to help SME's and public administration to equip their personnel with the needed advanced skills to be able access to new opportunities offered by supercomputing, artificial intelligence and cybersecurity.

- Ensuring a wide use of digital technologies across the economy and society

IMPLEMENTATION

Digital Europe Programme will be implemented by European Digital Innovation Hubs (EDIH). EDIH will play a central role in the Digital Europe Programme to stimulate the broad uptake of AI, High performance computing and Cybersecurity as well as other digital technologies by industry and public sector organization in Europe. EDIH will have both local and European functions. In Portugal there are four hubs, three operational and one in preparation:

1. Fully operational DIHs

Hub name	City	NUTS2 region	Country	Smart Specialisation (SS)	Link to SS	AI	HPC	Cyber Security	Association to EU-funded project
HUB for Agriculture (HUB4AGRI)	Lisbon	Área Metropolitana de Lisboa	Portugal	Smart agriculture	Forestry	X	-	-	-
iMan Norte Hub - Digital Innovation Hub for Customer-Driven Manufacturing @ Norte	Porto	Norte	Portugal	Smart manufacturing	Advanced Manufacturing Technologies	X	X	X	I4MS (BEinCPPS)
PRODUTECH Digital Innovation Hub National Platform	Porto	Norte	Portugal	Smart manufacturing	Advanced Manufacturing Technologies	X	X	X	-

2. In preparation DIHs

Hub name	City	NUTS2 region	Country	Association to EU-funded project
Emerging Transactional and Financial Technology Hub (ETFTH)	Coimbra	Centro (PT)	Portugal	SAE (DIATOMIC)

FIGURE 14: OVERVIEW OF DIGITAL INNOVATION HUBS IN PORTUGAL

HUB for Agriculture

iMan Norte Hub, one of the partners is INESC TEC

PRODUTECH

SUGGESTED ACTION

- Approval of the budget for 2021-2027 that can change this programme and the implementation of the funds at regional or European level – Revisit the program and opportunities;
- Make some contacts with the existing Portuguese Hubs, especially with iMan Norte Hub where INESC TEC is a partner to clarify, for example, the structure, objectives, implementation and funding scheme for the HUB, startups, SME, R&D entities;
- Prepare and organise a meeting with the EC regarding creation of a health DIH in Portugal (First semester 2021)

COVID-19 (TO BE UPDATED)

Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) is the name given to the 2019 novel coronavirus. COVID-19 is the name given to the disease associated with the virus. SARS-CoV-2 is a new strain of coronavirus that has not been previously identified in humans.

Coronaviruses are viruses that circulate among animals with some of them also known to infect humans. Bats are considered natural hosts of these viruses yet several other species of animals are also known to act as sources. For instance, Middle East Respiratory Syndrome Coronavirus (MERS-CoV) is transmitted to humans from camels, and Severe Acute Respiratory Syndrome Coronavirus-1 (SARS-CoV-1) is transmitted to humans from civet cats.

The novel coronavirus detected in China in 2019 is closely related genetically to the SARS-CoV-1 virus. SARS emerged at the end of 2002 in China, and it caused more than 8 000 cases in 33 countries over a period of eight months. Around one in ten of the people who developed SARS died.

While the viruses that cause both COVID-19 and seasonal influenza are transmitted from person-to-person and may cause similar symptoms, the two viruses are very different and do not behave in the same way.

The European Centre for Disease Control (ECDC) estimates that between 15 000 and 75 000 people die prematurely due to causes associated with seasonal influenza infection each year in the EU, the UK, Norway, Iceland and Liechtenstein. This is approximately 1 in every 1 000 people who are infected. Despite the relatively low mortality rate for seasonal influenza, many people die from the disease due to the large number of people who contract it each year. The concern about COVID-19 is that, unlike influenza, there is no vaccine and no specific treatment for the disease. It also appears to be more transmissible than seasonal influenza. As it is a new virus, nobody has prior immunity, which means that the entire human population is potentially susceptible to SARS-CoV-2 infection

EUROPE

As of 07 May 2020, **1 203 381 cases** have been reported in the EU/EEA and the UK: Spain (220 325), Italy (214 457), United Kingdom (201 201), Germany (166 091), France (137 150), Belgium (50 781), Netherlands (41 319), Portugal (26 182), Sweden (23 918), Ireland (22 248), Austria (15 651), Poland (14 740), Romania (14 107), Denmark (9 983), Czechia (7 974), Norway (7 953), Finland (5 573), Luxembourg (3 851), Hungary (3 150), Greece (2 663), Croatia (2 119), Iceland (1 799), Bulgaria (1 778), Estonia (1 713), Slovenia (1 448), Slovakia (1 429), Lithuania (1 428), Latvia (900), Cyprus (883), Malta (484) and Liechtenstein (83).

As of 07 May 2020, **141 999 deaths** have been reported in the EU/EEA and the UK: United Kingdom (30 076), Italy (29 684), Spain (25 857), France (25 809), Belgium (8 339), Germany (7 119), Netherlands (5 204), Sweden (2 941), Ireland (1 375), Portugal (1 089), Romania (858), Poland (733), Austria (608), Denmark (506), Hungary (383), Czechia (262), Finland (252), Norway (209), Greece (147), Slovenia (99), Luxembourg (98), Croatia (85), Bulgaria (84), Estonia (55), Lithuania (48), Slovakia (25), Cyprus (21), Latvia (17), Iceland (10), Malta (5) and Liechtenstein (1).

SUMMARY OF R&I MEASURES AT EUROPEAN LEVEL

The European Commission has been supporting research and innovation and coordinating European and global research efforts, including preparedness for pandemics. In addition to a number of past and ongoing research actions related to coronaviruses and outbreaks, the Commission launched several special actions in 2020. These actions address epidemiology, preparedness and response to outbreaks, the development of diagnostics, treatments and vaccines, as well as the infrastructures and resources that enable this research.

The Commission and national ministries have also agreed on the first ERAvsCorona action plan which lays out 10 priority short-term coordinated actions to tackle coronavirus:

10 priority actions for coordinated research and innovation actions:

1. Coordination of R&I funding against the Coronavirus
2. Extending and supporting large EU wide clinical trials for clinical management of Coronavirus patients
3. New funding for innovative and rapid health-related approaches to respond to coronavirus and deliver quick results relevant to society and a higher level of preparedness of health systems
4. Increasing support to innovative companies
5. Creating opportunities for other funding sources to contribute to R&I actions on Coronavirus
6. Establish a one-stop shop for Coronavirus R&I funding
7. Establish an ad-hoc High Level R&I Task Force on the Coronavirus
8. Access to Research Infrastructures
9. Research data sharing platform
10. Pan-EU Hackathon to mobilise European innovators and civil society

The funding available for Corona-relater R&I is the following:

- €1 billion mobilised under H2020 for Coronavirus Global Response to help reach the objectives of the Coronavirus Global Response, €1 billion will be mobilised under the EU's flagship programme for research and innovation, Horizon 2020.
- €450 million for developing scientific solutions for testing, treating and preventing against the coronavirus and developing health systems
- €400 million European Commission guarantee of the European Investment Bank lending to finance pre-commercial stage investments in COVID-19 (including scale-up of related production facilities)
- €150 million for disruptive innovations on COVID-19 under the European Innovation Council's Accelerator

PORTUGAL

The **first case** of COVID-19 in Portugal was diagnosed on **March 2, 2020.** The **isolation measures** have been applied for approximately **5 weeks** (schools, cafes and non-essential stores are closed). We are supposed to be on the **pandemic plateau**. **Field hospitals** are now more common, and the **national health system** has been able to provide all means for the diagnosis and treatment of this pandemic.

Status on the 07 May 2020:

-- **26715 confirmed infections**;

-- 2666 awaiting laboratory result;

-- 2258 recovered cases;

-- **1105 deaths.**

SUMMARY OF R&I MEASURES AT NATIONAL LEVEL

FCT Calls and initiatives

- The "Science 4 COVID19" portal is an initiative of the FCT and AICIB in partnership with public and private health authorities and scientific research institutions, to mobilize the scientific communities in joint Research and Development (R&D) projects and activities aimed at combating COVID-19. The portal groups metadata, datasets or hyperlinks, problem registration, research results in epidemiological surveillance and other anonymous public health data necessary to combat the coronavirus epidemic, such as clinical, analytical and demographic results.
  https://www.science4covid19.pt/

- 1st Edition of "RESEARCH 4 COVID-19", closed (1.8 M €)
  Results: 66 projects were approved for funding.

- 2nd Edition of "RESEARCH 4 COVID-19", until May 15 of 2020 (2M €)

- Research scholarships for PhD "DOCTORATES 4 COVID-19", until May 15 of 2020

- Competition for R&D projects "AI 4 COVID-19: Data Science and Artificial Intelligence in Public Administration". This is the 3rd edition of an annual competition program aimed at research in Data Science and Artificial Intelligence applied to Public Administration, which this year is exclusively oriented towards data processing within the current pandemic of the new SARS CoV2 coronavirus and the COVID-19 disease, until May 28 of 2020 (240k €)

- "CaixaImpulse COVID-19" closed

ANI initiatives

- Covid-19 - Projects of R&D SMEs, research and development (R&D) and innovation projects and initiatives between technological interface centers and collaborative laboratories and companies, which respond to the immediate and medium-term needs of the National Health Service relevant in the context of combating Covid-19, until May 29 of 2020 (23 M€)

- ANI provides a space for the dissemination of technologies and solutions to respond to the negative impacts of Covid-19. It is intended to give greater visibility to the efforts of start-ups, companies and entities in the scientific and technological system to support the resolution of this problem. This space is promoted in conjunction with COVINDEX.

https://www.ani.pt/pt/portugal-inovador/portugal-inovador/covid-19-solu%C3%A7%C3%B5es-e-tecnologias/

- INOV 4 COVID-19, support and reimbursable financing for the immediate development of ongoing R&D and technological innovation projects and initiatives developed by the Interface Centers and Collaborative Laboratories, closed (4 M€)

INESC

Matching capacity and contribution to COVID 19 across the 5 INESCs

- Prevention:

-- Tracking (of contacts with the infected)

-- Disinfection (with robotics)

-- Individual Protection Equipment (e.g. 3D printed visors)

-- Stock management models for individual protection materials.

-- Optimal location of testing centers

-- Robust supply chain management

- Diagnosis:

-- Complementary Systems (e.g. X-Ray, CT, vital signals)

-- New Methods of Rapid and Early Diagnosis (e.g. Magnetic sensors, Optics based, MEMS-systems)

-- Material Management (e.g. reagents supply chain management, operational investigation methods)

-- Bioinformatics for strain analysis and comparison

-- Artificial Intelligence to forecast infection evolution

-- Symptoms and/or clinical indicators smart analysis to identify infection severity degree

- Treatment:

-- Support to full treatment (e.g. vaccine development)

-- Hospital Management (e.g. capacity, human resources, equipment)

-- Ventilators

-- Data science for analysing current treatment plans and design new optimized treatment plans

- Information:

-- Build Credible Information Sources (with summaries and without false news)

-- Remotely Interactive Systems

-- Information Systems (group in a complementary and intuitive way)

-- Predictive systems (for clinical and policy makers)

-- Gamification platforms for patients follow up/ people in quarantine

- Post-Pandemic:

-- Tele-Health and Tele-Medicine (to avoid hospital capacity, future illnesses and physical/psychological degradation)

-- Hospital Reorganization Planning (consultations, surgeries, and capacity), including scheduling of patients with medical interventions/consultations postponed due to Covid19

-- Optimization models for work organization (scheduling of mirror teams)

-- Optimization of human and material resources

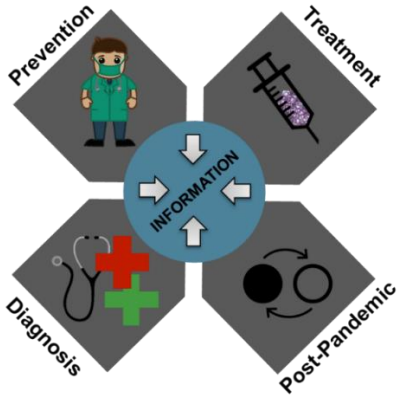


FIGURE 15: COVID19 DIMENSIONS OF INTERVENTION

INITIATIVES ALREADY RUNNING

THE ALTERNATIVE LOW-COST VENTILATOR FOR HOSPITALS

Pneuma allows the control of volume, respiratory rate and inspiration / expiration ratio, including stop detection alarms and hepa filter to mitigate risk of infections, among other features. It is easier and faster to replicate and costs than 100 times the market (200€). The prototype has already been tested in pre-clinical trials. 200 will be delivered next month (two Portuguese companies) and requests have already arrived from Morocco, India and Brazil. (https://www.linkedin.com/company/inesc-tec/)

PANDEMIC DIARIES

This study includes a questionnaire covering the perception of emotional well-being that allows to know how, during the diaries, the participants lived and summarized their well-being. The first results highlight that the older ones do not show so much fear and anxiety regarding the pandemic and that the perception of the risk of being infected is less as the level of education increases (+-7000 people in the first week alone - 23 March).

TEAM FROM 11 COUNTRIES LAUNCHES QUESTIONNAIRE TO FIND OUT WHO HAS SYMPTOMS

Researchers are collecting information through an online questionnaire to estimate the number of real cases with symptoms of covid-19 in their territories, which will allow to trace the evolution of the disease. The number of confirmed cases always depends on the number of performed tests. Although the estimates are not entirely accurate, they are expected to be in the same order of magnitude as the actual value. Estimates have been observed that are very similar to other indirect methods.

CHEST RADIOGRAPHY-BASED AI FOR SUPPORTING CLINICAL DECISION ON COVID-19

Chest radiography can play an important role in the decision-making process for COVID-19 detection and management, given the low sensitivity of RT-PCR. Because the number of experienced radiologists is scarce,

many CXRs are analysed by interns with low experience. AI methods play a significant role, identifying the images with features indicative of COVID-19 to give a second opinion to support the clinician in the triage of COVID-19 patients.

Autonomous Robot to Disinfect Hospitals

RADAR - Autonomous Robot for Disinfection in Hospital Environment will help, through sensors and ultraviolet lamps, in the disinfection of spaces in hospital units. The robot will have autonomous navigation, that is, it will be able to locate and navigate through contaminated rooms, monitor the presence of people in the environment, and carry out the disinfection process autonomously. The architecture is modular and adaptable to different robotic platforms that already exist.

The Voluntary App, with Beeps, to track contagions

The app will be a platform for voluntary use, and free of charge, which will allow interested users to discover, by themselves, through public information and certified by health authorities, if they have had contact with someone confirmed as infected. with the new coronavirus.

Initiatives under preparation

The 2nd outbreak

The aim of the project is to provide a framework of policies for improved management of medical staff in Cancer Centers, in the widely anticipated event of a second wave of Covid-19. The validation of such policies is supported by a simulation-optimization tool fed by the most recent, near real-time data. The framework incorporates algorithms capable of assigning the full capacity of the workforce when it is most needed and avoiding unnecessary disruptions.

Smart PCR

This solution aims to impose optical methods and artificial intelligence to target sequence amplification to both classify samples (positive or negative) and quantifying the genetic material concentration. By using this technology, it will be possible do greatly decrease the number of amplification cycles, speeding up the PCR in the short term.

Dual diagnostic

A portable device with disposable cartridges for the diagnostic of Covid-19 based on magnetic sensors to perform quantitative molecular and serologic tests in parallel. The viral RNA will be directly detected, without amplification, by an on-chip magnetic concentration. In addition, blood serum analysis will allow for immunization assessment of the general population. (https://sites.google.com/site/inescmn/)

PATIENT STRATIFICATION BASED ON PRO-INFLAMMATORY CYTOKINES

Based on a bioanalytical platform for the detection of a multiple set of Covid-19 immunological biomarkers (pro-inflammatory cytokines) the aim is to develop a predictive tool of severe COVID-19 forms able to replace ELISA methods.

FUTURE ACTIONS

The proposed plan of activities that we present below is broken down into three areas of activity, fully in-line with the HUB Strategic Plan for 2020-2022. The activities listed below are subject to change if others are deemed more relevant due to new information on the European funding programmes and instruments that may arise. We recall that at time of writing there are no work programmes and the budget for the next programming period is not approved. Moreover, the national community framework programme is still in the initial planning phase and will undergo what can be a long negotiation between national representatives and the European Commission.

VISIBILITY AND REPRESENTATION

Develop external communication about the capacity of INESC in HT. It was made clear from the characterisation exercise and even more from the initial matching exercise that we need to make known our already existing capacity to contribute to many of the challenges, policy objectives and concrete calls and topics that are now being developed. Along with this, we will strengthen the external network of INESC institutes in diverse ways, namely by:

- interacting and finding synergies with key European stakeholders in life sciences and other areas that are complementary and synergic to those of INESC;
- looking to complement our capacity and track record through best-practice exchange and closing the gaps existing today with institutes and SMEs that operate in both lower and higher TRLs;
- Developing innovative communication actions.

The proposed activities are:

- Continue talks with the recently created AICIB – Agency for Clinical Research and Biomedical Innovation, finalise and propose programme for Health Technologies major event (co-organised with AICIB), including a back-to-back matchmaking event, in the scope of the Portuguese Presidency of the EU (preparation of proposal already ongoing and throughout 2020 – event to take place in February 2021);

- Continue talks and meet with EU-LIFE institutes to initiate discussion on potential synergies between INESC capacity in HT and EU-LIFE 15 life sciences institutes (Second semester 2020);

- Continue talks with IGC (and other life-sciences institutes in Portugal) and meet with the intent of complementing life-sciences research knowledge and capacity, especially that of lower TRLs (2020-2021);

- Develop a collection of podcasts with health technologies internationally renowned experts and policy makers, hosted by the WG HT members (second semester of 2020).

CAPACITY BUILDING

It is clear that capacity building across INESC through both the awareness and understanding of policy and concrete opportunities is crucial and needed. This is done through continuous information gathering and internal (across the 5 INESC institutes) awareness actions.

- Characterisation report open to consultation by INESC community until 17th July;
- Meet with the INESC community to discuss the HT characterisation of capacity and matching report conclusions (11th September of September 2020);
- Organisation of two events with the goal of mobilising the INESC HT community and supporting the opportunity awareness and needs for proposal development (Coinciding with MC meeting in December 2020 and June 2021).

POLICY AND AGENDA-SETTING INFLUENCE

We will continue to build upon the higher levels of knowledge and understanding about European programmes and move onto to a more "interventionist" phase. This will be done through direct approach to the European Commission and other policy-making bodies responsible for determining the R&I agenda in HT, as well as targeted approaches to European partnerships, research infrastructures and other key platforms and initiatives that hold clear leverage in influencing agenda-setting, get early information and build winning consortia as a result. This will be done through continuing the exercise of matching capacity with opportunities in European programmes and instruments, along revision of the characterisation and matching report, as well as a set of concrete activities such as the ones mentioned below. These activities are broken down according to areas of the Framework Programme, Horizon Europe.

MISSION CANCER

- Full understanding of the funding across HE for accomplishing the mission:

INESC needs to understand as deeply as possible which are the areas of the Horizon Europe programme that will include specific funding for the accomplishment of this mission. It is clear that Cluster 1 is one of them, but also other areas, such as partnerships, research infrastructures and all bottom-up instruments, such as EIC and ERC. Understanding the goals of the mission and where the funding will be ring-fenced for its objectives is crucial for better positioning.

- The WG HT will meet with the three Portuguese Mission Cancer Board and Assembly members for advice and opinions and presentation of the INESC capacity and potential contributions (second semester 2020)
- Meet with the Chair of the Mission Board or a member of the EC Units responsible for Health Cluster (second semester 2020)
- Organising an event (online or physical) within the Portuguese Presidency programme, mobilising other national and international institutions (first semester 2021).
- Monitor all related events and publications (ongoing).

CLUSTER HEALTH

- Further develop matching exercise and prepare meeting with EC unit member responsible for Health Cluster (June to December 2020)
- Contribute to consultations on WPs for Health Cluster for 2021-2022 (second semester 2020 and first semester 2021)

PARTNERSHIPS

- Study the SRAs and composition of the Health-related partnerships (second semester 2020)
- Organise bilateral meetings with those of strategic interest to further understand in which could INESC further participate and what are the conditions and strategic interests. (Second semester 2020 and first semester 2021)

Health related PPPs: Transformation of health systems, ERA for health, Personalised medicine, Rare diseases, One Health/AMR

RESEARCH INFRASTRUCTURES

- Contact FCT representants for the ESFRI National Roadmap to understand when is the national roadmap being effectively revised and advice on how can INESC best position itself for the future regarding RI initiatives in Portugal (second semester 2020).
- Study if there are funding opportunities where INESC can be present at European level. Examples of HT being mobilised and used in already implemented and RI projects under preparation (second semester 2020).
- Study the RIs in Portugal in the areas of Biological and Medical Sciences and e-Infrastructures and see if it possible INESC to be involved (2020-2021).
- Analyse other Health and Food RI initiatives at European level and how can INESC be involved (2020-2021).

EIT HEALTH (SECOND SEMESTER 2020)

- Schedule a meeting with some of the main drivers of EIT Health in Portugal to allow the improvement of INESC activity: Jorge Figueira (University of Coimbra) and Nuno Viegas (Regional Manager of EIT Health Innostars Portugal)
- Find the EIT Health point of contact at the following partners: - Centro Hospitalar de Lisboa Norte, EPE; - Coimbra Hospital and University Center, EPE (CHU Coimbra); - Faculty of Pharmacy, University of Lisbon; - Faculty of Human Motricity; - Pedro Nunes Institute (IPN); - Higher Institute of Economics and Management; - Instituto Superior Técnico; - University of Coimbra; - University of Lisbon; - Glintt;
- Disseminate and further promote the participation of INESCs in EIT Health initiatives.

DIGITAL INNOVATION HUBS

- Approval of the budget for 2021-2027 that can change this programme and the implementation of the funds at regional or European level – Revisit the program and opportunities when budget is approved;
- Make contact with the existing Portuguese Hubs, especially with iMan Norte Hub where INESC TEC is a partner to clarify, for example, the structure, objectives, implementation and funding scheme for the HUB, startups, SME, R&D entities; (second semester 2020)
- Prepare and organise a meeting with the EC regarding creation of a health DIH in Portugal (First semester 2021).

MEETING AND REPORTING TO MC – GENERAL PLAN:

- Submit first version of Characterisation and matching report to MC (June 2020);
- Report to MC (December 2020);
- Revise characterisation and matching document (March to May 2021), prepare activities plan for second semester 2021 and intermediate reporting to MC (June 2021);
- Prepare activities plan for 2022 and report to MC (December 2021).