STRATEGIC PLAN 2018-2023

INTERIM UPDATE 2020

ISTITUTO ITALIANO DI TECNOLOGIA

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President’s Foreword

The continuous evaluation of the Institute’s research activity is a fundamental element of IIT’s governance model. The current Strategic Plan, launched in 2018, laid out the framework for this evaluation.

The Strategic Plan defined our scientific and technological goals and the strategy to achieve them. Today, after three years and as we update the Strategic Plan, we can see how much our scientists’ daily effort has contributed to our progress toward achieving the goals set in 2018.

This analysis comes at an extraordinary moment, which is affecting social, personal, and productive processes across the world in ways that are dramatic and difficult to assess. However, the pandemic has demonstrated to us the value of scientific discovery and its technical applications. We now understand that these applications are greatly needed in the healthcare sector, but are also essential to sustainable development and a new balance between humanity’s progress and the environment. We understand that a smart mix of different disciplines can create new pathways to this sustainable progress.

In this mid-term evaluation and update of IIT’s Strategic Plan, the reader will find all these elements, corroborated by precise technical indications, and peppered by the enthusiasm and curiosity that have always been our trademark.

Scientific Director's Introduction

The Strategic Plan is IIT's fundamental research organization document. Here we define our vision, derive our mission, and describe how we will implement our plan to realize our vision.

Preparing the Strategic Plan is a delicate process. We must balance external stimuli (i.e. the direction of science worldwide) with our scientific curiosity, considering the desired direction of our scientists. This process is delicate because we want to encourage curiosity-driven research, but also to follow a coherent path towards well-defined goals.

IIT's Strategic Plan is updated every three years. This is the 2020 update.

In IIT's brief history, research has consolidated around four Research Domains (RDs), which are the pillars of our research organization. These RDs are Robotics, Nanomaterials, Technologies for Life Science, and Computational Sciences. Of course, the RDs cannot fully capture the richness of our researchers' scientific profiles. IIT's staff includes engineers, physicists, biologists, medical doctors, chemists, and many more. Importantly, research groups are formed transversally at IIT with the goal of bringing together the expertise needed for a given task. This is the true interdisciplinary synthesis of our research program.

We can surely agree that computational techniques, epitomized in 2020 by machine learning (ML) and artificial intelligence, can be blended with any "traditional" scientific discipline. Advanced statistics (in the form of ML) can improve how we analyze data, how much signal we detect from the vast amounts of noise, how quickly we can perform experiments, how we understand the results of these experiments and, perhaps soon, even how we analyze the scientific literature.

This Strategic Plan thus incorporates a gentle message for our scientists to consider computational methods in their "personal" interdisciplinary synthesis.

What's new?

The interim 2020 update of the Strategic Plan mixes elements of innovation and continuity with respect for the plan we conceived in 2018. It is continuous with the 2018 plan because it maintains the structure of the **Research Domains** and their **Priorities**.

It is innovative because it introduces **six new Scientific Initiatives** and **four additional Strategic Research Directions**, and it acknowledges that computational methods are pervasive in science and may therefore enrich any scientific enterprise. IIT's vision (from page 15) has been updated to reflect the introduction of these new elements into the Strategic Plan.

The main motivation for the new grassroots **Scientific Initiatives** is that, while IIT has excellent scientists and research groups, the Institute lacks the project structure to attack large-scale problems. This may be because large problems require extremely transversal skills or much larger teams. In the long run, this may become a limitation of what IIT can achieve. Scientific Initiatives are visionary large-scale collaborations (larger than one-to-one collaborations) across research lines and domains and with well-defined ambitious goals. Initiatives aim to consolidate IIT's presence and visibility in the respective research sector.

Scientific Initiatives were prepared by IIT's scientists and evaluated by the **Scientific and Technical Committee (STC)**. Six were selected because of their scientific quality, their opportunities with respect to global scientific trends, and their compatibility with existing areas of strong expertise at IIT. They will be evaluated on a yearly basis, measured, and possibly confirmed rather than terminated if unsuccessful. In principle, the Initiatives do not receive additional funding. However, PIs are encouraged to use the Initiatives as instruments to attract additional competitive funding (e.g. European), or to strengthen them with a portion of their institutional budgets. We expect successful Initiatives to serve as the basis for the preparation of the next Strategic Plan (starting in 2024).

The six selected Initiatives are: Robotics for a Better Life; Cognitive Architectures; AI for Materials Sciences; Sustainability; RNA Technology; and the Visualization of Nanomaterials in Operando. They are described briefly on page 30 and in detail in the Technical Annex. Not surprisingly, almost all Initiatives have a substantial commitment to computational techniques.

In addition, the updated Strategic Plan includes **four Strategic Research Directions** for investment in the next three years. They are Machine Learning (ML) and Artificial Intelligence (AI) in their own right; Atomistic and Molecular Simulation; Non-Turing Computation; and the combination of Neuroscience with ML and AI. They are described briefly on page 30 and in detail in the Technical Annex. Here too, these strategic research directions are all related to computation. The study of ML and AI is one of IIT's research strengths, with high-quality theory and application to robotics, computer vision, and neural and cognitive sciences. Given the central importance of ML technology in the near future, IIT must leverage this strength and augment its existing activities in deep learning,

reinforcement learning, natural language processing, and so on. IIT was the first Italian institution to join the European network Ellis following competitive selection. Ellis is a network of laboratories working on ML and AI, including the top institutions in Europe.

Atomistic and Molecular Simulation is another of IIT's research strengths with top-class scientists. This must be exploited in the theory of simulations to strengthen complementary research areas. For example, simulations are a key tool for many of IIT's research lines in biology and materials science. IIT aims to become a global reference in this field

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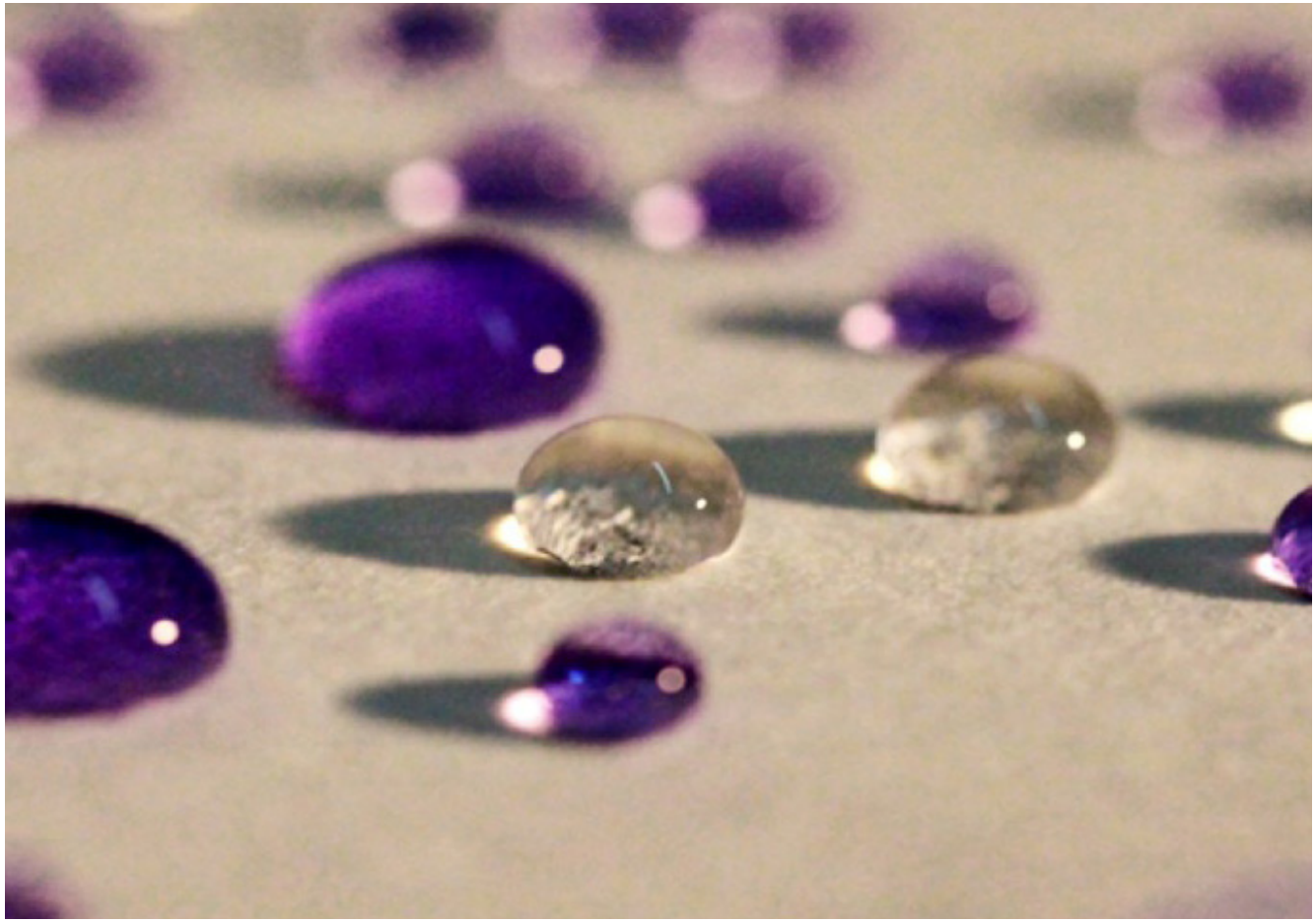
Non-Turing Computation clearly deserves attention, but an in-house approach is impossible at IIT on financial grounds. However, we can feasibly focus on quantum algorithms, which are accessible to existing standardized platforms, and rely on a network of interested parties in Italy and Europe. IIT will pursue this approach proactively, as a key actor in the proposal to build an Italian network for non-Turing computation by tapping national and European funding opportunities (e.g. Flagships).

IIT will promote the combination of ML and AI with neuroscience with the dual goal of more deeply understanding neural phenomena at the systemic level and designing new algorithms modeled on neuroscience experiments. A further priority goal is to promote partnerships between neuroscience and other areas of IIT's research, such as materials science, in the field of neural interfaces.



In its **Technology Transfer (TT) mission**, IIT will invest in two complementary strategic directions to increase its output. The first direction involves **sponsored research contracts and licensing**.

A comprehensive plan to scout, contact, and engage companies will begin in 2021. The goal is to augment our vast network of partner companies to multiply the TT opportunities. The second direction involves the start-up world, where IIT will **further structure its network of VCs, BAs, and funds** to offer a stronger service to our prospective entrepreneurs. The goal is to connect IIT with State-promoted TT initiatives that were recently launched in Italy.

The project's umbrella structure is called "IIT^4". IIT^4 aims to create a **start-up incubator/accelerator** in Genoa as part of a larger European Digital Innovation Hub infrastructure. This strategy will receive funding from the State and from Horizon Europe programs. As part of IIT^4, the infrastructure in Genoa will be expanded to host the industrial robotics facility, several Joint Labs with industry, a European facility, and other projects. This expansion began in 2020, with robotics as the starting point. Later expansions are planned for the areas of space, sustainability, and healthcare.

An important **strategic change in the Brain Magnet Program** is how new Tenure-Track or Tenured positions are created and how new principal investigators are selected. These new positions will complement and reinforce the RDs and existing programs, rather than expanding into completely new fields. ERC and other individual prestigious grants are still important but are no longer the sole factor in deciding whether to open a research line.

The Strategic Plan launches several new training and education programs, described on pages 38 and 41. These include a **virtual PhD school** to organize IIT's existing doctoral courses and training programs, a **mentoring program** to support our researchers (especially the younger ones) in career building, and a **stronger equal opportunity program** (with the creation of a Diversity and Inclusion Office).

The infrastructural updates and upgrades will take place in line with the original Strategic Plan. The expansion of the **headquarters in Genoa will be completed by 2022** with 5 fully functional Centers (i.e. buildings) guaranteeing adequate room for all laboratories (see page 21). The **network of IIT's Centers** (the academic network, see page 41) will also be consolidated (but not expanded) according to the original plans. This will involve on-site visits, recommendations, and detailed action plans defined with the STC, including attracting new PIs, merging activities, and increasing the space where needed.

The **Horizon 2020** European RTD program **ended in 2020**. The Strategic Plan therefore analyzes IIT's position relative to the first calls of the new **EU Horizon Europe program** (section: A Strategic Plan Designed for Europe). The Strategic Plan defines a series of actions to strengthen participation in European programs. IIT's plans align particularly well with at least four of the EU Commission's six headline ambitions. IIT's plans align with the following areas of new interest of the Commission: the Green Deal, healthcare (with specific Missions), and AI.
2020 was also the year of the **Covid-19 pandemic**. IIT has been active in numerous projects, which are briefly reported on page 53. However, the Strategic Plan does not envisage a specific Covid-19 research direction. IIT can certainly provide specific know-how, but the Institute does not have a full program to intervene in the consequences of the pandemic. Therefore, IIT's approach will be that of partnering with a variety of actors (institutions, hospitals, companies) as opportunities arise to deliver specific know-how in the battle against the virus.

This Strategic Plan also envisages innovation in **IIT's communication and promotion plan**, in areas where the Institute is strong and unique. This is one of the strategic targets (described on page 37) and part of the implementation (see: "**Implementation: Enabling Strategies**"). As stated on page 37:
"State-of-the-art scientific infrastructures, transparent international peer-reviewed evaluation, and a high-quality international environment have made IIT a place of opportunity for interdisciplinary research."

There is a strong impulse to ensure that IIT remains the "place of opportunity".

The Istituto Italiano di Tecnologia (IIT)

The Istituto Italiano di Tecnologia (IIT) is a Private Foundation, established by the State at the end of 2003, and regulated by article 14 et seq. of the Italian Civil Code.

IIT is predominantly financed by the State with the goal of stimulating technological development, technological training, and higher education, in line with Italy's scientific and technological agenda. IIT's ultimate objective is to foster the innovation and competitiveness of Italy's production system.

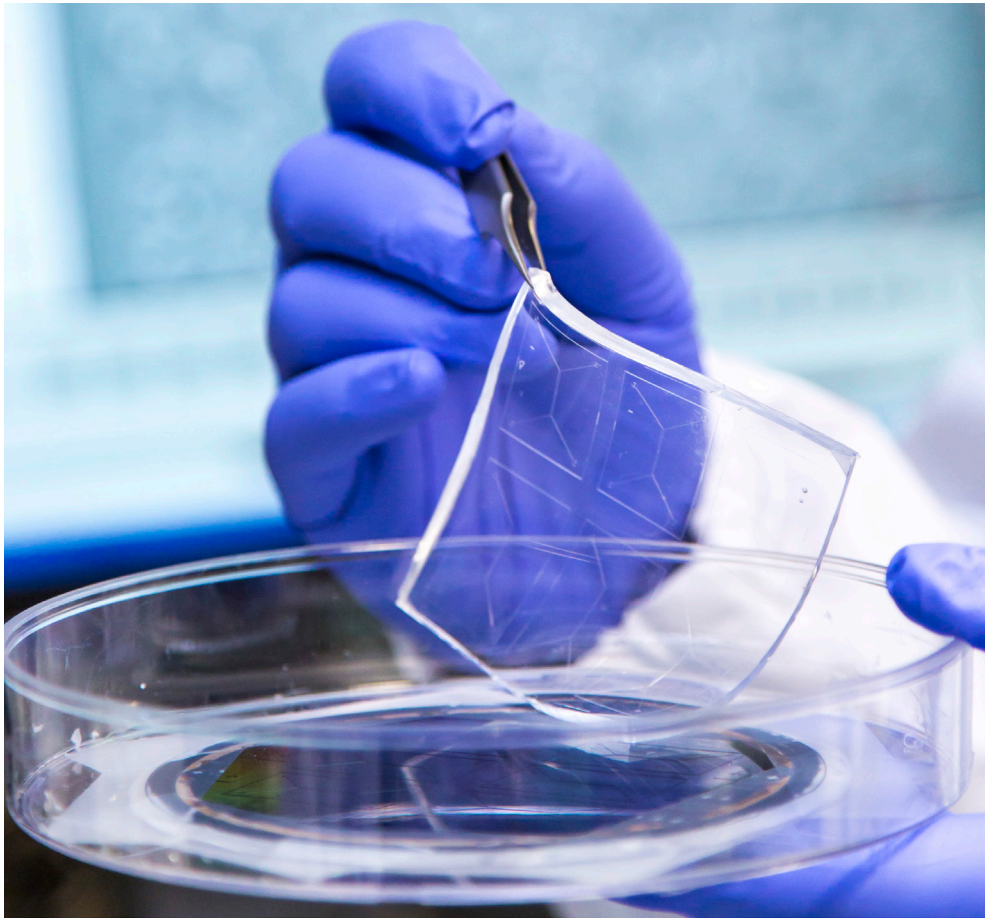
IIT develops a program of basic and applied research with the aim of transferring research results to companies for commercial exploitation.

IIT's activities include the development of scientific capacity, the construction and maintenance of state-of-the-art research laboratories, the development of excellent practices and positive competition, training and higher education at the postgraduate level, the creation of programs to attract talent, and the broad dissemination of knowledge and scientific results.
IIT operates in four Research Domains (RDs): Robotics, Nanomaterials, Technologies for Life Science, and Computational Sciences, with a distinctive multidisciplinary approach to the pursuit of excellence.

Since its establishment, IIT's driving force has been the development of new knowledge and its translation into concrete applications in a fully interdisciplinary approach. With its first strategic plan, the Humanoid Technology Program (2009-2011), IIT introduced the concept of bioinspired intelligent machines to support humans in everyday life. This concept brought together disciplines such as neuroscience, nanotechnology, and mechatronics, which had often barely communicated with each other.

The 2012-2014 plan expanded this interdisciplinary vision by introducing the concept of Translating Evolution into Technology, i.e. systematically mimicking natural systems to develop new technologies in the fields of robotics, materials science, and life science. This created the

Figure 1: IIT's Central Research Laboratories in Genoa and the location of the Centers in Italy.



knowledge basis for the most recent strategic plan of 2015-2017: an interdisciplinary research program centered on the Human Being. In accordance with this plan, IIT started to apply different bioinspired technologies to healthcare, sustainability, and personal assistance.

The new 2018-2023 Strategic Plan revolves around Human-Centered Science and Technologies (see: Our Vision). More specifically, in the first three years (2018-2020) the newly defined RDs were established and consolidated, while several infrastructural upgrades were completed, including the genomic facility in the new Center for Human Technologies, the high-performance computing cluster for atomistic and molecular simulation and AI and ML research, and the new extreme conditions laboratory to support nanomaterials research.

Fourteen years after the inauguration of its headquarters in Genoa, IIT is well into its second decade with a solid critical mass of infrastructure, people, and skills. As of 2020[1] , the Institute comprises five large Centers in Genoa (see Figure 1), an additional 11 Centers across Italy, and two outstations in the USA (Boston area), for a total of more than 50.000 m^2 of laboratory space.

IIT's staff comprises around 1.750 people from 64 countries with an average age of 36. Among IIT staff, there are 22 different scientific profiles from medicine to engineering, and around 80 principal investigators, including 32 ERC winners (with more under negotiation).
IIT staff have generated more than 14.500 scientific publications, more than 700 industrial projects, 22 Joint Labs with companies and/or research institutions, 261 European projects, 24 start-ups (with several more business ideas in development), and about 1.000 patents.

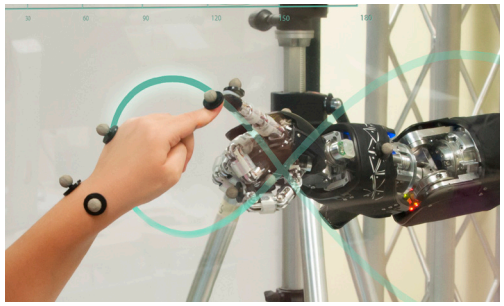
We are highly motivated, enthusiastic, skilled, and mostly young researchers, technicians, administrators, and support staff who work every day for humanity's common good.

[1] Unless otherwise indicated, all IIT's statistics, facts, and figures are as of August 2020.

Our values

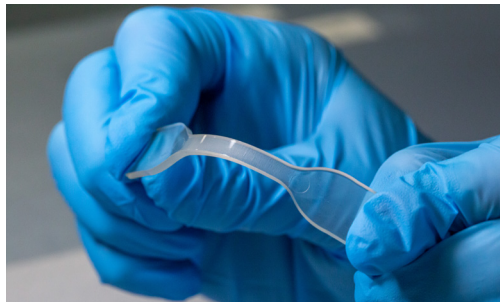
Integrity

We adhere to scientific and moral integrity. We value and strive for openness, honesty, authenticity, sincerity, and transparent behavior. We communicate transparently.



Societal responsibility

We aim to benefit humanity worldwide. We strive to help society develop for the common good.



Courage

We like challenges and we face them with determination, striving for excellence

Inclusion

We welcome and cherish diversity in every form. We do not tolerate discrimination in any form. We are always inclusive, respecting individual freedom.

Our vision

IIT's research vision reflects our overarching priority of developing Human-Centered Science and Technology with an approach that is not merely multidisciplinary, but rather merges different skills and expertise into a truly interdisciplinary synthesis[2].

In line with this vision and the Institute's scientific identity, the Strategic Plan identifies four Research Domains (RDs) to be developed over the period 2018-2023, namely, Robotics, Nanomaterials, Technologies for Life Science (LifeTech), and Computational Sciences. Each domain identifies well-defined Priorities to consolidate IIT's leadership in research/technology areas and to explore innovative high-risk/high-gain ideas.

To foster IIT's vision of true interdisciplinary synthesis, the 2020 update launches several new Scientific Initiatives by grouping our principal investigators (PIs) under the umbrella of coherent research directions. Initiatives are visionary research directions that leverage IIT's unique standing and excellent research infrastructure to lead us where no one has been before.

Initiatives contribute to IIT's positioning in the respective fields, in training young scientists and, importantly, in creating the necessary critical mass for ambitious projects. Initiatives further contribute to addressing the big societal challenges defined in the Strategic Plan, namely, sustainability, healthcare, and the aging population.

[2] Mind meld, Interdisciplinary science must break down barriers between fields to build common ground. Nature 525, 289–290 (17 September 2015) doi:10.1038/525289b

Research

Robotics and Nanomaterials are the core areas of IIT's excellence.

In the Robotics RD, there is well-established activity on humanoids, human-machine interaction, and robotic rehabilitation.

In addition, there will be an expansion of research in soft robotics and companion robots, supported by the new artificial intelligence (AI) and machine learning (ML) teams established in collaboration with the Computational Sciences RD.
The Nanomaterials RD will continue to develop its basic materials science research in nanocomposites, environmentally friendly materials, colloidal chemistry, and graphene-based compounds. The Nanomaterials RD will progressively expand its technological activity to target new solutions for energy storage, photovoltaic devices, and biodegradable materials. Important new developments are expected in nanosensors and nanomaterials for medical therapy, high-sensitivity diagnostics, and food tracing.
The LifeTech RD's research direction is evolving from basic neuroscience (the focus under the previous Strategic Plan) to patient-centered technological platforms. These technological platforms are co-designed in collaboration with research hospitals and clinical research institutes (IRCCS). The patient-centered approach involves a broad combination of scientific expertise, including genomics and RNA technologies, nanomaterials, robotics, and computational sciences.

4 research domains
- robotics
- nanomaterials
- life tech
- computational sciences

€120M annual investment

30% external funding

1.750 staff members

The LifeTech RD will build an interdisciplinary framework to co-develop technologies for healthcare, including genomics, robotic-assisted surgery and neurorehabilitation, optical and electronic sensing, and patient-tailored theranostics.

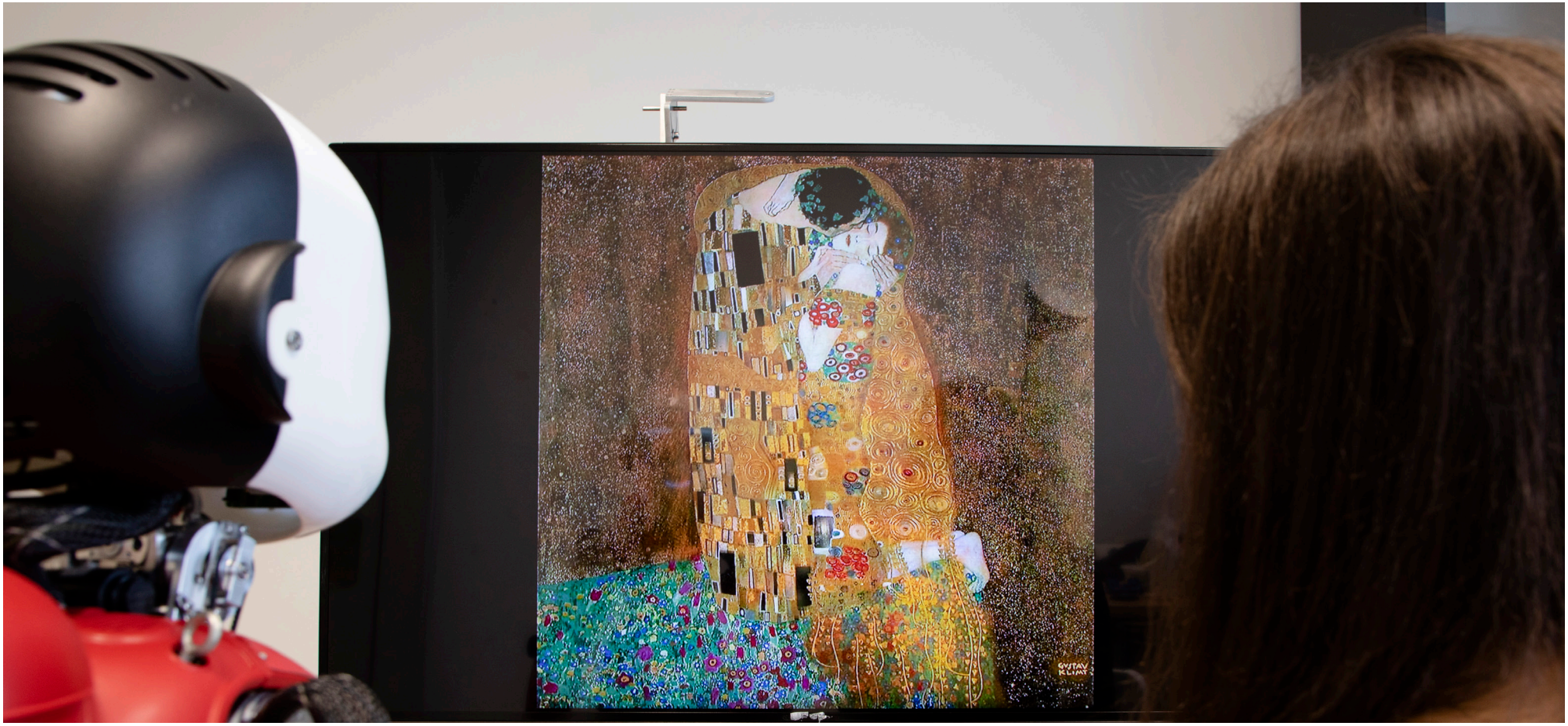
Finally, the Computational Sciences RD will substantially expand the COMPUNET initiative, which was launched during the 2015-2017 Strategic Plan. Its core areas will be multiscale modeling, high-performance computing (HPC), AI, and ML. The core areas of the Computational Sciences RD will form a transversal knowledge base, so that modeling and computing can be applied to all research areas, from materials science and biology to robotics.

The last few years have witnessed the application of computational techniques to almost every scientific endeavor. Data are being generated at an ever-increasing rate. Their interpretation requires computational power and advanced processing methods. New automatic methods and in silico approaches are creating new possibilities to drive science forward. AI and robotics are used to produce and analyze omics data to bring order to biological complexity.
They are used in chemistry to guide synthesis, automate experiments, simulate molecules, and discover potential new drugs. They are naturally also used in robotics to build robots that can have safer and more natural interactions with human workers and patients.

This rapidly evolving scenario creates new challenges and requires that IIT update our strategies to maintain our leadership in research. Our response is to launch several new Scientific Initiatives and, simultaneously, to adjust our research focus by promoting the inclusion of computational techniques in the development plans of the RDs.

2 targets
- industry
- clinics

2 strategic directions
- licensing
- start-ups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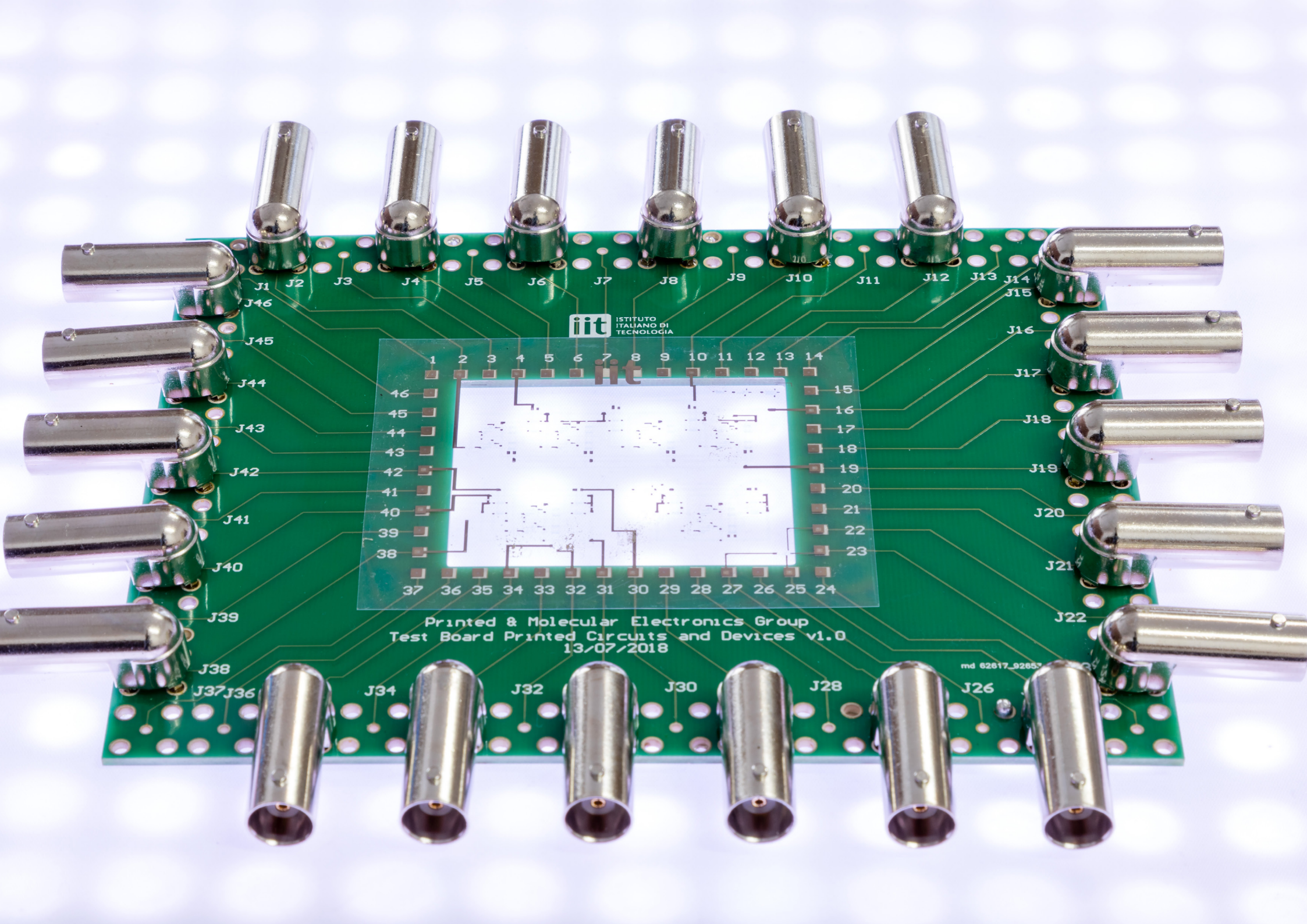
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Technology Transfer

Technology Transfer (TT) is one of IIT's two foundational pillars. TT will target two main application areas:

- Translating technologies to industry and to the production system by developing joint research programs with industry and by exploiting IIT's large patent portfolio to create new start-ups.

  We will promote the creation of Joint Labs with national and international companies in all research areas of the Strategic Plan.

- Translating technologies to healthcare by co-designing and transferring IIT technology platforms (e.g. robots, sensors, materials, genomics) to the healthcare sector for innovation in surgery, diagnostics, and therapy.

  Initially, we will promote joint research programs and Joint Labs with research hospitals and clinical research institutes (IRCCS). Subsequently, we will focus on innovation programs with companies.

The TT strategy is built on traditional Sponsored Research Agreements with companies, IP protection and consequent licensing, the creation of Joint Labs with companies or research institutions, and the creation of start-ups.

To increase opportunities for entrepreneurship originating in IIT, additional initiatives will be launched in the next three years. By the end of 2021, the IIT incubator[3] will become operational, offering laboratory and workspace to start-ups in the Erzelli Science Park in Genoa. A business accelerator will also be launched to support early-stage technology ventures from IIT or, more generally, to support the technological acceleration of companies at any stage of development.

In summary, IIT's TT strategy has two main directions:

1. Patenting and licensing: we will structure and expand our industrial network with structured scouting activities and direct outreach actions. This area includes activities to select and actively contact companies to promote IIT's technologies and solutions. In particular, this project aims to increase the number of Sponsored Research Agreements, the value of license agreements, and the number of Joint Labs, as described above.

2. Incubation and acceleration: we will organize our venture capital network with investors, private stakeholders, and new public initiatives (e.g. participation in the European network of Digital Innovation Hubs). This area envisages a structured action to create a business accelerator to multiply the opportunities to transfer IIT's technologies. The target is to create new start-ups and increase TT to established companies. The accelerator, named "IIT[4]", has attracted the interest of a major public investment fund[4]. The current plan envisages a broad focus on robotics and AI, with verticals in industry, space, healthcare, and sustainability.

[3] Agreement between IIT, a public investment fund, and Regione Liguria.

[4] Currently in negotiations.

Human Capital and High-level Education

Excellence in recruitment will be IIT's key success factor. To reach steady state (estimated at around 1.800 people, given the current level of extramural funding), new PIs will be hired according to the highest international recruitment standards. IIT's main instrument in securing top-quality human capital will be its globally competitive tenure-track program.

Ad hoc measures, such as the Brain Magnet Program (see: Implementation: enabling strategies), will enhance the Institute's attractiveness to recipients of prestigious individual research grants (e.g. ERC, Armenise), and further improve IIT's excellent research quality. Similarly, new international agreements for PhD positions and junior postdoc selection through European Networks of Excellence (e.g. the Marie Skłodowska-Curie Actions) will strengthen IIT's high-level education.

In the period 2020-2023, IIT will structure its high-level education programs into a virtual PhD school. This will serve as a unified entry point to all education activities, including soft skills, TT, patenting, grant preparation, open science, and data management. Simultaneously, a mentoring program will be launched to support our researchers throughout their IIT career and to help them build a career outside IIT.

Equal opportunity, career building, and diversity activities will be strengthened with several specific initiatives. The starting point will be the creation of a Diversity and Inclusion Office to coordinate all actions around equal opportunity and gender gaps, aligning IIT with international standards.

50 PIs in the tenure-track system

82 research lines

A new virtual PhD school

A new diversity & inclusion office

5 sites in Genoa

50.000 m^2 of labs

11 centers in Italy

2 outstations in the US

Completion of IIT's Infrastructure

In the next three years, IIT's infrastructural expansion of its laboratories on the west side of Genoa will be completed with the creation of the Center for Robotics and Intelligent Systems (CRIS; San Quirico Building). CRIS joins the Center for Human Technologies (CHT; at the Erzelli Science Park), which was opened in mid-2019.

IIT has begun expanding its industrial robotics laboratories in the Center for Joint Industrial Research (CJIR; at the Business Incubation Center also on the west side of Genoa), which will host the abovementioned business accelerator IIT[4]. These expansions have been almost entirely funded by donations and agreements with local institutions.

The CHT will connect to a network of research hospitals and clinical research institutes (IRCCS), under the umbrella of a national agreement with the Ministry of Health and Regione Liguria, to accelerate the exploitation of different IIT technology platforms in the field of healthcare.

The infrastructure updates for IIT's network of Centers will take place according to the standard timing of the periodic on-site evaluations. In 2018, IIT and the Cà Foscari University in Venice launched a new Center for materials and digital technology for cultural heritage, with a program to translate IIT's technology into a new application domain. In 2020, we began reorganizing the Centers in Milan (CNST, CGS), Pisa (CNI, CMBR under the new name of CMI), Trento (CNCS), and Rome (CLNS) in order to improve the infrastructure following considerable growth in the number of PIs and the amount of extramural funding. Interactions between the Centers and the headquarters in Genoa will be strengthened by new Scientific Initiatives and existing one-to-one collaborations.


OLYMPUS
JAPAN
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Axon Instruments

Our mission

The Strategic Plan is designed to fulfill IIT's statutory twin mission:

- **Scientific Mission**: To conduct cutting-edge research, generating new knowledge at the forefront of science and technology.
- **Technology Transfer Mission**: To transfer technology to the production system and to society. This mission's end users are companies and clinical institutions.

The two missions are closely connected, with new knowledge and discoveries giving rise to new technology. To translate pioneering research ideas into invaluable technology in a realistic timeframe, one must work hard to balance basic research and technological development.

To implement IIT's Human-Centered Science and Technology vision, the 2018-2023 Strategic Plan defines four Research Domains (RDs): Robotics, Nanomaterials, Technologies for Life Science, and Computational Sciences. By leveraging our recent success, the four RDs aim to consolidate IIT's high-quality research and to identify new cutting-edge development areas to investigate in the coming years. The RDs focus on selected scientific and technological Priorities, which are designed to blend curiosity-driven and technology-driven research with a strong interdisciplinary commitment. The Strategic Plan envisages the combination of research and technology in order to positively impact some of the most important societal challenges of the 21st century, namely:

- **Sustainability and the Environment.** These challenges include research and technological progress in water cycle/water remediation, waste recovery and biodegradability, sustainable materials by design, food traceability, and smart packaging.

- **Healthcare.** This challenge includes research and technological development for robotic surgery, drug delivery and diagnostics, personalized approaches to medicine with a special emphasis on RNA technologies and the genomics of the noncoding portion of the genome, and the computational modeling of complex multiscale systems.

- **Aging Society.** This challenge includes research and robotic technology for disabled individuals or the elderly, robotic assistants and companions, the investigation of neurodegenerative diseases, neurorehabilitation, and prosthetics (hand, retina, exoskeletons).

These challenges reflect the priorities of Horizon 2020, the recently concluded European Framework Program. They will be maintained in the upcoming Horizon Europe Framework Program, particularly in the Program's targeted Impacts and Missions.

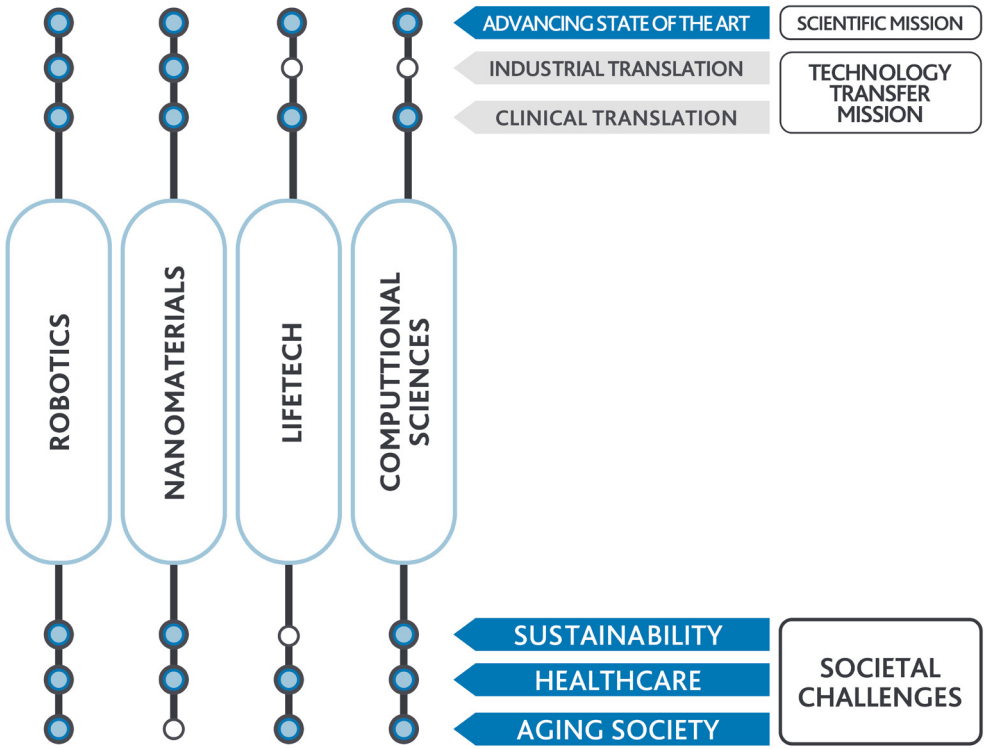


Figure 2: Architecture of the Strategic Plan: RDs, their expected contribution to IIT's twin mission, and their impact on societal challenges.

Strategic Plan Architecture

Figure 2 (previous page) schematically depicts the Strategic Plan's architecture, highlighting the contribution of the four Research Domains (RDs) to IIT's mission and the impact of the research results on the above-mentioned societal challenges. RDs are expected to contribute to advancing the state of the art in their respective fields (Scientific Mission) and to developing new technologies (Technology Transfer Mission) to benefit industry and/or clinics. Research impact on the societal challenges will reflect the specific technological orientation of each RD.

In addition, the Technical Annex defines a number of Scientific Initiatives, meant to add momentum to and define clear development goals for certain subsets of IIT's research. Initiatives include robotics for better life, cognitive robotics, artificial intelligence (AI), RNA technologies, and sustainability (see pag. 30).

Initiatives are cross-RD interdisciplinary endeavors with concrete and measurable goals and will form the basis of IIT's evolution from 2023 onward. Initiatives are briefly introduced in the "**Scientific Initiatives and additional research directions**" section and presented in full in the Technical Annex.

Below, we outline the RDs' activities and the rationale for the selected Priorities. Figure 3 shows the Priorities for each RD.

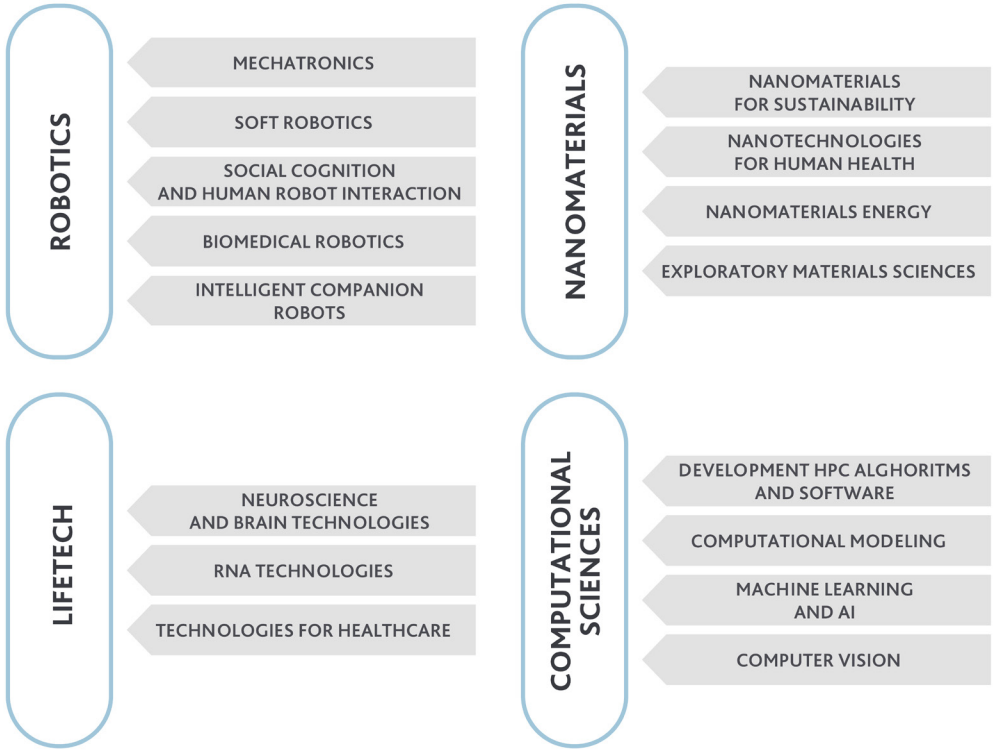


Figure 3: Strategic Plan 2018-2023, the Research Domains (RDs) and their Priorities.

Robotics

The Robotics team comprises 239 scientists and PhD students, and 81 technicians. There are 11 Principal Investigators (PIs) and 6 ERC grant holders.

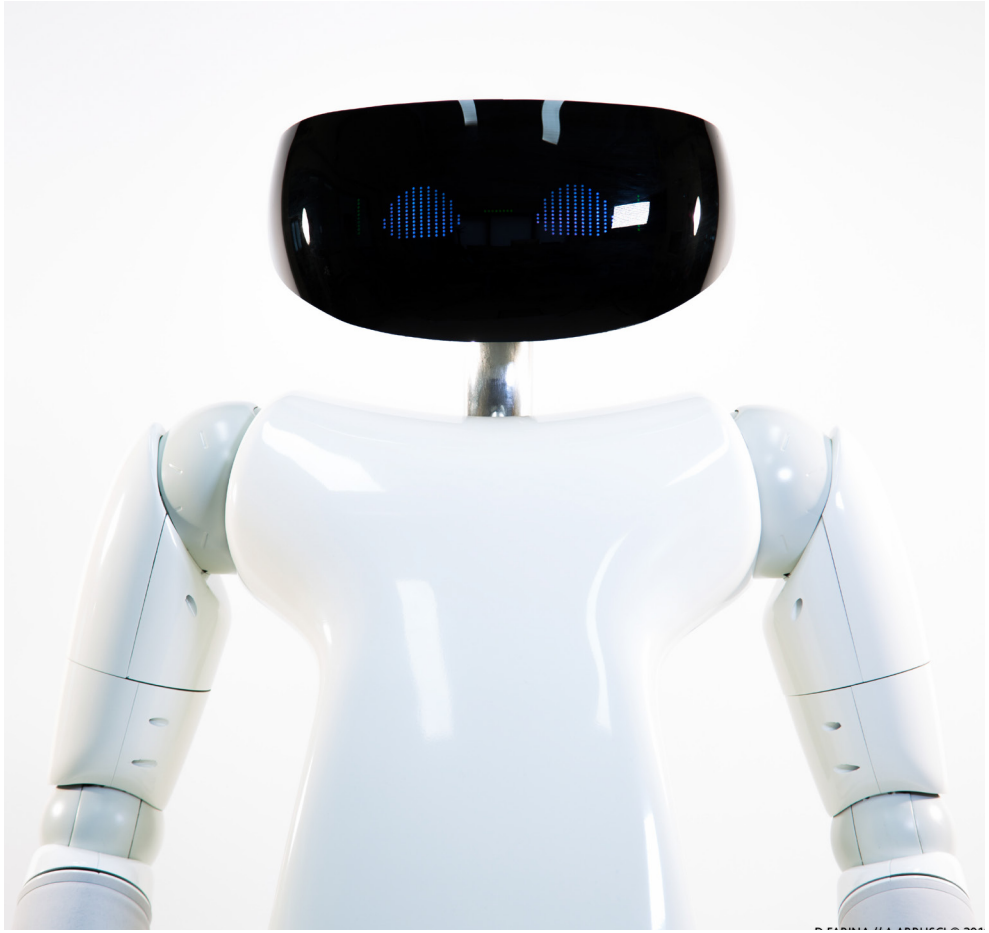
The Robotics RD is involved in 27 ongoing European projects and has produced 153 patents. Robotics will continue along the successful path developed in the past ten years.

The Robotics RD comprises five Priorities. Mechatronics, Social Cognition and Human Robot Interaction, and Intelligent Companion Robots are predominantly basic-research priorities, for which IIT has already achieved international leadership with its humanoid robots, socially attuned robots, and robotic rehabilitation platforms. These activities will be further strengthened in the new 10.000 m² facility in Genoa (CRIS, San Quirico Building) and the additional 1500 m² of the CJIR (Center for Joint Industrial Research), which will also host Joint Labs with, among others, Moog, Camozzi Group, and INAIL in the field of rehabilitation robotics.

The important technological outcomes of these Priorities will include next-generation robots for application in the fields of service robotics, human assistance, and disaster recovery.

The Soft Robotics Priority originates from the pioneering work on the plantoid robot and bioinspired technologies. A new dedicated laboratory with additional staff in the CCT (Morego Building) will strengthen this Priority's activities.

Biomedical Robotics will be the most technology-oriented Priority, developing new technologies for surgery, rehabilitation, and prosthetics in collaboration with a large research network of research hospitals. The Biomedical Robotics Priority will focus on technology transfer (TT) to healthcare applications.



Nanomaterials

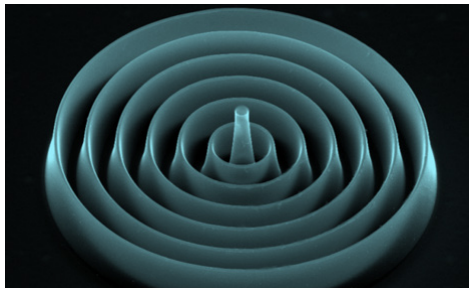
The Nanomaterials team comprises 366 scientists and PhD students, and 32 technicians. There are 24 PIs, including 12 ERC winners and the only Italian Coordinator of a Marie Skłodowska-Curie Cofund Network.

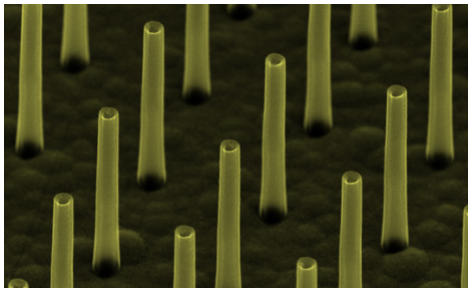
The Nanomaterials team is involved in 26 European projects and has produced more than 300 patents. The Nanomaterials RD has developed innovative science and technologies in the fields of environmentally friendly materials, colloidal chemistry, 2D compounds, and novel devices for sensing and energy conversion.

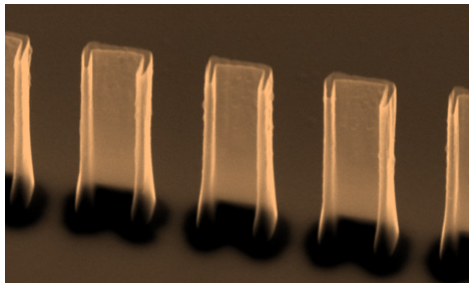
The Nanomaterials RD identifies four Priorities. The Nanomaterials for Sustainability and Nanomaterials for Energy Priorities build upon this RD's internationally recognized activities in the field of nanocomposites, biodegradable materials, and graphene. Some of these activities originated from and will be developed further within the framework of the European Flagship Graphene (recently renewed for an additional three years). These Priorities balance basic and applied research activities to contribute to the Scientific and TT Missions.

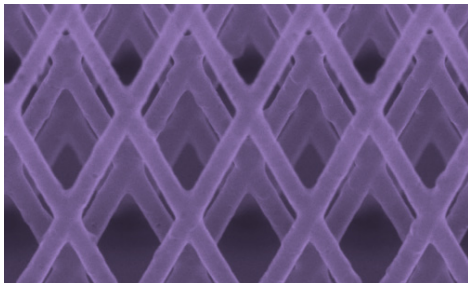
The Nanomaterials for Health Priority, strengthened by three new ERC grants, aims to develop drug carriers and high-sensitivity sensors for therapy and diagnostics. These activities will expand in collaboration with a network of research hospitals and clinical research institutes (IRCCS), which is being established under the umbrella of the Ministry of Health. This Priority balances curiosity-driven and applied research.

Finally, the Exploratory Materials Sciences Priority brings together several teams conducting research in colloidal chemistry (where IIT is a world leader), together with polymer synthesis and 2D materials. This research has a strong impact on many of IIT's other key areas, such as energy, optoelectronics, and biomedical applications. It is further strengthened by the new laboratories for ultra-high-resolution microscopy, time-resolved electron microscopy, and materials science









under extreme conditions (temperature and pressure), which will establish new standards for investigating matter at nanoscale (propelled by several new ERC winners).

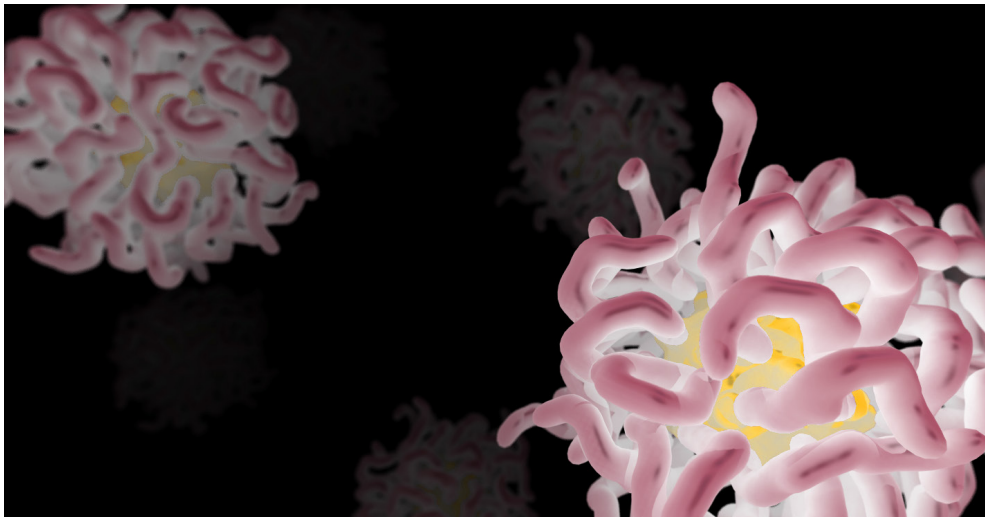
Overall, TT in the Nanomaterials RD has grown remarkably in recent years. We foresee a growing demand for IIT technologies in the fields of diagnostics and sensing, materials for packaging, and healthcare. This is consistent with the Joint Lab initiatives with Nikon, Novacart, Enel-Nissan, Camozzi Group, and several research hospitals.

Technologies for Life Science (LifeTech)

The LifeTech team comprises over 343 scientists and PhD students, and 39 technicians. There are 30 PIs, including 14 ERC grant holders.

The LifeTech team is involved in 27 European projects and has produced 170 patents.

Research in life sciences at IIT has evolved considerably in the past few years. Investment in basic molecular neuroscience has been reduced, and drug development activity has been transformed into a Facility to support basic research questions. The focus is increasingly on genomics and new technologies for healthcare.



The LifeTech RD comprises three Priorities. The Neuroscience and Brain Technology Priority will carry out most of the fundamental research into neuroscience and cognition. It will develop new tools for brain recordings on multiscale levels. The RNA Technology Priority will implement new platforms for RNA-based drugs for personalized medicine, building on discoveries about the noncoding portion of the genome. Finally, the Technologies for Healthcare Priority will develop innovative technology platforms for healthcare, including sensors for detecting single biomolecule events, noninvasive devices for recording brain activity, nanoparticles for diagnosis and drug release, robots for surgery and rehabilitation, technologies for visually impaired people, and software and high-performance computing (HPC) methods for genomics and neuroscience.

The co-development of these technologies will benefit from the interdisciplinary collaboration of researchers across the RDs, with about 50 scientists from the Robotics, Nanomaterials, and Computational Sciences RDs contributing to this Priority. Collaborative clinical projects will be established to analyze large-scale genomic and medical data for personalized medicine, with a focus on the role of the noncoding portion of the genome.

A key facilitator of this Priority will be the Center for Human Technologies (CHT) at the Erzelli Science Park and IIT's Center for Genomic Science (CGS) in Milan. CHT comprises a state-of-the-art genomic facility and IT infrastructure, laboratories dedicated to theranostic robotics and point-of-care diagnostics, and an interdisciplinary computational laboratory.

As part of CHT, several initiatives are in place with the Ministry of Health and Regione Liguria to accelerate TT to the clinic. These initiatives include establishing Joint Labs with research hospitals and clinical research institutes (IRCCS) across Italy. The CGS supports the integration of genomic technologies with biomedicine at the single-cell, single-molecule omics level.

Computational Sciences

The Computational Sciences RD has grown considerably since its origins in COMPUNET, the computational sciences network launched as part of the 2015-2017 Strategic Plan.

The Computational Sciences team now includes 150 scientists and PhD students and 8 technicians. There are 13 PIs, including 2 ERC grant holders. The Computational Sciences team is involved in 5 European projects and has produced 58 patents.
The Computational Sciences RD comprises 4 Priorities.

The Development HPC Algorithms & Software Priority will build computational infrastructure and internal skills in algorithm and software development, focusing on TT and applications.

The Computational Modeling Priority will involve curiosity-driven research with the transversal application of advanced theoretical methods to problems generated by other RDs, including materials design, molecular dynamics, and computational chemistry.

The other Priorities (Machine Learning and Artificial Intelligence, and Computer Vision) will develop their own basic research, while supporting the activity of the Robotics, Nanomaterials, and LifeTech RDs. The transversal impact of the Computational Sciences RD on all of IIT's scientific activities is a major asset for IIT's research.

Scientific Initiatives and Additional Research Directions

The 2020 update of the Strategic Plan introduces Scientific Initiatives in order to bring together and organize the activities of several research lines across RDs.

The goal is to tackle problems that cannot be addressed by a single team, either because the required skillset is too broad or because the problem is too big or difficult.

Initiatives are well-defined and visionary with a broad scope and a reasonable time horizon (4 years). They are subject to evaluation according to standard IIT procedures. They are meant to structure technical projects, create critical mass, increase IIT's visibility in a specific field, attract talented researchers, and build complementary and integrated expertise.

Title	LifeTech	Robotics	Comp Sciences	Nanomaterials
Artificial Intelligence and Automation for Materials Science		•	•	•
Visualization of Functional Nanointerfaces in Operando: from Fundamental Processes to Device Design (VISPI)				•
iCog: the iCub Cognitive Architecture	•	•	•	
Sustainability	•	•	•	•
The RNA Initiative	•		•	•
Robotics for a Better Life		•		

Table 1: The six Scientific Initiatives defined in the 2020 interim update of the Strategic Plan.

This interim update of the Strategic Plan also highlights themes of increasing importance to science, particularly the growing computational power being employed in any scientific area. This computational power impacts and supports progress in every scientific field, particularly in IIT's "traditional" RDs. The opportunities generated by the Computational Sciences RD must therefore be widely exploited.

Increases in computational power have led to a renaissance in AI and advanced statistical techniques in the form of machine learning (ML). These are used to interpret data generated by quantum and material simulations, to extract meaningful correlations from omics data, and to control sophisticated robots of various shapes and skills. To this end, we have identified additional research directions to guarantee that IIT plays a leading role in new computational developments in science. These research directions are: (i) Artificial Intelligence, (ii) Atomistic and Molecular Simulations, (iii) Non-Turing Computation, and (iv) Integrative Neuroscience. IIT will therefore progressively steer part of its yearly investment into disciplines connected to computation.
Table 1 lists the Scientific Initiatives and how they intersect with the RDs, making clear how much these large-scale projects leverage IIT's interdisciplinarity. The Initiatives will be launched in 2021 and monitored until 2023 (end of the current Strategic Plan). The Scientific Initiatives will form the initial backbone of the next Strategic Plan, which will be drawn up in 2023 and launched in 2024.

Both the Initiatives and the additional research directions are described in detail in the Technical Annex.

The Technology Transfer Strategy

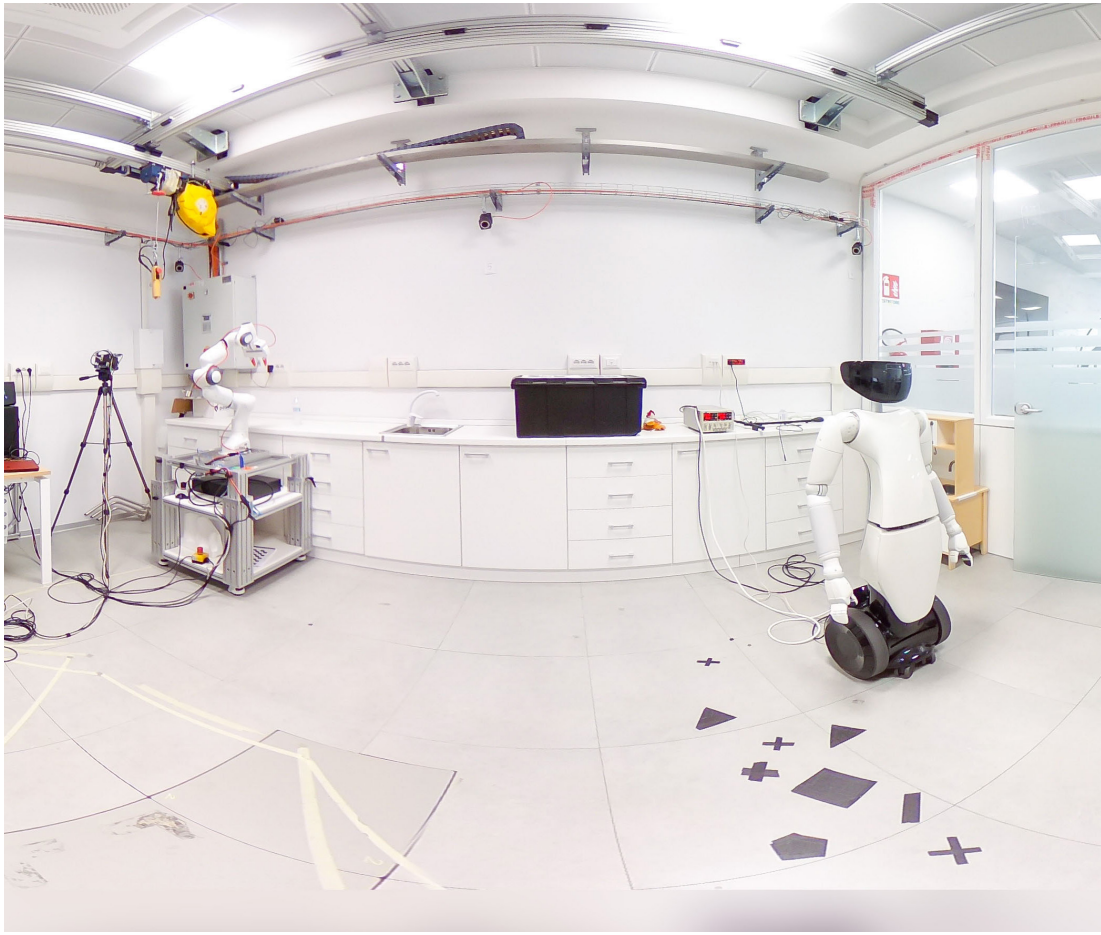
TT is a fundamental component of IIT's core mission. TT activities have grown considerably with IIT's growing intellectual property (IP) portfolio and collaborations with industry in Italy and abroad. IIT has established a network of companies that has resulted in more than 700 sponsored research agreements, more than 1.000 patents, 21 Joint Labs with companies and research institutions in Italy and abroad, and 24 start-ups. The Joint Labs have raised more than €41M in funding in the past five years. In the same period, IIT start-ups raised more than €90M in funding and employed around 170 people. Additionally, extramural funding created about 500 research positions.

TT will be central to IIT's strategy, with a focus on two main areas:

- Translating technologies to industry and to the production system. We will develop joint research programs with industry and exploit IIT's large patent portfolio to launch new start-ups and Joint Labs with national and international companies in all research areas of the Strategic Plan.

- Translating technologies to healthcare and clinics. We will co-design and develop technologies for healthcare, surgery, diagnostics, and therapy via joint research programs and clinical trials with clinical and medical research institutions, and via Joint Labs with research hospitals.

Although "hard" technologies (e.g. from robotics and materials science) are typically transferred to industry, they often also find application in physical and cognitive rehabilitation. This is the result of strong cross-fertilization between engineering, nanotechnology, and life sciences. Clinical and healthcare translation thus forms the second area of IIT's TT strategy. The network of IIT's industrial partners already supports the transfer of research results to industry. Similarly, for healthcare applications, a solid network of clinical research institutions is fundamental



to co-designing and adapting IIT's technologies for clinical translation. This network is being built under the umbrella of different bilateral agreements between IIT, Regione Liguria, and the Ministry of Health. It already includes several Joint Labs with clinical research institutes in Genoa and across Italy.

More specifically, IIT's TT strategy will develop in four main directions:

I. Sponsored Research Agreements with companies.

On average, IIT carries out more than 80 industrial projects every year, ranging from short-term to strategic and long-term partnerships. In 2018, IIT created an industrial robotics laboratory to improve responsiveness to companies seeking collaborative R&D. In 2020, IIT launched the Center for Joint Industrial Research (CJIR) in an agreement with Regione Liguria (FILSE) with 1.500 m² of space in the Business Incubator Center (BIC) in Genoa. Once completed (2021), the CJIR will host the robotics industrial laboratories, a shared EU facility for testing walking robots, several Joint Labs with companies, the nodes of the Italian Competence Centers (Artes 4.0, Start 4.0), and form the seed for the development of a European Digital Innovation Hub as part of the Digital Europe program. "4.0" will be a key activity of the 2021-2023 Strategic Plan, including digitalization challenges in industry (Industry 4.0), health (Health 4.0), and art (Art 4.0). IIT has invested in digital capacities such as HPC and AI because computation will be key to the TT strategy. The initial team at CJIR will comprise approximately 50 researchers and technicians, mostly funded through external grants. In parallel, IIT has intensified its interactions with research hospitals and clinical research institutes (IRCCS) in order to foster TT to healthcare.

IIT's main conceptual development is to work directly with research hospitals to co-design, optimize, and test new healthcare technologies. In particular, the Joint Lab with INAIL on rehabilitation robotics was recently expanded to include additional projects with funding of more than €15M.

II. Protection of IIT's IP and Licensing. The above activities have positively impacted IIT's IP. The patent portfolio has grown consistently, with more than 1000 filed and active patents as of August 2020. These are distributed as follows: Robotics (22%), Nanomaterials (45%), LifeTech (25%), Computation (8%). The patent portfolio is steadily growing thanks to the combined effort in developing basic research, curiosity-driven programs, and TT programs.

License revenues have increased in the past five years thanks to continuous dissemination and networking efforts with companies and investors. The income from licensing covers more than 40% of the cost of patenting activities and, as of 2020, the remainder (60%) is covered by overheads and surplus from industrial projects enabled by the same IP. In future, IIT will continue to protect new inventions internationally, while surrendering patents that have not attracted industrial interest in the previous 5 years.

III. Creation of Joint Labs. Joint Labs are centers with ambitious mid-to-long-term industrial R&D targets, developed jointly by IIT and a partner company, with a direct return on industrial production/technology. Joint teams of researchers work side by side at IIT or at the industrial partner's production sites. IIT and the companies share R&D programs, roadmaps, resources, and IP resulting from Joint Lab activities. To date, Joint Labs have been established on IIT sites by international market leaders, such as Nikon, Moog, Nissan Motor Co., Honda Research Institute, and IBM, and by important national companies, such as Novacart, Bracco, Camozzi, Danieli Automation, Intellimech, and Leonardo. Joint Labs have also been established with clinical institutions and hospitals for clinical translation.

For example, Italy's largest national work insurance institute, INAIL, established a large-scale Joint Lab with IIT to translate robotic rehabilitation solutions to the clinic. In addition, a Joint Lab agreement was signed with IRCCS G. Gaslini Children's Hospital, and agreements are in place with the IRCCS San Martino Hospital in Genoa (as part of the CHT program), with Fondazione Don Gnocchi in Milan, with Villa Beretta – Ospedale Valduce near Lecco, and with the IRCCS networks selected by the Ministry of Health (see Appendix 3: Joint Labs). We count more than twenty agreements to date. Notably, IIT's Joint Lab model is in line with several proposed directions of the EU's Horizon Europe program, which envisages the participation of multiple institutions (public and private) in large-scale R&D programs.

IV. Creation of start-ups. The launch of start-ups is another key parameter for evaluating IIT's TT quality and direct impact on Italy's GDP. As of August 2020, there are 24 start-ups based on IIT technologies (created by IIT researchers). IIT's start-ups employ more than 170 people. Dozens of new ideas are being continuously evaluated as potential businesses. These start-up creation activities at IIT are healthy, with an increasing amount of capital being raised.

Two other important TT initiatives will start and be completed in the 2021-2023 period, namely:

V. A start-up incubator at the Erzelli site, supported by public investment, to set up laboratories and working areas for high-tech start-ups. Invitalia provided €4.5M of funding and 1.500m² of space for the incubator, which will be operational by the end of 2021.

VI. A business accelerator, called "IIT^{4*}, to support technology ventures at medium-to-high technology readiness level (TRL) with supervision and technological support from IIT. This is being negotiated with a major public investment fund in Italy and will likely target the main technology of robotics and AI with verticals in the domain of industrial robotics, space, healthcare, and sustainability.

With respect to the IIT^4 verticals identified above, three of them are core businesses for IIT. IIT's highest TRL know-how is in industrial robotics, with dozens of established collaborations with companies of all sizes. Healthcare and sustainability are two of the three Societal Challenges identified as core impact areas for IIT's research, with two Scientific Initiatives to be launched (the RNA Initiative and the Sustainability Initiative).

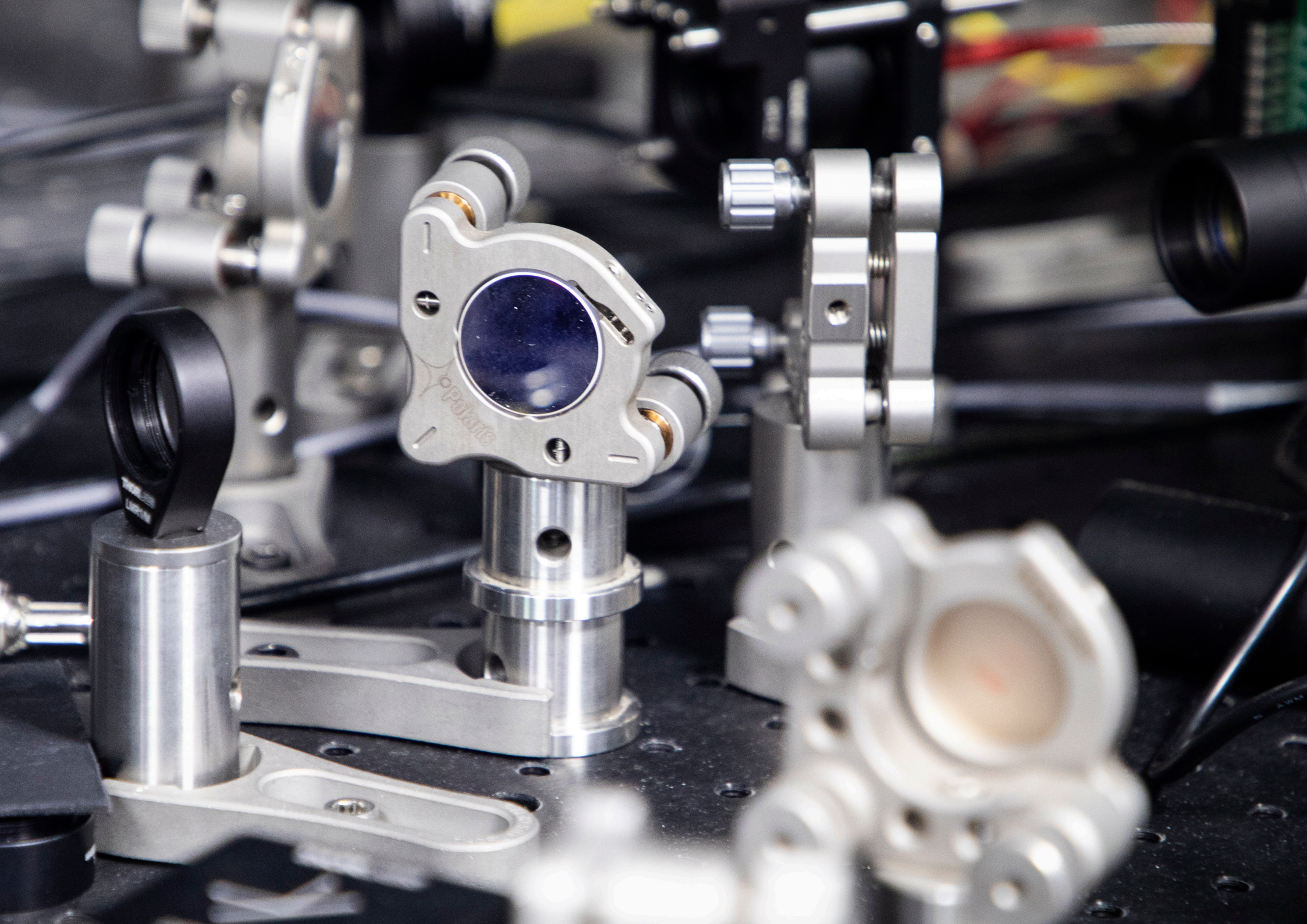
The vertical of "technology for space" requires further elaboration to guarantee that it is a potential market for IIT technology and that IIT's research can be easily translated to space applications.In terms of generated revenues, the global space industry is expected to grow to $1T by 2040. Italy plays an important role in this industry, with over 600 SMEs, several large multinational players, 11 active districts in Puglia, Campania, Lazio, Lombardia, Piemonte, Umbria, and close synergy between research institutes and universities. Net profit is already in the range of several billion dollars. The main reason for this renewed interest is a new cycle of space technological development, with mature off-the-shelf technologies and new commercial downstream activities derived from satellite signal and data. There are high expectations for the upcoming space exploration programs, such as the Artemis program to colonize the Moon (Italy is part of this program). Promising innovations and new space technology systems are coming of age, including microsatellites, megaconstellations of hundreds of satellites, small launchers, broadband and Internet of Things (IoT) from space, and commercial human spaceflight.

Space is thus an excellent TT opportunity and IIT has developed considerable IP and know-how in this area. We have 20 research projects funded by ASI or ESA and five additional projects under evaluation, including the realization of a CubeSAT worth €15M. In addition, IIT signed two framework agreements in 2019-2020 with ESA and ASI respectively. A Joint Lab with Leonardo, which is worth more than €5M, was also launched in 2020.

All RDs contribute to microgravity experiments (nanomaterials), robotics technologies for the aerospace industry, sensing and data processing for in-orbit activities, and satellite observation with AI techniques.

Finally, the TT strategy envisages two additional networking activities. IIT will begin a dedicated initiative to proactively scout and structure its network of companies. The main goal is to increase TT via sponsored R&D agreements, Joint Labs and licensing contracts. Similarly, in the domain of start-up creation, TT will expand its network of venture capitalists (VCs) and related stakeholders. IIT will comprehensively revise its business development processes in order to expand its partnerships in Italy and abroad.

The initiatives related to the start-up incubator and the IIT^4 business accelerator will complement IIT's ambition to become the reference research partner in technologies for robotics, space, healthcare, and sustainability.



Targets for IIT's Leadership

The goal is to make IIT an outstanding international scientific and technological brand name, whose credibility and prestige are recognized not just by the research community but also by the general public. Below, IIT's leadership targets are expressed as a series of commitments:

- Consolidate IIT's scientific leadership in the Research Domains (RDs) of the Strategic Plan.

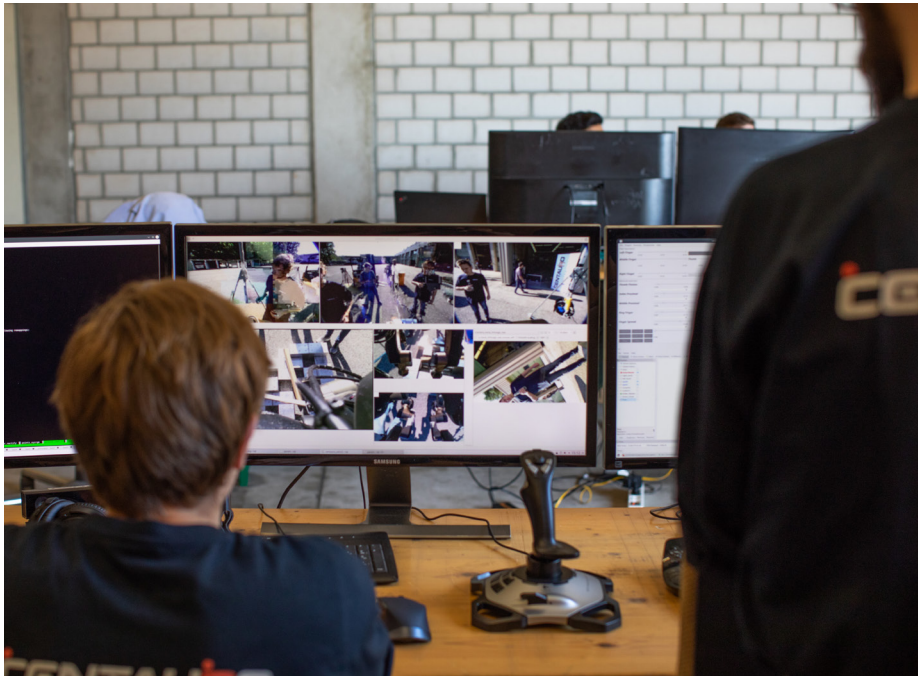
  In terms of scientific excellence in the RDs, IIT aims to close the distance to its strongest competitors, the world's leading research institutions. State-of-the-art scientific infrastructures, transparent international peer-reviewed evaluation, and a high-quality international environment have made IIT a "place of opportunity" for interdisciplinary research. It will be increasingly important for IIT to build on these assets to attract the best researchers from around the world.

- Reverse the brain drain and attract top international scientists to Italy.

  As of 2020, about 50% of IIT's PIs are winners of an ERC grant (or similar individual grants) in the RDs identified by the Strategic Plan. The Brain Magnet Program has been instrumental to reaching this goal. This special budget is dedicated to attracting young researchers who have secured an individual research grant (e.g. ERC, Armenise), as well as senior scientists with an outstanding reputation. The program's next phase (2021-2023) will involve the targeted hiring of new PIs to consolidate the RDs and new Scientific Initiatives.

- Transform research into usable technologies, ultimately creating new jobs and contributing to the GDP.

  To accelerate the transformation of new knowledge into new technology, IIT must continually work on its network of companies, end users, and investors. In addition to standard sponsored research agreements, Joint Labs, patenting and licensing, and the creation of start-ups, the IIT^4 business accelerator will be the main instrument for increasing TT. IIT^4 will multiply the opportunities for TT to companies, thus growing IIT's ability to deploy inventions to multiple target market segments. IIT's target indicators will include the number and value of Joint Labs with companies and clinical institutions (to co-design new healthcare technologies), its patent portfolio (especially the ratio of portfolio costs to licensing revenues), and the capital invested in IIT start-ups.



Implementation: Enabling Strategies

Investment in human capital, research infrastructure, and networks are the keys to achieving IIT's strategic objectives. Here, we describe the enabling strategies needed to fully implement the 2018-2023 Strategic Plan.

Human Capital

Human capital is IIT's most important asset. To date, approximately 1.400 employees (out of 1.750 in total) conduct research at IIT. There are 82 principal investigators (PIs), including tenure-track or tenured scientists and Center coordinators. PIs autonomously manage their assigned budgets, laboratories, and facilities, contributing to the Strategic Plan's global development. In 2018-2020, IIT hired 17 new PIs and expanded its national and international collaboration network.

The Brain Magnet Program has been an important instrument in securing top-quality researchers. This program, launched in 2016, targets young recipients of individual research grants (e.g. ERC, Armenise) and outstanding senior scientists. The completion of two large-scale facilities in Genoa by 2021 (described in the next section) will be crucial to recruitment success. In 2021-2023, IIT will hire new PIs to consolidate the research programs of the four RDs. Besides excellence, IIT will look for complementary skills and research directions to foster additional collaborations in line with the Scientific Initiatives.

A crucial aspect of IIT's research strategy is interdisciplinarity, implemented by promoting interactions between experts across disciplines. IIT's scientific staff come from 22 fields, from philosophy to materials science. Interactions between scientists from different fields have been effective in addressing themes that require diversified expertise. This interdisciplinarity will be strengthened in the coming years through the Scientific Initiatives. As discussed in the Technical Annex, the pool of expertise at IIT may need to be expanded in fields such as artificial intelligence (AI) (for research lines in mainstream deep learning or reinforcement learning), food technology (to develop a traceability and packaging program), and computational science (to strengthen bioinformatics for genomics applications or computational chemistry).

IIT promotes high-level education by collaborating with Italian universities on PhD courses (and undergraduate courses through teaching agreements between IIT's PIs and universities). Excellent research underpins IIT's ability to do this successfully. A virtual PhD school will be launched in the period 2021-2023 to organize all the Institute's PhD activities and to increase the visibility of our training program. Specific actions are planned to position IIT as a place of opportunity, capable of attracting the best students worldwide. These actions include:

- Fostering participation in Marie Skłodowska-Curie initial training network (ITN) projects, which support joint PhD programs with European research institutions, academic institutions, and industry, guaranteeing competitive salaries for students and often resulting in dual-PhD degrees.

- Establishing agreements with European and overseas institutions for joint PhD programs.

- Promoting the mobility of PhD students (as well as postdocs and researchers) by financially supporting both medium-term and long-term visits to top non-European institutions. This will be done via the EU Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE) program where IIT has already been successful.

- Improving the number and quality of training programs for PhD students, providing a range of opportunities for students to broaden their soft, managerial, and communication skills while studying science and engineering.

Actions also include attracting, hiring, and training the best national and international postdoctoral candidates. As part of this strategy, IIT will strengthen its participation in the Marie Skłodowska-Curie Actions (MSCA) Individual Fellowship program. Candidates awarded a Seal of Excellence

Certificate by the EU Commission (i.e. candidates whose MSCA Individual Fellowship proposals received a score of 85% or above, but could not be funded by EU) will be especially considered for postdoctoral positions.

Finally, the educational program will include training for scientists in evaluating and managing intellectual property (IP), business modelling and business planning, the fundamentals of management and hi-tech entrepreneurship, licensing and IP exploitation, pitching business ideas, and developing relationships with investors. Dedicated courses have been created in collaboration with national and international universities and with the participation of mentors from industry and the venture capital world. Training and education in exploiting research results will be a major focus of the virtual PhD school program and part of a specific mentoring program for young scientists.

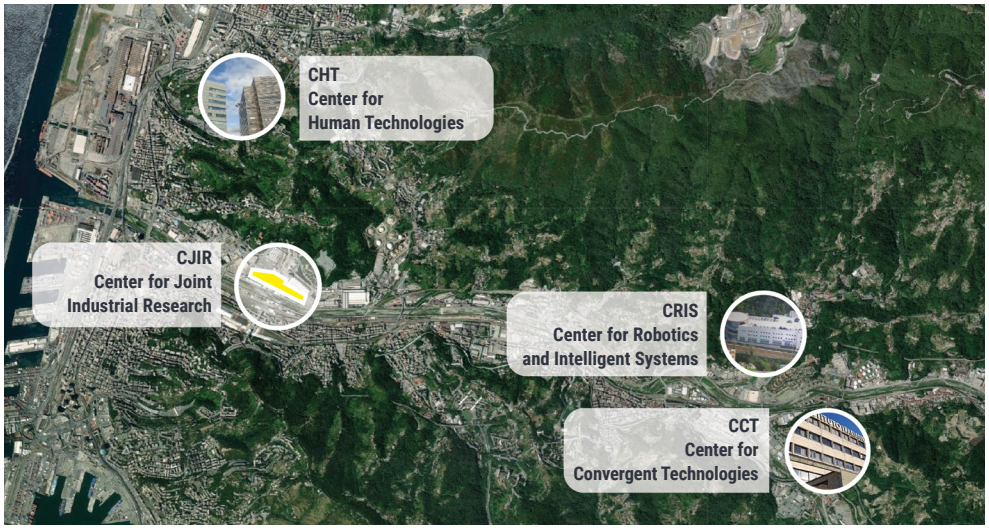


Figure 4: Location of IIT's central laboratories. From left to right: CHT in the Erzelli building, CJIR in the newly acquired BIC building, CRIS in the San Quirico building, and CCT in the Morego building.

Completion of the laboratories in Genoa

IIT's organization revolves around the central laboratories in Genoa, and a wider network of Centers in relevant academic institutions in Italy and abroad. The central laboratories comprise four buildings on Genoa's west side along an 8km stretch of the Polcevera valley.

The central laboratories host most of the large-scale equipment and facilities with more than 1.200 staff members (out of a total of 1.750). The Centers outside of Genoa are smaller structures, hosting between 30 and 100 people who collaborate with the staff of our partner institutions.

Figure 4 shows the approximate locations in Genoa of the central laboratories, including the Center for Human Technologies (CHT, Erzelli Science Park), the Center for Joint Industrial Research (CJIR, BIC), the Center for Robotics and Intelligent Systems (CRIS, San Quirico), and the Center for Convergent Technologies (CCT, Morego). In addition, the Center for Synaptic Neuroscience (NSYN) is located at IRCCS San Martino-IST in Genoa.

IIT's rapid growth in personnel and infrastructure has filled the central laboratories and some Centers to maximum capacity. To date, about one-third of our staff is funded through industrial contracts or competitive European projects. These include 54 ongoing European projects (20 in Robotics, 16 in Nanotechnology and Materials, 16 in Life Sciences and 2 in Computational Sciences) and 19 ERC grants (with 7 new awardees for the most recent 2020 calls). In 2018, IIT began expanding the premises of the central laboratories with the addition of five floors

in Tower B at the Erzelli Science Park and an entire building in San Quirico (near the Morego laboratories). The Erzelli premises were inaugurated in mid-2019 and are now fully operational, hosting the CHT, including most of the genomic and computational laboratories. The San Quirico building is being completely renovated (due in 2022) and will host the CRIS, including all the robotics laboratories and the machine shop. The Morego building hosts the CCT, including all chemistry and nanomaterials labs (Nanomaterials RD) and consequently the research lines of the Nanomaterials RD, the clean room, the new high-resolution STEM microscope, the animal facility, and several research lines mostly in neuroscience aspects of the LifeTech RD. In addition, the central laboratories host several industrial laboratories and start-ups. Since IIT has almost reached steady state in terms of size, the number of staff members will increase only moderately in the next few years, mainly due to more industrial partnerships and European and industrial projects, but also due to international recruitment of a few more PIs.

In 2021-2022, IIT plans to complete the renovation of its premises in Genoa and to consolidate its network of Centers, particularly through joint initiatives with medical research institutions across Italy. In Genoa, IIT will complete the start-up incubator in the Erzelli Science Park and the new CJIR in the BIC building.

The business accelerator (IIT[4]) next to the CJIR will also be fully operational by Q1 of 2022. By Q1 of 2022, the infrastructure expansion in Genoa will be complete, greatly improving the laboratory space for IIT researchers.

This will allow the hosting of about 1.800 staff members, which is the expected number for an annual budget of about €120M (including the current public contribution and competitive fundraising) and a full cost pro capita of about €80.000. As part of this plan, IIT will complete the research facility (re-)organization that began in 2015, namely:

- Mechanical Workshop and Mechatronics (CRIS, San Quirico).
- Electronics Facility (CHT, Erzelli).
- Electron Microscopy Facility (CCT, Morego).
- Materials Characterization Facility (CCT, Morego).
- Nanofabrication and Clean Room Facility (CCT, Morego).
- Chemistry Facility (CCT, Morego).
- Animal Facility (CCT, Morego).
- iCub Tech Facility (CRIS, San Quirico).

IIT will also complete several additional shared facilities:

- High-Performance Computing (HPC) Facility (CHT, Erzelli).
- Genomics Facility (CHT, Erzelli).
- Pharma/Medicinal Chemistry Facility (CCT, Morego).
- Magnetic Resonance Facility (CCT, Morego).

The Centers and the Academic Network

The academic network is central to IIT's Strategic Plan, both to recruit PhD students from a wider pool, and to expand collaborations with other institutions to acquire additional expertise.

The list of Centers established in Italy and abroad is reported in Appendix 5: Academic network.

In the 2021-2023 period, we plan to:

i. continue to periodically evaluate the Centers' performance and their contribution to the Strategic Plan;

ii. consolidate their infrastructure in terms of equipment and laboratory space.

In particular, the following Centers require attention, especially in relation to the available laboratory space:

- CNST@PoliMi in Milan.
- CNI and CMBR in Pisa.
- CNCS@UniTn in Trento.
- CLNS@Sapienza in Rome.

Further, we will promote consolidation by attracting a few additional PIs to strengthen each Center's scientific focus. This happened recently in Milan and Rome.

The CMBR's scientific focus in Pisa will also change due to the reorganization of its Research Lines, which will be reflected in a new name, Center for Materials Interfaces (CMI), effective from January 2021.

The Clinical Network

The clinical network aims to create an environment where new discoveries and new knowledge can be immediately tested, applied, and evaluated for the benefit of patients. To this end, IIT has launched many bilateral collaborations with clinical research institutions, and has already proposed a handful of large-scale initiatives, which will form a large national clinical network in the coming years.

The main initiatives include:

1. The CHT has been established in partnership with Regione Liguria to co-develop and test technology in actual clinical environments (i.e. by creating Joint Labs for clinical trial programs). In pursuing CHT's mission, we signed agreements with four research hospitals (IRCCS G. Gaslini Children's Hospital, IRCCS S. Martino-IST, Galliera Hospital, Santa Corona Hospital) and two clinical institutions (Istituto Chiossone, Fondazione Don Orione) in Liguria.

CHT's network implements a hub-and-spoke model to promote the sharing of data (e.g. integration of electronic medical records) and technology (e.g. genome-sequencing technologies).

The main research lines will involve:

a. Optimizing and testing IIT's surgical robots at IRCCS San Martino-IST and IRCCS G. Gaslini Children's Hospital.
b. Optimizing and testing novel nanocarriers for multifunctional drug delivery in oncology, neurological diseases, and cardiac diseases with IRCCS San Martino-IST, IRCCS G. Gaslini Children's Hospital, and Galliera Hospital.
c. Testing robotics rehabilitation systems with Santa Corona Hospital.
d. Co-designing and testing new devices for the blind with Istituto Chiossone.
e. Testing new noninvasive brain stimulation protocols for cognitive and motor rehabilitation in stroke recovery at the "Ospedale Riabilitativo Villa Rosa", Trento Hospital.
f. Co-designing and testing humanoid robots for the rehabilitation of children with neurodevelopmental disorders (NDVDs) with IRCCS G. Gaslini Children's Hospital and Fondazione Don Orione.
g. Developing a genomic-based personalized medicine approach to NDVDs by integrating genomics and clinical data.
h. Modernizing digital infrastructures to make access to public services easier for citizens and companies.

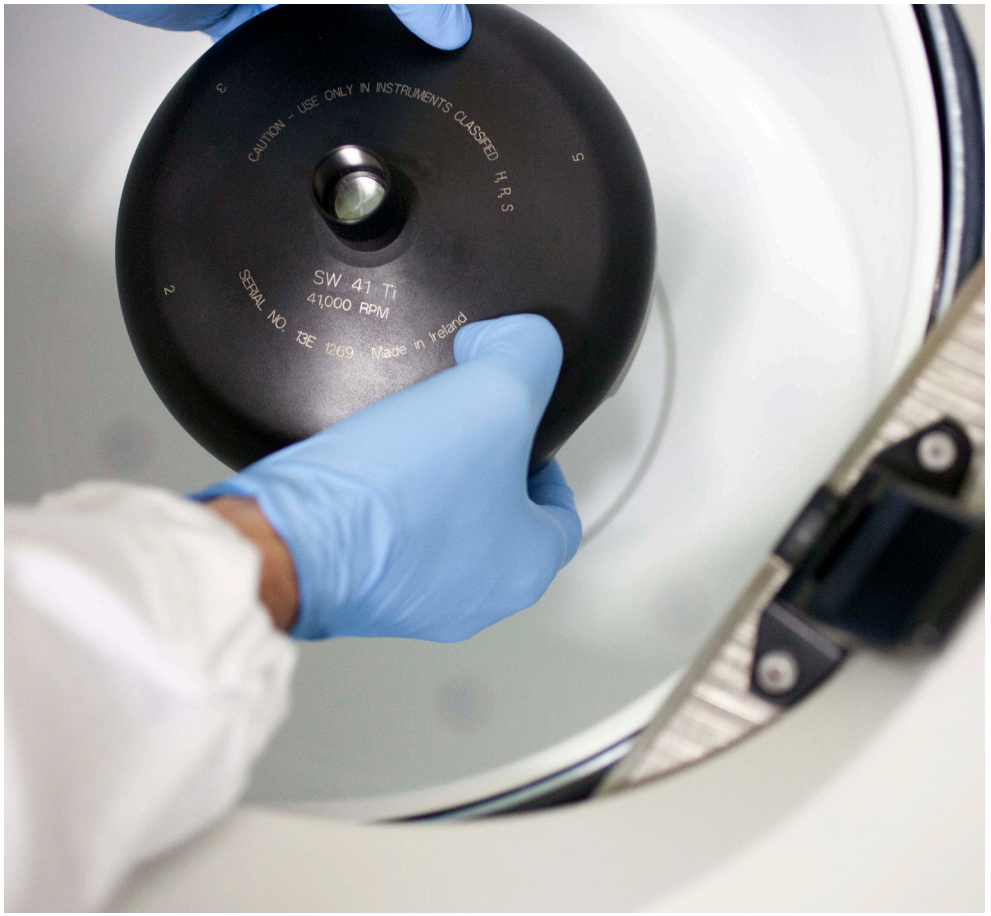
CHT is Italy's first example of full synergy between technological research and development with the public healthcare system. It may become a guiding example for the entire country.

2. The 5000-genome project, Valle d'Aosta (5000genomi@vda) is a 5-year long project which aims to make precision medicine a commonly used tool with high-throughput sequencing, genomics, and big data analysis.

   The project targets neurodegenerative diseases, cancer, and NDVDs. Impact is expected in the following areas:
   a. Science: addressing fundamental biological questions with innovative modeling and data analysis, including with AI.
   b. Patients: improving risk analysis, diagnosis, and prevention in healthcare with precision medicine (for individuals or groups of individuals).
   c. Economy: creating opportunities in the domains of personal medicine, therapy, software models for genomics and the clinic in general.
   d. Public health: improving results and optimizing cost, increasing life expectancy and quality of life.
   e. Decision makers: providing predictive models in the domain of healthcare.
   f. Research institutes: providing a research platform, including optimized software for HPC and a large dataset to train predictive algorithms.

   A direct link between the 5000-genome project and the CHT in Genoa will be established, forming the seed of an integrated Italian network for precision medicine.

3. Alliance Against Cancer (Alleanza Contro il Cancro, ACC). ACC is the largest Italian network of IRCCS for comprehensive cancer care and research. ACC was established by the Italian Ministry of Health. An agreement between IIT and ACC is being finalized and will enable IIT participation in large cancer genomics programs in Italy. Cancer is one of the five Horizon Europe Mission Areas. IIT is already collaborating with several hospitals in the ACC network, including the European Institute of Oncology (IEO-hospital), the Humanitas Research Hospital, San Raffaele Hospital in Milan, and the Parini Hospital in Aosta as part of the 5000-genome project.



4. The network of Joint Labs involves collaborations between IIT and national clinical institutions to co-design innovative technologies to improve human health. INAIL-IIT Rehab Technologies is one successful partnership within this model. This Joint Lab was launched in 2013 by IIT and INAIL. The INAIL-IIT Joint Laboratory was extended in 2020 for another three years (until 2024). Its mission is to develop and implement advanced prosthetic, orthotic, and rehabilitation devices. New initiatives in the Joint Lab network include:

    a. National agreement between IIT and five national networks of research hospitals and clinical research institutes (IRCCS) overseen by the Italian Ministry of Health. In collaboration with IIT, these networks seek to accelerate the translation, uptake, and diffusion of IIT technologies into the clinics. The five networks are in the areas of neurodevelopment (IRCCS IDEA, the Italian Developmental Age Health Network), oncology (IRCCS ACC, the Alliance Against Cancer Network), cardiology (IRCCS Cardiology Network), neuroscience and neurorehabilitation (IRCCS Neuroscience and Neurorehabilitation Network), and geriatric medicine (IRCCS Healthy Ageing Network). The agreement was formalized in April 2018 by a special agreement between IIT and the Ministry of Health.
    b. Joint Lab with Fondazione Don Gnocchi in Milan to co-develop companion robots for patient assistance.
    c. Joint Lab with Villa Beretta – Ospedale Valduce in Costa Masnaga (Lecco) (from mid-2021) to develop neurorehabilitation tools and protocols, and to identify predictive biomarkers of recovery in brain injury

Network of Technology Transfer Partners

In the period 2018-2020, IIT proactively developed a network of technology transfer partners, including investors (investment funds), industrial associations (e.g. the Confindustria's Digital Innovation Hubs), competence centers (as established by the Ministry of Economic Development), academic partners engaged in business training and education (e.g. Bocconi University), and associations (e.g. Associazione Italiana Fondi Investimento, Italia Startup).

The list of industrial and investment funds includes more than 40 agreements with venture capital funds, banks, incubators, and accelerators. Agreements with TT systems in Europe and the USA are also under negotiation.

IIT has joined three industrial associations (the Digital Innovation Hubs of Confindustria) and participates in the Competence Centers for Industry 4.0, funded by the Ministry of Economic Development. The latter envisages a continuous development of proof-of-concept projects in collaboration with SMEs, thus multiplying opportunities to deploy IIT's industrial technology. Finally, our ecosystem is completed by an agreement with the Bocconi University in Milan and University of Genoa to develop business programs (e.g. incubation, training) for IIT's young entrepreneurs.

Figure 5: The number of partners per country/continent of IIT in the Horizon 2020 program (source European Commission tender statistics).

A Strategic Plan Designed for Europe

IIT has always been extremely active in the European framework programs (FPs). Starting with FP6, IIT's success increased rapidly, especially under Horizon 2020. IIT received 180[5] grants under Horizon 2020, almost doubling its result under the earlier FP7 program and reaching €110.3M[6] in value (48% of IIT's fundraising for 2014-2020).

Horizon 2020 and IIT's Twin Mission

During the EU RTD programs, such as FP7 and particularly Horizon 2020, the EC has progressively shifted towards more impact-oriented research. This reflects a new political drive to couple research to innovation while responding to the concrete challenges faced by European companies. The more practical approach of Horizon 2020 was aligned with IIT's vision of human-centered application-oriented science and technology. This alignment is reflected in IIT's growing success rate in the EU programs.

European funding for research and innovation matches almost entirely IIT's twin mission. Grants funded under the Excellent Science pillar of Horizon 2020 contribute to IIT's cutting edge research. This includes ERC grants, which represent more than 20% of IIT external funding and 45% of the funding received under Horizon 2020.

The Excellent Science pillar also includes the Future Emerging Technologies (FET) projects, where IIT was particularly successful, especially in the biorobotics field.

Conversely, collaborative projects funded under the Industrial Leadership and Societal Challenges pillars of Horizon 2020 are about creating a basis for translating technology to the production system and to society (e.g. healthcare). Thanks to these collaborative projects, IIT developed a network of partners that includes research institutes, universities, companies, and hospitals. This network is an important asset for IIT as it participates in large-scale EU programs.
European projects have also contributed to the development of IIT's know-how, which eventually translates into TT activities. The direct impact of EU projects can be measured in 4 active start-ups, 5 ongoing start-up projects, 6 business ideas (in development), and two Joint Labs. EU-funded projects have also contributed to increasing the TRL of IIT's technology. IIT's know-how has been refined and improved, starting from basic research supported by ERC and FET programs, and through collaborative and applied research with greater TRL, which is supported by Research and Innovation Actions (RIA) and Innovation Actions (IA). IIT's researchers have also successfully used the ERC Proof of Concept (PoC) scheme. This scheme allows excellent basic research to become the proof of concept for cutting edge technology, ready for translation to society and transfer to the market.

To support the alignment between IIT's twin mission and the European funding programs, IIT has launched the internal Exploitation Booster pilot project. The project's goal is to assess and support the exploitation of results from European projects, namely where EU project results are required to have an economic and social impact.

Furthermore, European projects have supported IIT's education and career development goals thanks to training and education activities funded under the Marie Skłodowska-Curie Actions (MSCA), which cover 37% of IIT projects under Horizon 2020. Many MSCA fellows have continued a career in science specifically because the MSCA funding offered the initial opportunity. Several MSCA fellows at IIT later became ERC awardees or FET project coordinators.

[5] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999596447

[6] https://webgate.ec.europa.eu/dashboard/sense/app/a22d6695-65d1-4f7a-a06f-b5bf3f3cc59c/sheet/3bcd6df0-d32a-4593-b4fa-0f9529c8ffb0/state/analysis (filter: PIC e H2020)

IIT's Participation in Horizon 2020

Robotics. Robotics was extremely successful under the Horizon 2020 ICT work-program. The ICT work-program covered collaborative projects to validate and demonstrate new technology in various application fields (e.g. health; industry and production; security; inspection and maintenance). Robotics projects typically have a medium-to-high TRL, with 45% being Research and Innovation Actions and 67% being Innovation Actions.

The last programming period (2018-2020) saw a consistent shift towards the application-oriented schema of Horizon 2020 Pillar 3. This trend is expected to continue in Horizon Europe because robotics is an enabling technology, eligible for funding under all clusters and domains of future calls.

Nanomaterials. Nanomaterials was also very successful in various Horizon 2020 domains. Pillar 1 accounted for around 50% of IIT's grants in materials science, including the European Flagship Graphene. Pillar 3 funded research in three of the four Priorities of this RD: Sustainability, Energy (6 projects), and Health (3 projects). At the European level, the RD is also active outside of Horizon 2020, with 8 projects funded by the European Space Agency, demonstrating the enabling role of nanomaterials research in various space applications.

Technologies for Life Sciences (LifeTech). The LifeTech RD was primarily active in Pillar 1, which accounts for 30% of EU funding received by IIT, mainly in the form of ERC grants and MSCA. Indeed, 25% of IIT ERC grants were awarded to the LifeTech RD. LifeTech research groups have focused on alternative funding bodies such as AIRC, Telethon Foundation, and NIH (international or private foundations). This trend will likely change because Horizon Europe has a new focus on cancer research (with a dedicated Mission) and on "unlocking the full potential of new tools, technologies and digital solutions for a healthy society". This will be a good opportunity to involve IIT's clinical network in EU collaborative projects.

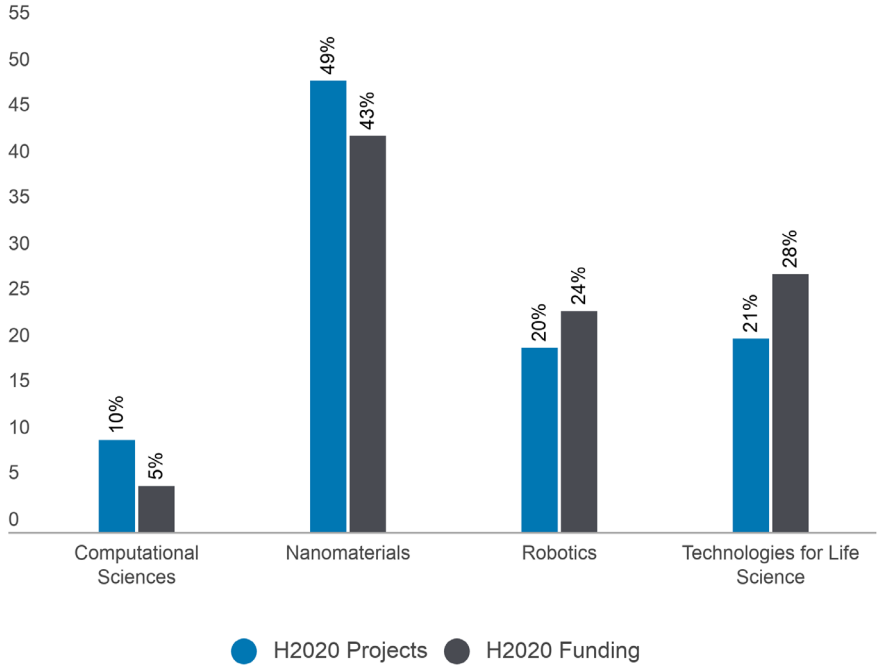
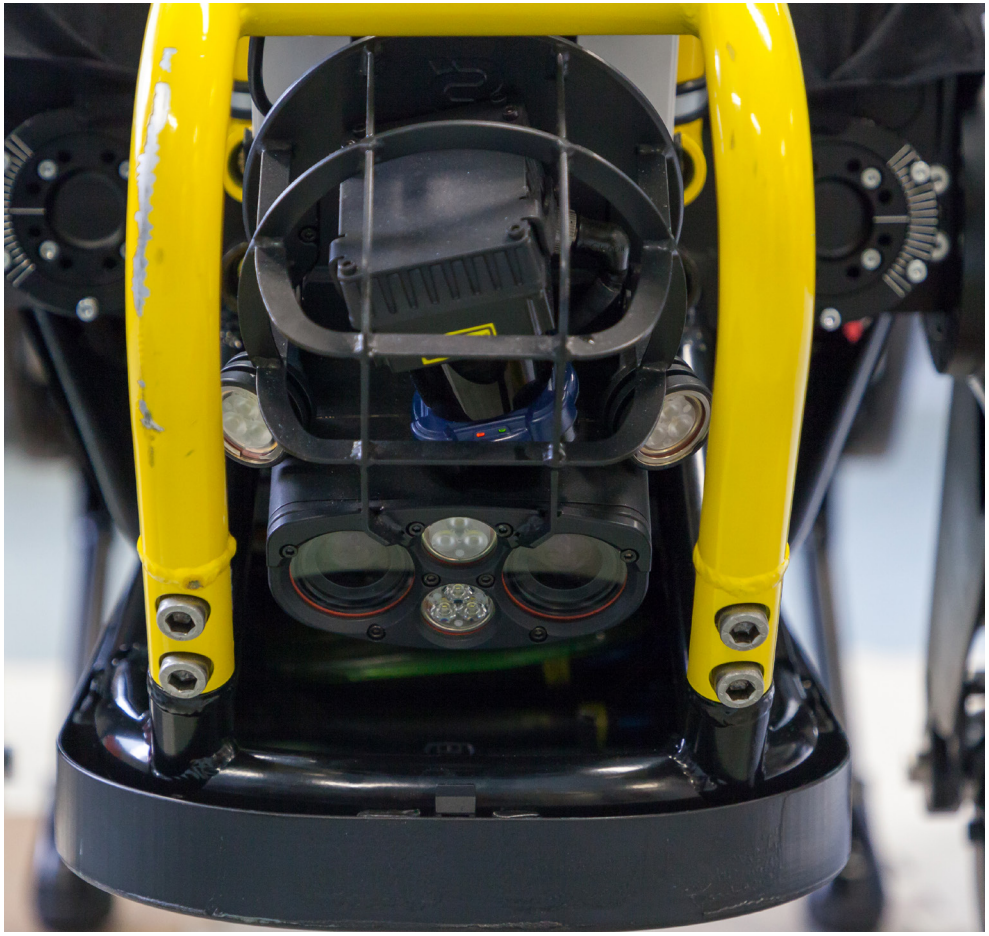


Figure 6: H2020 projects and funding share per IIT Research Domain.



Computational Sciences. As IIT's newest RD, created in 2018, the Computational Sciences RD has mostly focused on individual grants for training (MSCA) and excellent basic research (ERC). Interestingly, all funded projects involve an interdisciplinary combination of computational techniques to various application domains: healthcare, cultural heritage, materials development, and industrial leadership. Given the fundamental role of artificial intelligence (AI) in Horizon Europe work programs, including the dedicated partnership "AI, Data and Robotics", funding opportunities may span the three Pillars of Horizon Europe, covering the entire spectrum from basic science to industrial applications.

Interdisciplinarity. Since the early days of IIT, there has been an increase in cooperation across research groups (within or between RDs), reaching its peak in Horizon 2020. Nanomaterials and Robotics have been the most interdisciplinary RDs, with 38 and 31 intergroup projects, respectively. Collaborative projects funded under the second and third Pillar have the highest cooperation rate between groups within the same RD, while FET projects have facilitated interdomain cooperation. This positive trend will continue in Horizon Europe and thanks to the new Scientific Initiatives whose actions can be supported by the new FET work-program or the dedicated Missions.

IIT's Expectations of Horizon Europe

Horizon Europe is the European Commission's most impact-oriented program. It aims to promote growth, trade, and investment and create a significant social and environmental positive impact. IIT's strategic positioning allows it to continue along the path identified during Horizon 2020. Horizon Europe matches IIT's mission to "produce new knowledge and transfer it to the society".

Horizon Europe is structured in three Pillars, as follows (see: Appendix 2):

Pillar 1 – Excellent Science. Pillar 1 is substantially equivalent to the Excellent Science of Horizon 2020. Pillar 1 will continue to play a pivotal role for IIT. IIT will continue promoting researchers' ERC grant applications to support excellent frontier research, particularly where there is complementarity and synergy with existing research lines, in order to strengthen the RDs and the new Scientific Initiatives. IIT will also continue to support the training and mobility of young researchers via the MSCA programs. In a new development, IIT will encourage applications to Research Infrastructure calls, since they are a unique opportunity for IIT's facilities, laboratories, Joint Labs, and other networks to further develop their infrastructure.

Pillar 2 – Global Challenges and Industrial Competitiveness. IIT will continue pursuing funding for collaborative projects under Pillar 2. Pillar 2 projects are designed to develop and scale up key technologies in cooperation with excellent partners. Pillar 2 is subdivided into six Clusters. IIT aims to participate in consortia in all six Clusters. IIT's network of partners includes top European players such as Max Planck, Fraunhofer, INRIA, DLR, CEA, KTH, University of Cambridge, and TUM.

This network is a key asset for successful applications for Pillar 2 funding. Substantial effort will be made to strengthen IIT's network of clinical institutions and industrial players. Because of the relatively high TRL, the results of Pillar 2 projects will contribute to TT. We will also increase our effort to monitor and actively participate in European Partnerships.

Pillar 3 – Innovative Europe. Pillar 3 has most of the new instruments and represents the largest reorganization of Horizon Europe. Here, IIT plans to increase its success rate with projects that support the development of innovative breakthrough technologies (FET program). The FET program will continue under the umbrella of the "European Innovation Council" actions. Particularly relevant for IIT will be the EIC Pathfinder, which builds on FET Open and FET Proactive to support deep-tech research and innovation with prospective market exploitation. EIC Pathfinder was launched as a pilot in 2019-2020 and IIT has been extremely successful. In the last two calls, IIT was awarded five projects as a coordinator (of a total of 15 successful projects awarded to Italian coordinators under these calls) and two more projects as a partner.

IIT and the European Commission's Agenda (2019-2024)

The von der Leyen Commission strategic agenda sets six headline ambitions for Europe for 2019-2024. The six headline ambitions have been adopted as guiding principles for the development of the Horizon Europe strategic agenda. Four are particularly relevant to IIT priorities.

European Green Deal. In the fight against climate change, the EC has set the ambitious goal of making Europe the first climate-neutral continent by 2050. In line with the UN Sustainable Development Goals, the European Green Deal is a core set of policy initiatives that form the EU's action plan for achieving climate neutrality via a clean circular economy. This is particularly relevant for IIT's Sustainability Societal Challenge and the launch of the Sustainability Initiative as part of this Strategic Plan.

Europe fit for the digital age. With the EU digital strategy, the Commission aims to strengthen its digital sovereignty with a clear focus on data, AI, machine learning (ML), and infrastructure such as high-performance computing (HPC). This is particularly relevant for IIT's Computational Sciences RD focusing on HPC, big data analytics and AI. In addition, AI, ML, and physical simulations are the leitmotif of the interim update of the Strategic Plan.

Protecting our European way of life. One of the main policy areas here is the creation of a European Health Union, with all Member States working together to improve prevention, treatment, and care for disease, and responding together to health crises. This reflects IIT's Healthcare Societal Challenge and its mission to transfer technology to clinical institutions. We plan to strengthen IIT's clinical network by participating in European collaborative projects.

Economy that works for people. The EU's unique social market economy allows economies to grow and reduce poverty and inequality. The EU economy should be strengthened to be resilient to future development and challenges. Key priorities are growth, jobs, youth potential, and gender equality. Human capital, recruitment policies, and high-level education are key enabling strategies to achieve IIT's strategic objectives (and are part of Horizon Europe). IIT's TT mission further contributes to bringing innovation to small businesses. This, together with health, is a key element of the Commission's policies.

Action Plan

In addition to the strategy described in "Implementation: enabling strategies", Horizon Europe calls for specific actions. IIT aims to strengthen its position in Europe's research and innovation landscape with the following actions:

- EU policies. IIT's success in EU grant applications will increasingly depend on alignment with EU policies. IIT will increase its participation in EU policy-making initiatives via participation in EC open consultations, involvement in European Partnerships, cooperation with key European associations, and the establishment of an EU Liaison Office in Brussels.

- Exploitation Booster. The Exploitation Booster project will map the technological assets developed under European projects. For each EU project, it will define the most suitable exploitation strategy to transform results into IP assets. This will involve conducting economic and market analysis, consolidating business cases, and building pathways to TT.

- Facilities. Under Horizon 2020, IIT facilities have contributed to research projects by supporting specific activities of the research groups. Facilities will have many opportunities to participate in Horizon Europe within European infrastructure networks (Research Infrastructure programs). Facilities can therefore become leading actors in piloting, validating, and applying innovative research in cooperative projects with industry (Pillar 2 and EIC projects).

- Life Sciences. The Horizon Europe Health Cluster envisages a wider technological approach. IIT will encourage LifeTech researchers to participate more broadly in European projects for basic and applied research.

- Computation. AI is one of the EC priorities and has a pivotal role in Horizon Europe work-programs. IIT will therefore encourage the Computational Sciences groups to participate in EU grant applications, particularly as coordinators. Collaborative projects across RDs will be particularly encouraged in order to apply computational methods to other scientific endeavors (e.g. chemistry, materials science, genetics).

Covid-19

The Strategic Plan does not contain any specific action related to the Covid-19 pandemic. We did debate whether to design and reposition our know-how to help tackle the virus.

We decided that, given IIT's expertise, the best course of action was to let IIT's scientists contribute by collaborating with national and international institutions, rather than setting up a new Covid-19 research program.

Where possible, we encouraged our researchers to join European consortia or other national projects to work on solutions. In addition, especially during the pandemic's first wave, researchers conducted independent small-scale projects with various results[7].

These small-scale projects fall into four areas of intervention:

- Artificial Intelligence (AI) and computer vision.
- Personal protection equipment (PPE).
- Molecular simulation.
- Robotics (and engineering).

The AI and computer vision projects have been the most successful to date, leading to solutions for monitoring physical distance in public spaces (airports, shopping malls, workspaces), measuring temperatures at a distance (in large spaces), and analyzing medical images of Covid-19 patients. All these projects are proceeding to testing in the field and successive transfer of IP.

The PPE projects helped companies to re-purpose protective equipment (scuba-diving masks) and off-the-shelf (medical grade) filters. Certification was unfortunately a long process which was successful only in certain cases. The engineering teams also directly supported local hospitals by fabricating many small components (e.g. valves, splitters) for ICUs that were lacking during the pandemic's first wave.

The robotics teams were particularly active in designing robots for telepresence (patient-doctor interaction). In one solution, a vacuum cleaner robot was hacked to support remote operation and to transport a tablet for communication in and out of a Covid-19 ward. This experiment suggests a potential market opportunity for personal assistance robots.

IIT rapidly designed two different respirators (in about five weeks). The simple DIEGO mechanical respirator was registered with the Ministry of Health as a class I device and immediately released under an open-source license. A more complicated but complete respirator, named FI5, was designed with the help of Ferrari's Formula 1 team. FI5 was also released under an open-source license.

Some of the robotics technology was used to develop a simple distancing device (a bracelet/card). Despite hundreds of contacts with companies interested in the technology, it was extremely challenging to be fast enough to reach market. The interest from companies faded quickly as a function of the perceived number of cases in Italy.

In February 2020, our molecular simulation teams analyzed a series of molecular targets for Covid-19 and performed in silico screening of a database containing more than 3000 FDA-authorized drugs. The goal was to identify candidates for repositioning. The results were shared with Italy's main Covid-19 hospital (Spallanzani in Rome).

In summary, IIT has shown its ability to quickly repurpose its know-how and engineering skills for focused Covid-19 projects. However, it is neither practical nor effective to repurpose entire research groups. This does not exclude participation in EU or national Covid-19 projects, but a strategic Covid-19 research direction is not included in this updated plan.

[7] https://www.iit.it/iit-vs-covid-19

Outlook: IIT in 2023

IIT will be the place of opportunity for interdisciplinary research, to participate in and contribute to ambitious research programs such as the Scientific Initiatives.

At least four out of the six Initiatives will be consolidated in the next Strategic Plan (2024 onward).

The number of Research Lines (PIs) **will grow to approximately 100** (82 at the moment of writing) which is to be considered steady state and calculated to be sustainable. The total staff will peak to 1800, where most of the increase is costed on external projects. The ratio of permanent positions vs. the total staff will remain at the 2021 level.

The ratio of **internal vs. competitive funding will approach 50-50 for most Research Lines**. IIT will centrally provide space and laboratory equipment as well as its maintenance and upgrade.

The **infrastructure expansion will be completed**. This concerns the five sites (central research laboratories) in Genoa and the Centers of the network in Milan, Rome, Trento and Pisa.

The CJIR in Genoa will be fully infrastructure hosting the robotics industrial Joint Laboratories and most of the industrial robotics projects.

The **start-up incubator in the Erzelli Science Park** in Genoa will be fully operational.

The **business accelerator (IIT^4)** will be operational, including agreements and processes defined with public technology transfer (TT) programs. The overarching theme will be Robotics and AI with verticals in industry, space, healthcare, and sustainability.

The **Centers and Academic Network** will be consolidated with the existing sites, including the final evaluation of the Center for Cultural Heritage Technology in Venice and the 5000-genome project Center in Valle d'Aosta.

The **Clinical Network will be consolidated** along common research lines around genomic/computational projects (CHT/Genova, CGS/Milano, CMP3/Aosta, IRCCS network) and robotics applications for healthcare (Budrio, Volterra, Rome with INAIL).

Participation in **Horizon Europe will be more extensive, including exploitation programs** (Pillar 3), European infrastructure, healthcare (e.g. Cancer Mission), and the Digital Europe initiatives. A European Digital Innovation Hub will be set up in Genoa to coordinate TT activities.

Computational techniques will permeate all Research Domains. **Artificial intelligence (AI) and machine learning (ML) will become central to all research endeavors at IIT**, supporting faster progress.

The **number of PIs in AI and ML** will double.

Appendix 1: Facts & Figures

The Italian Government's total expenditure on IIT since its creation (from January 2004 to December 2019) is approximately €1.170M.

The 36-month start-up phase for the construction of the central research laboratories in Genoa started on January 2006 with the adaption/modification of the Morego building to host the Center for Convergent Technologies (CCT), which was completed in 2009.

The first laboratories in Genoa were inaugurated in mid-2007 (Robotic Brain and Cognitive Sciences) and the CCT building was completed in April 2010 with the opening of the Drug Discovery and Development laboratory.

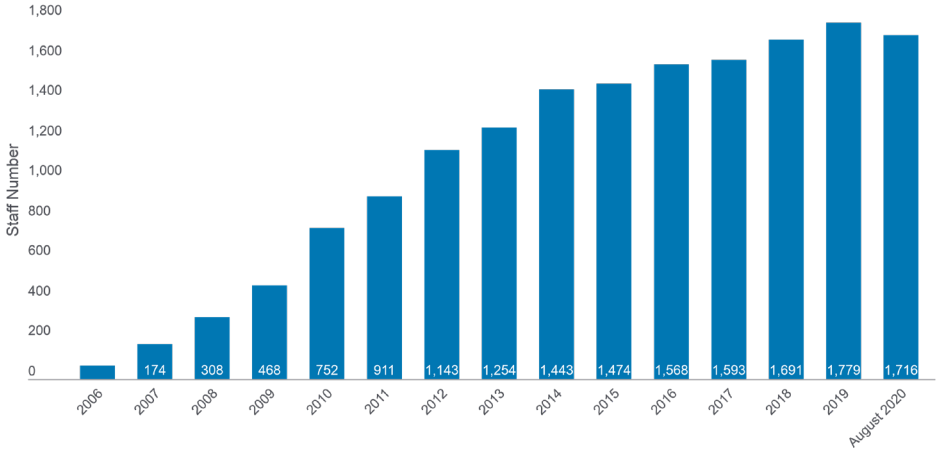
After 13 years of scientific activity (from 2007 to date), IIT has accomplished the following:

- Supported about 16.000 person-years of salary for scientists, technicians, and administrators (including about 3.600 person-years of PhD salaries).
- Built more than 45.000 m^2 of laboratories on 13 sites.
- Published more than 14.500 papers in peer-reviewed international journals, conference proceedings, and book chapters. IIT's scientists are listed among the Highly Cited Researchers (HCR) by Clarivate Analytics (Web of Science).
- Ranked first among public research institutions in Italy (ANVUR national ranking) in its research areas (second in Physical Sciences).
- Won 534 competitive grants (261 European grants) and more than 700 industrial projects.
- Secured €319M of competitive and industrial funds.
- Secured 43 ERC grants in total, with several additional new grants currently in the negotiation phase.
- Established 14 Joint Labs with international companies.
- Filed more than 1.000 patents (more than 400 granted).
- Launched 24 start-ups.

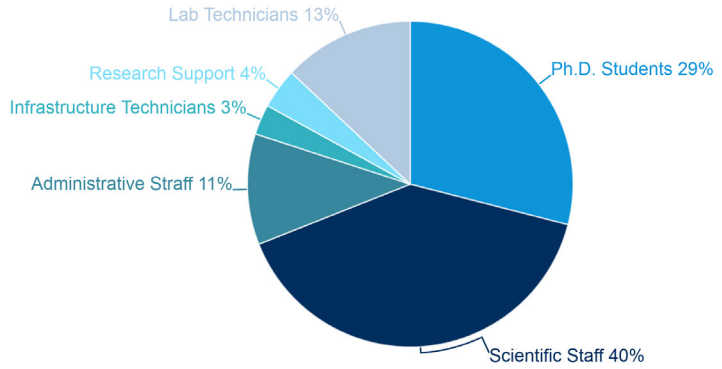
Personnel and scientific output

With reference to the personnel and bibliometric data in Figure 7, IIT begins 2021 with the following strong figures:

- With 50% of scientific staff from Italy and 50% from more than 60 other countries, IIT is one of the most attractive research institutions in Italy. The proportion of scientists coming from international institutions is comparable to that of Europe's best institutes.
- IIT is Italy's youngest institute in terms of personnel, the average age of its personnel being below 36 years. This average age has increased by less than 3% in the last 10 years because of the high turnover and recruitment policy.
- IIT is one of Italy's most interdisciplinary institutes, recruiting scientists with 22 different PhD profiles. This figure is comparable to that of Europe's best institutes.
- IIT has a very low administration-to-research personnel ratio, with approximately 14% of personnel dedicated to administration.
- With 42% of personnel being women, IIT is among the Italian institutions with the best gender ratio.
- IIT was ranked first among public research institutions by the Italian national research assessment (VQR ranking 2011-2014) in Informatics/Mathematics, Chemistry, Biology/Life Sciences, Industrial Engineering, Psychology, and second in Physical Sciences. Moreover, IIT was ranked first in Technology Transfer activities.
- IIT has the highest patent-filing rate in Italy's public research system. IIT is steadily in the top ten of Italian applicants to the European Patent Office, and the number one nonindustrial Italian applicant.

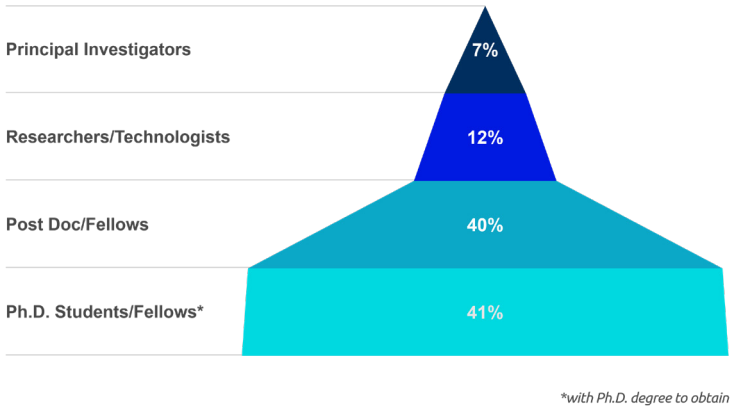


(a)

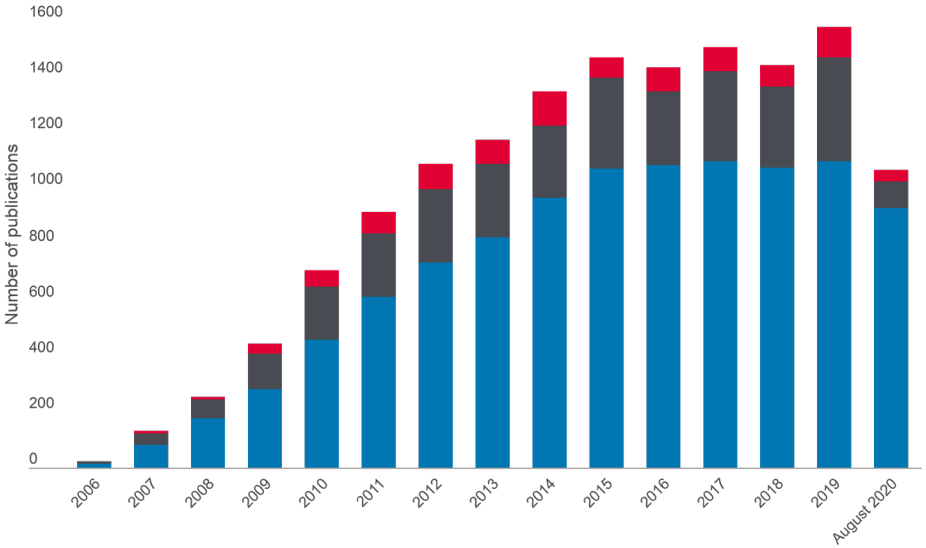


(c)

Figure 7 (right and next page): Overview of the IIT staff (overall count in panel a, position in b, role in c, profile in d), publications (panel e), and citations per year (Source Scopus-Elsevier in panel f).


Principal Investigators
7%
Researchers/Technologists
12%
Post Doc/Fellows
40%
Ph.D. Students/Fellows*
41%
*with Ph.D. degree to obtain

(b)


Number of publications
1600
1400
1200
1000
800
600
400
200
0
2006
2007
2008
2009
2010
2011
2012
2013
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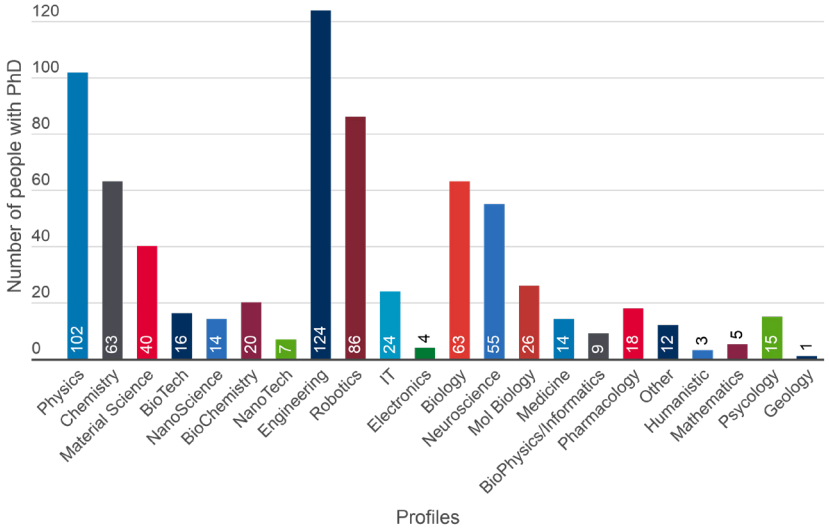
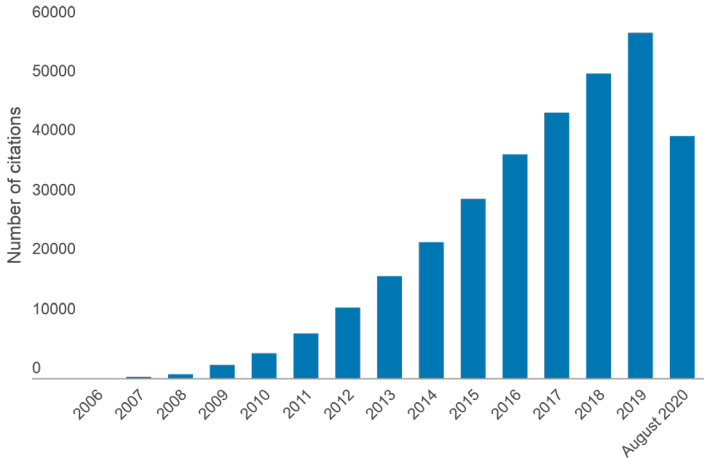
2016
2017
2018
2019
August 2020

(e)


Number of people with PhD
120
100
80
60
40
20
0
102
63
40
16
14
20
7
124
86
24
4
63
55
26
14
9
18
12
3
5
15
1
Physics
Chemistry
Material Science
BioTech
NanoScience
BioChemistry
NanoTech
Engineering
Robotics
IT
Electronics
Biology
Neuroscience
Mol Biology
Medicine
BioPhysics/Informatics
Pharmacology
Other
Humanistic
Mathematics
Psycology
Geology
Profiles

(d)


Number of citations
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2006
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2019
August 2020

(f)

Fundraising

As shown in Table 2, competitive fundraising performance depends on the Research Domain with Robotics, for example, acquiring almost one euro for each euro invested by the State.

Research Domain	EM/IM
Robotics	96%
Nanomaterials	69%
LifeTech	44%
Computational Sciences	33%

Table 2: Percentage of Extramural (EM) vs Intramural (IM) funding per research domains (2019 data).

Figure 8 displays the independent financial resources from fundraising activities since 2006.
The total fundraising amounts to 339M€ with the following subdivision: Competitive Projects (e.g., European competitive Projects, 239.6M€), Industrial Projects (79.7M€), In-kind Projects (e.g., equipment, 19.7M€).

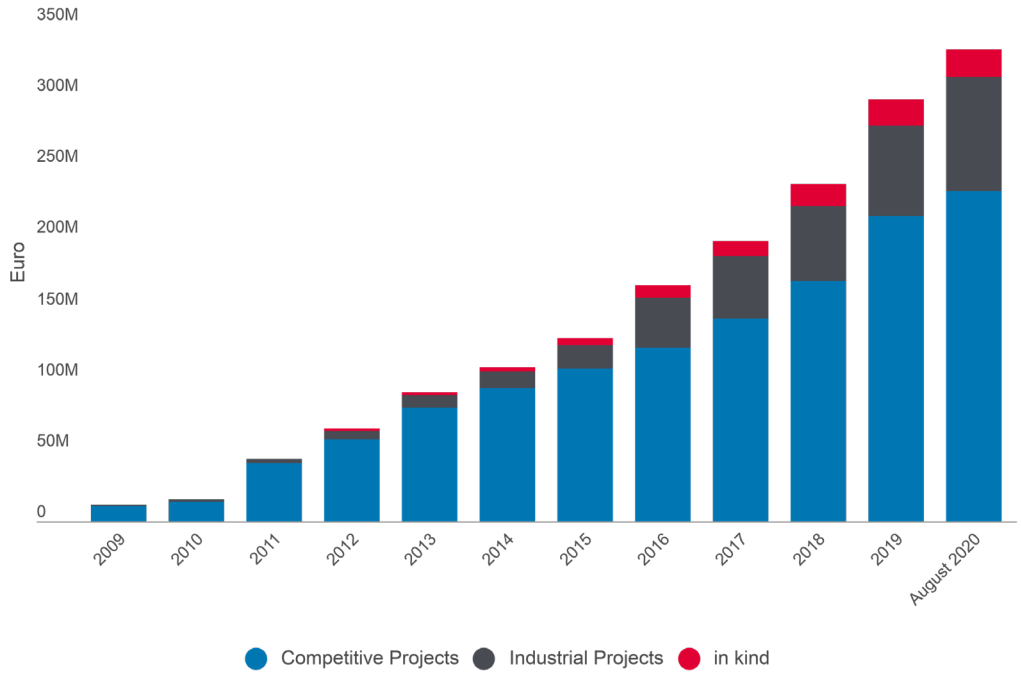

Figure 8: Fundraising trend of IIT since 2006. Blue: Competitive Projects, Grey: Industrial Projects, Red: In-kind

Technology Transfer

Sponsored Research Agreements and Industrial Collaborations

As shown in Table 3, industrial collaborations have been growing steadily in the past five years. From 2018-2020, sponsored research agreements have involved more than 170 companies. Of the 40 contracts with a value greater than €100K, 47% are with Italian companies and 53% with foreign companies (Figure 9).

	2016	2017	2018	2019	2020 (Aug)
Commercial Agreements (*)	152	130	147	152	133
Non-Disclosure Agreements	254	249	289	257	220
Inter-Institutional Agreements	16	14	12	11	13
IP consulting	85	104	107	190	137
Total	507	497	555	610	503
	22%	-2%	11%	10%	

Table 3: Technology Transfer activities in the last 5 years. (*) includes research contracts, Joint Laboratories, licenses.

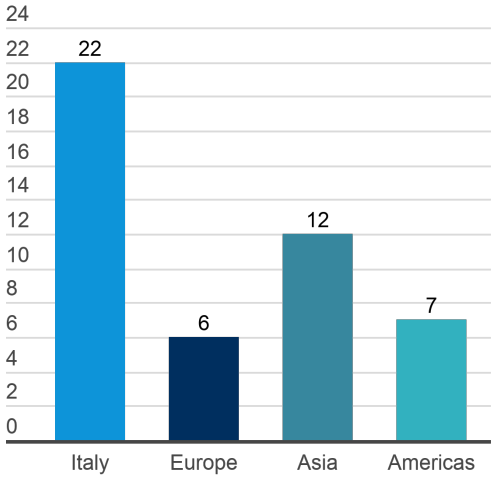

Figure 9: Sponsored research agreements in the last 2 years (2018-2020) have involved more than 170 companies. The top contracts (investment > 100 K€) involve 47% Italian companies and 53% foreign companies.

Patents and Licensing

IIT's patent portfolio has grown steadily since the startup phase (2006-2010). IIT's portfolio now includes more than 1000 patents, as shown in Figure 10.

Figure 11 shows the contribution of the four Research Domains to the intellectual property (IP) portfolio.

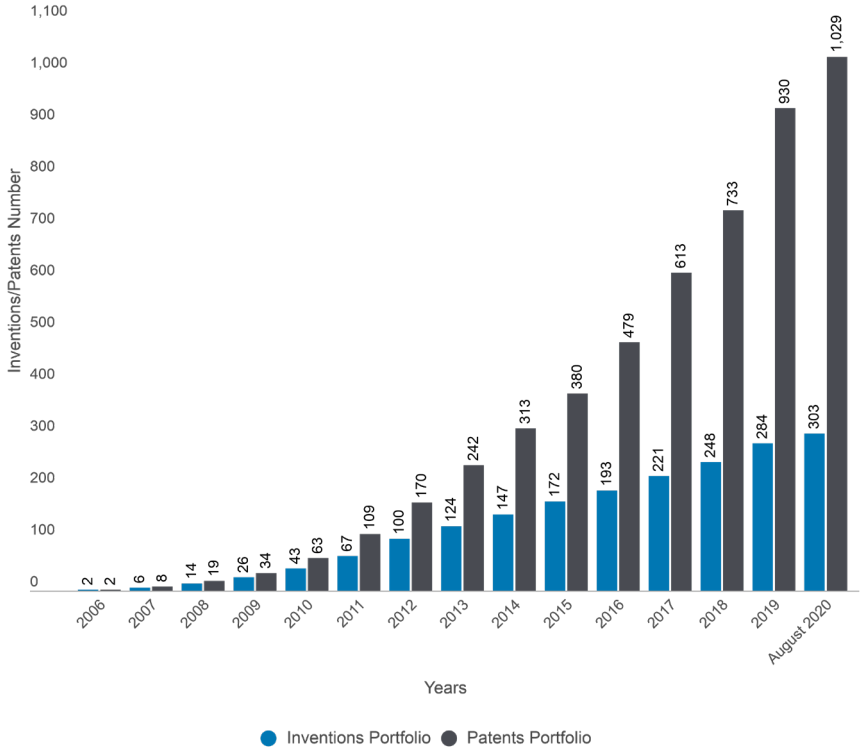

Figure 10: The patent portfolio (October 2020) comprises 1029 patents and applications (70% granted).

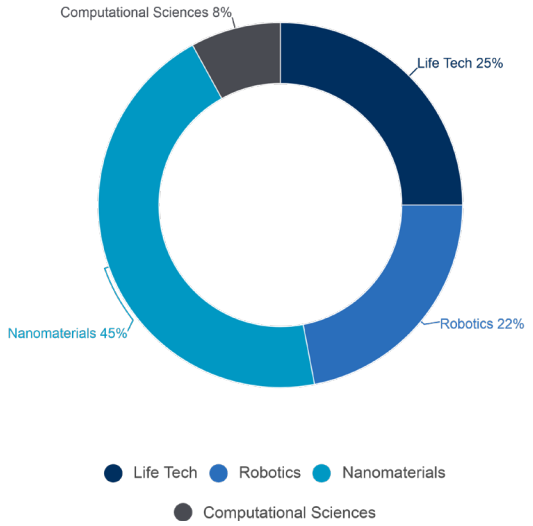

Figure 11: IP created by the four Research Domains (as at August 2020): Nanomaterials 45% (314), Robotics 22% (153), Technologies for Life Science (LifeTech) 25% (170), Computational Sciences 8% (58).

Among Italian applicants in 2020, IIT filed the seventh highest number of patent applications to the European Patent Office (EPO) (Table 4).

Ranking	Company name/institution
1	G.D. SpA
2	Pirelli &C SpA
3	Prysmian SpA
4	Chiesi Farmaceutici SpA
5	Saipem SpA
6	Leonardo SpA
7	Fondazione Istituto Italiano di Tecnologia
8	Ansaldo Energia SpA
9	Freni Brembo SpA
10	Telecom Italia SpA

Table 4: IIT's ranking among the top Italian applicants to the EPO.

Figure 12 shows how IIT licensing revenues compare to those of other European institutes and universities surveyed by ASTP[8]. IIT is a positive outlier.

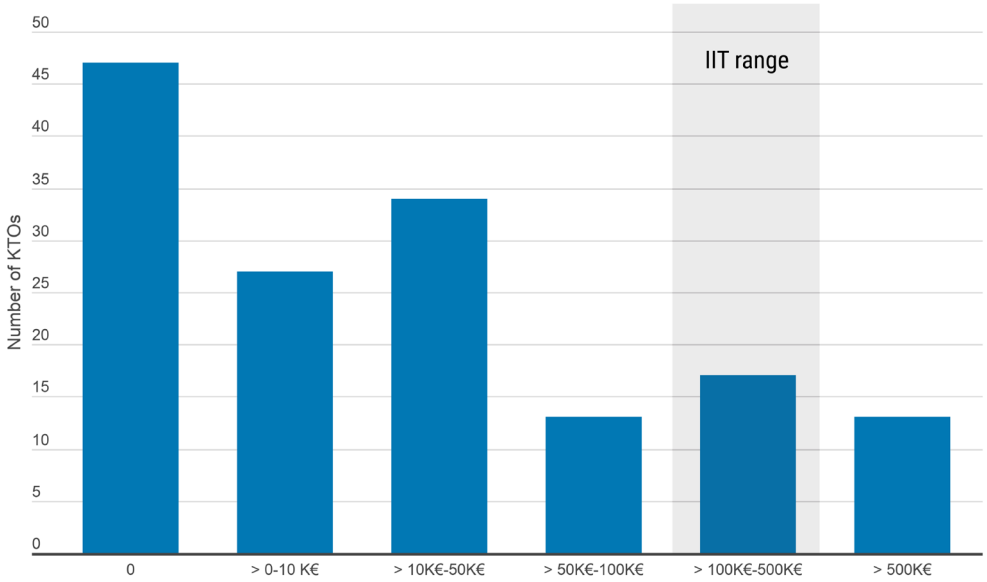

Figure 12: Distribution of European institutes and universities gross revenues generated from patent licenses across responding KTOs. IIT lies within the outlier range (IIT: 420 K€).

[8] ASTP 2019 survey report: https://www.astp4kt.eu/download/astp-2019-survey-report/

Appendix 2: European Funding

The EU RTD Framework Program, Horizon 2020, finished at the end of 2020 with the final call being for proposals to support the European Green Deal. With a €1B budget, the European Green Deal call was Horizon 2020's biggest call, shaping the transition to the new programming period.

In early 2017, discussions and preparations began for Horizon Europe, the European Commission's 9th Framework Program for Research and Innovation. The final program is expected to begin in Spring 2021, having been delayed by the Covid-19 pandemic.

Horizon Europe will run from 2021 to 2027 with a dedicated budget of €95.5B[9]. This is almost 30% more than for Horizon 2020, making Horizon Europe the world's most ambitious research and innovation program[10].

The planning phase results are summarized in "Orientations towards the first Strategic Plan for Horizon Europe"[11]. This orientation document describes the major policy drivers, strategic policy priorities, and targeted impacts to be supported by Horizon Europe's first Work Programs (2021-2024). These are being finalized, with publication expected in Spring 2021.

Below, we briefly discuss the orientations that are most relevant to IIT's scientific and technological strategy.

Key actions, as described in the Strategic Plan, are identified for each pillar of Horizon Europe's structure (Figure 13).

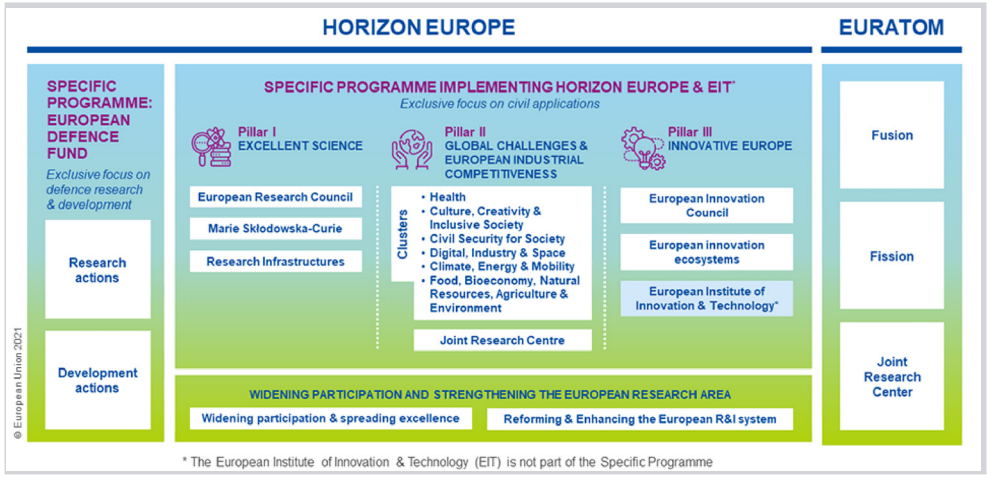

Figure 13: Schematic representation of the Horizon 2020 and Horizon Europe funding schemes, based on a three-pillar structure.

[9] Although the Commission requested over €100B.

[10] Horizon Europe, the EU research and innovation programme 2021-2027 general overview. European Commission. December 2020. https://ec.europa.eu/info/sites/info/files/research_and_innovation/funding/documents/ec_rtd_horizon-europe-overview.pdf

[11] Orientations towards the first Strategic Plan for Horizon Europe, European Commission. December 2019. https://ec.europa.eu/info/sites/info/files/research_and_innovation/strategy_on_research_and_innovation/documents/ec_rtd_orientations-he-strategic-plan_122019.pdf

Horizon Europe's Structure

Similarly to Horizon 2020, the Horizon Europe rests on three pillars:

- Pillar 1, Excellent Science, aims to promote scientific excellence, the creation and diffusion of new knowledge, skills, technologies, and solutions, as well as the development of and access to world-class research infrastructures. Pillar 1 aims to boost the training and mobility of researchers, thus increasing the attractiveness of the European Research Area.

- Pillar 2, Global Challenges and Industrial Competitiveness, aims to develop new knowledge and translate it into useful innovation, thus increasing the EU's global market leadership. Pillar 2 comprises six areas of intervention (Clusters): 1) Health, 2) Culture, Creativity, and Inclusive Society, 3) Civil Security for Society, 4) Digital, Industry, and Space, 5) Climate, Energy, and Mobility, 6) Food, Bioeconomy, Natural Resources, Agriculture, and Environment.

- Pillar 3, Innovative Europe, aims to strengthen Europe's innovative capacities by supporting the development and deployment of disruptive and market-creating innovation, and by linking together European ecosystems to create synergy between academia, entrepreneurs, SMEs, and market operators.

Horizon Europe's Target Impacts

Compared to previous Framework Programs, Horizon Europe focuses more on the impact of research and innovation actions. Horizon Europe aims "to deliver scientific, technological, economic and societal impact from the Union's investments in research and innovation" and, more specifically, "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 […] and society to address global challenges, including climate change and the Sustainable Development Goals"[12].

The Horizon Europe impacts will be structured in line with six priorities defined by the European Commission president in her political guidelines for 2019-2024: i) A European Green Deal; ii) An economy that works for people; iii) A Europe fit for the Digital Age; iv) Promoting our European way of life; v) A stronger Europe in the world; vi) A new push for European democracy.

IIT plans the following actions to better respond to Horizon Europe's target impacts:

- Establish an EU Liaison Office in Brussels as a source of early information to strengthen IIT's participation in EU Framework Programs and involvement in EU policymaking.

[12] Article 3, Common understanding regarding the proposal for Horizon Europe Framework Programme. Council of the European Union, 27 March 2019

Pillar 1 – Excellent Science

Continuity has been recommended[13, 14], for the main actions of Pillar 1, which supports next-generation science, technology, and research in a bottom-up approach.

Thanks to a budget increase of more than 22% compared to Horizon 2020, the European Research Council (ERC) will continue to fund groundbreaking, high-risk/high-gain research that advances the frontiers of knowledge in order to tackle European economic and societal challenges. Stronger links to other components of Horizon Europe will be established, especially with the Marie Sklodowska-Curie Actions (MSCA) to guide a new generation of highly skilled and emerging researchers towards ERC funding.

MSCA will continue its support of training actions, strengthening excellent doctoral and postdoctoral training programs as well as researcher training and career development systems. Cross-fertilization and the creation of broader communities are envisaged within the framework of Horizon Europe priorities and Missions (see Pillar 3). The Research Infrastructures actions will support the provision of state-of-the-art services, knowledge, and tools to address societal challenges, ensure evidence-based policy making, and help industry to strengthen its technical know-how.

IIT's planned actions for Pillar 1 are to:

- Support ERC proposals to promote groundbreaking, high-risk/high-gain research (and through the IIT mentoring program).
- Strengthen the attractiveness of the Brain Magnet Program for ERC winners (the BMP will close in 2025). New recruits will be evaluated for complementarity with existing research lines, potential synergy in completing research areas, and contributions to excellence in the Scientific Initiatives.
- Encourage applications to ERC Synergy grants to promote interdisciplinarity.
- Support ERC Proof-of-Concept proposals that have the potential to bridge the gap between fundamental research and precommercialization.
- Increase effort to support (e.g. MINDED project; MSCA Postdoctoral Fellowships), track, and evaluate (e.g. the mentoring program) early career development and training of researchers.
- Support MSCA Doctoral Networks proposals to train highly skilled early-stage researchers.
- Support MSCA winners in their career development and in ERC applications.
- Encourage applications to Research Infrastructure to strengthen IIT networks and systems at the European level.

[13] DRAFT REPORT on the assessment of Horizon 2020 implementation in view of its interim evaluation and the Framework Programme 9 proposal (2016/2147(INI)), European Parliament. March 6th, 2017

[14] LAB – FAB – APP: Investing in the European future we want. High Level Group on maximizing impact of EU Research and Innovation Programmes. July 3rd, 2017

Pillar 2 – Global Challenges and Industrial Competitiveness

Pillar 2 supports research relating to societal challenges and strengthens technological and industrial capacities. It is organized in clusters that promote interdisciplinary, intersectoral, transversal, and international cooperation. Pillar 2 takes a top-down approach to addressing the Global Challenges and European Industrial Competitiveness.

This places it at the center of Horizon Europe's Strategic Planning process, which defines the Key Strategic Orientations of the Work Programs published every two years.

Pillar 2 covers collaborative actions with medium-high Technology Readiness Levels (TRL)[15], which were formerly funded under Horizon 2020's Pillar 2 (Leadership in enabling and industrial technologies) and Pillar 3 (Societal Challenges), with a budget increase of more than 18% compared to the previous Framework Program. IIT was extremely active in these actions during Horizon 2020, with participation focused on ICT (46%), Health (21%), and NMBP+B (Nanotechnologies materials, biotechnologies and manufacturing, 17%) as shown in Figure 14.

According to an internal survey, our PIs' research interests are more homogenously mapped to the future clusters of Horizon Europe's Pillar 2 than in previous years (Figure 15).
There are only minor deviations in priorities across the Research Domains (RDs) as shown in Figure 16 (next page).

The Health sector is a key interest area for the four RDs, in line with the Strategic Plan's technology transfer (TT) target and the Societal Challenges of Healthcare and Aging Society. The PIs' general interest has shifted from technology-oriented programs (former ICT and NMBP) to more application-oriented ones (particularly Culture, Security, and Bioeconomy). This may indicate the Institute's progress in its TT mission and societal impact. This is particularly relevant for the Robotics, Nanomaterials, and LifeTech RDs.

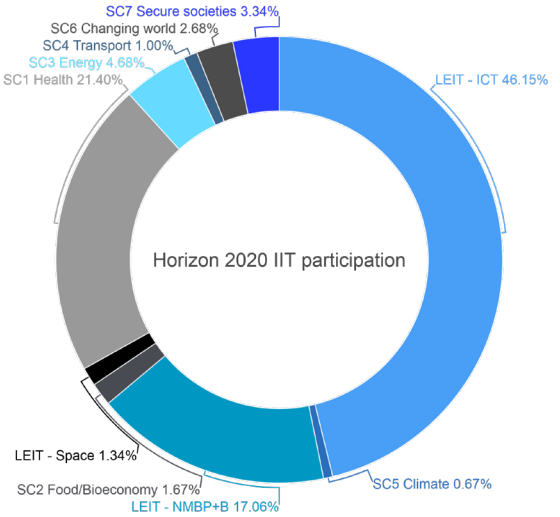

Figure 14: IIT participation in Horizon 2020 calls for collaborative projects (Pillars 2 and 3) for the 2014-2020 period.

[15] HORIZON 2020 WORK PROGRAMME 2018-2020 19. General Annexes – Annex G. Technology Readiness Levels. https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-g-trl_en.pdf

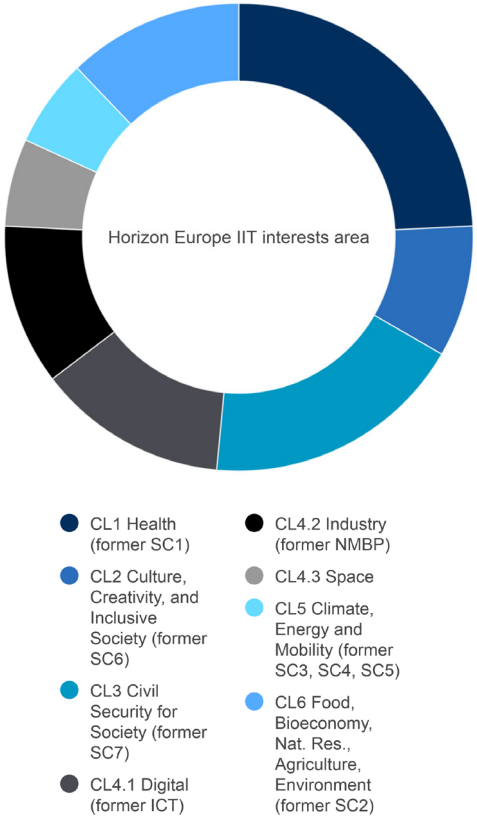

Figure 15: Mapping of IIT interest areas onto Horizon Europe Pillar 2 (June 2020 data).

This is in line with IIT's planned actions, which are:

- Create Joint Labs with corporations and clinical institutions to co-design/co-develop technologies.
- Set up the Center for Human Technologies (CHT), a new comprehensive and cross-disciplinary infrastructure for human-centered research and innovation, with links to the 5000-genome project and the CGS in Milan.
- Establish academic partnerships with educational and research institutions to integrate social sciences and humanities into research and technology development.

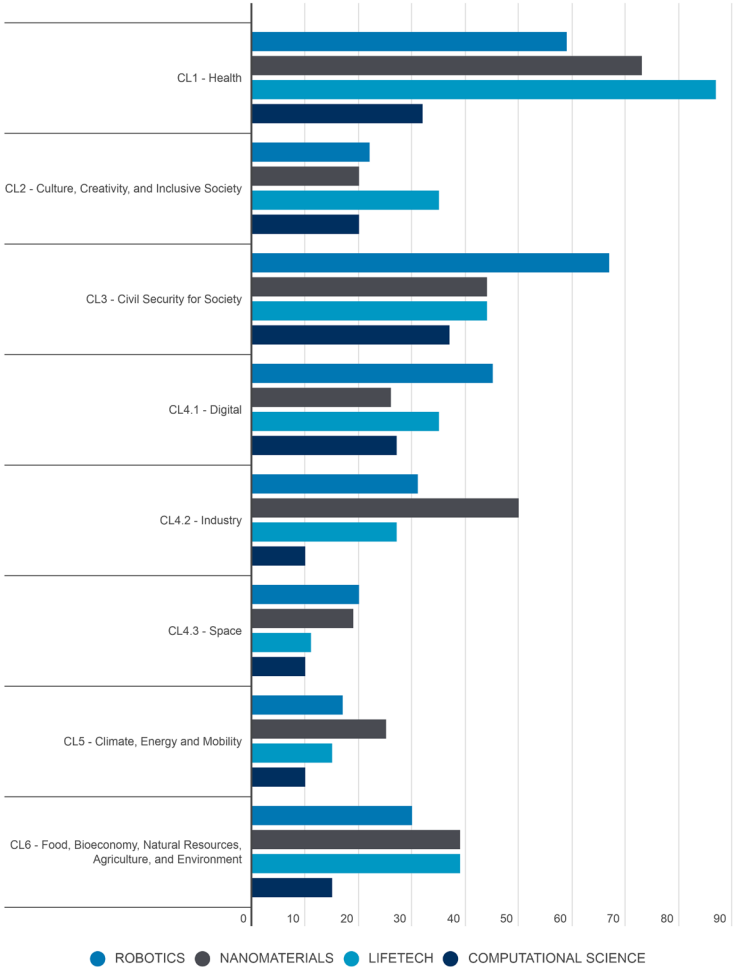

Figure 16: Mapping of IIT interest areas onto Horizon Europe Pillar 2 for each IIT Research Domain.

Pillar 3 – Innovative Europe

Pillar 3 is Horizon Europe's biggest departure from Horizon 2020.

It aims to make Europe a frontrunner in market-oriented innovation. With a budget of over €10B, the European Innovation Council will be a "one-stop shop" for bringing the most promising ideas from laboratories to real-world applications.

The EIC is an evolution of the FET program and will support the start-ups and companies in scaling up innovative ideas.

It will directly support innovators with Business Accelerator Services that are provided through two main funding instruments: 1) EIC Pathfinder is for early-stage breakthrough technologies with disruptive innovation potential, and will continue funding deep-tech research and innovation, building on FET Open and FET Proactive; and 2) EIC Accelerator is for product development and market deployment.

IIT's planned actions for Pillar 3 are:

- Proactively strengthen IIT's network of industrial collaborations.
- Continue building the collaborative network of clinical research institutes and hospitals (IRCCS).
- Consolidate IIT's training and education for scientists in entrepreneurship, TT, and research exploitation.
- Complete the start-up incubator in Genoa (by the end of 2021).
- Build the business accelerator IIT⁴, supported by the Italian public investment fund.
- Integrate the above elements (network of industrial and clinical partners, entrepreneurship training programs, financial operators, and high-TRL technology labs) in a European Digital Innovation Hub (EDIH).
- Connect IIT's EDIH with EIC initiatives and programs.
- Recruit one or more Innovation Officers who are fully dedicated to the business and exploitation plans of IIT projects.

Horizon Europe's Missions and Partnerships

Horizon Europe's main innovation is the introduction of Missions[16]. Missions are highly ambitious high-profile initiatives with measurable goals within a preset timeframe and with high impact for science and technology and/or society and citizens that could not be achieved through individual actions.

There are five missions:

- Adaptation to Climate Change, including Societal Transformation.
- Cancer.
- Healthy Oceans, Seas, Coastal and Inland Waters.
- Climate-neutral and Smart Cities.
- Soil Health and Food.

These are particularly relevant to IIT's three Societal Challenges (Sustainability, Healthcare, Aging Society) and are areas of interest identified by IIT research groups for Horizon Europe Pillar 2. They also connect well with IIT's Scientific Initiatives, particularly around the themes of Sustainability and Cancer (e.g. RNA Initiative).

The European Partnerships are another new element of Horizon Europe. European Partnerships are initiatives where the EU will work with private and public partners to jointly support the development and implementation of a given research program. European Partnerships[17] are meant to bring together a broad range of actors to work towards a common vision with concrete roadmaps and coordinated implementation of activities. Partnerships will cover a broad set of activities, including research and innovation projects, activities around societal, regulatory, and market uptake, and the development of synergies with national and regional programs for the deployment and scale-up of new clean technologies and solutions.

The portfolio of European Partnerships includes 49 candidates covering key themes of Pillar 2 and Pillar 3 in five main areas: i) health; ii) digital, industry, and space; iii) climate, energy, and mobility; iv) food, bioeconomy, natural resources, agriculture, and environment; v) partnerships across themes. IIT's planned action for the Partnerships is:

- Contribute to European Partnerships, including through active memberships in Co-programmed Partnerships (formerly Contractual Public-Private Partnerships).

Three Os: Open Science, Open Innovation, Open to the World

Open Science, Open Innovation, and Open to the World (the three Os) are a set of core values that will impact participation in European programs. In its preliminary consultation, the RISE group identified several actions to foster the public accessibility of science communication, public reusability of scientific data, and openness in innovation. Open science will be the modus operandi of Horizon Europe. Horizon Europe will therefore require open access to publications and data to assist market uptake and to increase the innovation potential of results generated by EU funding.

IIT's planned actions for the three Os scheme are:

- Appoint a Research Data Manager to map IIT's data and set up Open Data practices and infrastructures.
- Establish an IIT Open Access repository for scholarly publications to incentivize the Green Open Access Model.
- Implement an Open Science training program within IIT's training/mentoring program.
- Develop a communication plan to translate the results, innovation aspects, and implications of institutional projects into information that is understandable to the general public and to policy makers.

[16] Missions in Horizon Europe, https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/missions-horizon-europe_en

[17] European Partnerships in Horizon Europe, https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme/european-partnerships-horizon-europe_en

[18] Europe's future: Open Innovation, Open Science, Open to the World. Research, Innovation, and Science Policy Experts" (RISE) High Level Group. May 15th, 2017

Appendix 3: Joint Labs

1. IIT-INAIL: Created in Genoa in 2013 in an agreement between IIT Rehab Technologies and INAIL to develop and implement new prosthetic, orthotic, and rehabilitation devices with a high technological impact. In 2017, the IIIT-INAIIL Joint Lab was extended to include INAIL's Rome site.

   In May 2020, IIT and INAIL (Vigorso di Budrio site, Bologna) further strengthened their collaboration by signing a new 3-year agreement to develop 4 specific projects in the rehabilitation domain.

2. IIT-MOOG: Created in Genoa in 2016 to focus on precision control systems, next-generation actuators, and control technologies. IIT and Moog will develop technologies to push autonomous robots into real-world applications and the marketplace.

3. IIT-IBM: Created in Genoa in 2017 to create artificial intelligence application software to smoothly operate the plastic robotic R1 platform in everyday scenarios such as medical/ hospital help, information provision in shopping malls or airports, and home assistance.

4. IIT-NOVACART: Created in Lecco (at the Novacart production site) in 2016 to develop novel cellulose-based substrates and to produce biocompatible/biodegradable food-grade containers with enhanced performance.

5. IIT-DIRECTAPLUS: Created in Genoa in 2017 to improve the performance of Grafysorber®, developed by Directaplus, in applications related to water-oil separation, including oil spill clean-up and separation of oil from industrial wastewater.

6. IIT-NIKON: Created in Genoa in 2014, the Nikon Imaging Centre at IIT (NIC@IIT) is a core facility for light microscopy. NIC@IIT addresses the needs of a broad international community of scientists and professionals.

7. IIT-CRESTOPTICS: Created in Rome (IIT center CLNS) in 2014 to develop new microscopy techniques, extended and enlarged in 2018 to develop these microscopy techniques for the early diagnosis of neurodegenerative diseases.

8. IIT-FONDAZIONE DON GNOCCHI: Created in Milan in 2017 to test companion robots with patients and other robotic solutions for rehabilitation.

9. IIT-GASLINI: Created in Genoa in 2011 to develop technologies and clinical protocols to investigate motor, perceptive, and cognitive abilities in healthy and sick children.

   Expanded in 2020 to provide genomic analysis to diagnose pediatric diseases and direct patient-tailored therapy.

10. IIT-VILLA ROSA, APSS Trento: Created in 2014 to develop noninvasive brain stimulation and neuromodulatory rehabilitation protocols for stroke patients affected by visual and motor impairments.

11. IIT-CAMOZZI: Created in Genoa in 2017 to develop actuations systems and materials for robotics and advanced manufacturing.

12. IIT-DANIELI AUTOMATION: Created in Genoa in 2017 to conduct research and development in advanced robotics and AI applied to industrial automation in hostile environments.

13. IIT- MIND MAZE: Created in Ferrara in 2017 to conduct research and development in neurorehabilitation and to develop new models of Action-Observation Therapy.

14. IIT- EMS: Created in Ferrara in 2017 to develop novel electromedical systems to stimulate and record the human central nervous system.

15. LIGURIA HUMAN TECHNOLOGY HUB: Created in 2018 with research hospitals and clinical research institutes in the Liguria region. This initiative, launched in response to Regione Liguria's Growth Act, aims to accelerate the transfer of IIT technologies to the clinic and society.

16. JOINT LAB CATTOLICA: Created in 2018 in the Piacenza-based site of Università Cattolica del Sacro Cuore to test IIT's point-of-care technologies and its robotics technologies in the domains of food and agriculture.

17. IIT-BRACCO: Created in Genoa in 2019 to scout for a project of common interest. This project, wearable sensors for smart injections, was identified in 2020 and is now in progress.

18. IIT-HONDA RESEARCH INSTITUTE: Created in Genoa in 2019 to project and realize a control framework to allow a humanoid robot to help a human being in the execution of specific tasks.

19. IIT-NISSAN MOTOR Co: Created in Genoa in 2019 to design and realize a Social Sign Communication Robot.

20. IIT-INTELLIMECH: Created in Bergamo at KM Rosso to realize a teleoperated humanoid robot embedding many IIT technologies as a demonstrator for the Intellimech Consortium and its 30+ companies.

21. JOINT LAB IRCCS MONDINO VISUAL: Created in 2018 to develop tests and rehabilitation technologies for young patients with visual impairment and to analyze their perceptive, motor, cognitive, and neuropsychological abilities.

22. JOINT LAB IRCCS MONDINO REHAB: Created in 2020 to develop new preclinical and clinical neuroplasticity protocols for the rehabilitation of arm paralysis and cerebral neuromodulation after stroke.

23. JOINT LAB CNR NANOTEC: Created in 2020 to develop new 3D physiological in vitro models (organ-on-a-chip) to study cellular and molecular mechanisms in physiological and pathological conditions by mimicking in vivo conditions.

The Joint Labs employ about 250 people and have raised approximately €30M cash and €117M in kind over a 5-year period.

Appendix 4: Start-ups

IIT has generated 24 start-ups, with more than 40 start-up ideas currently undergoing due diligence. IIT's first three start-ups were launched in 2011, growing to 11 in 2015, 16 in 2016, and 24 in 2020. Notably, the entrepreneurial attitude of IIT's young scientists is uniformly distributed across the network's Centers, as shown in Figure 17.

The 24 start-ups originate from all research domains.

The following table summarizes the main financial information of IIT's start-ups. The start-ups have a total staff of more than 170 people, with total funds raised from private investors exceeding €90M. Twenty-six licensing contracts have been signed with IIT.

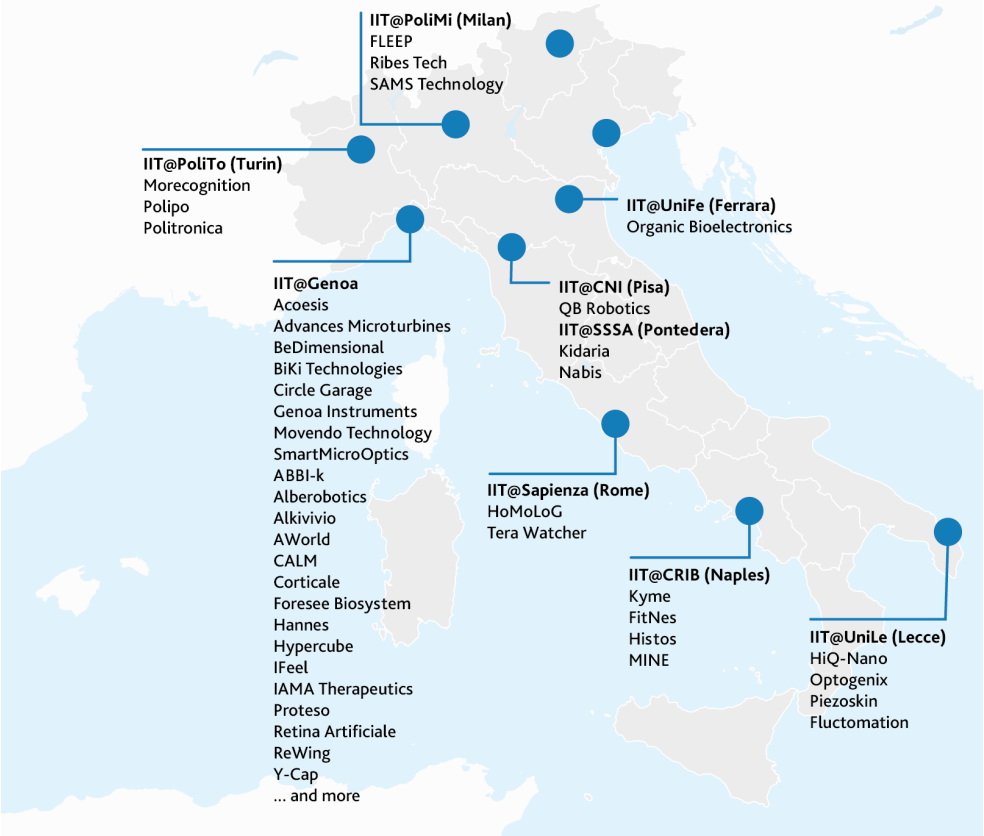

Figure 17: Selection of start-ups and start-up ideas undergoing due diligence in the IIT network.

Company Name	Staff count	Fundraising (€k)	Year	Research Domain	Headquarters	Licensing contracts
3 Brain AG	16	2000	2011	LifeTech	Switzerland	2
Acoesis Srl	4	960	2019	Robotics	Italy, Genoa	1
Advanced Microturbines Srl	2	900	2013	Robotics	Italy, Genoa	2
Alyra Therapeutics	N/A	N/A	2020	LifeTech	USA	1
BeDimensional Spa	24	20	2016	Nanomaterials	Italy, Genoa	1
Biki Technologies Srl	6	N/A	2014	Computational Science	Italy, Genoa	1
Circle Garage Srl	N/A	N/A	2013	Robotics	Italy, Genoa	2
Fleep Technologies Srl	N/A	800	2019	Nanomaterials	Italy, Milan	1
Genoa Instruments Srl	N/A	140	2019	Nanomaterials/ LifeTech	Italy, Genoa	1
HiQ-Nano Srl	6	590	2014	Nanomaterials/ LifeTech	Italy, Lecce	1
KYME NanoImaging Srl	5	100	2018	LifeTech	Italy, Naples	1
MoRecognition Srl	N/A	50	2016	Robotics	Italy, Turin	0
Movendo Technology Srl	43	15	2016	Robotics	Italy, Genoa	1
Neokera LLC	13	N/A	2015	LifeTech	USA	3
OptogeniX Srl	6	N/A	2014	LifeTech	Italy, Lecce	1
Organic Bioelectronics Srl	N/A	N/A	2019	LifeTech	Italy, Ferrara	0
Piezoskin Srl	3	38	2015	Nanomaterials	Italy, Lecce	0
Polìpo Srl	4	75	2016	Nanomaterials	Italy, Turin	0
Politronica Inkjet Printing Srl	19	5,5	2008	Nanomaterials	Italy, Turin	0
QBRobotics Srl	9	N/A	2011	Robotics	Italy, Pisa	1
Ribes Tech Srl	9	2	2016	Nanomaterials	Italy, Milan	1
Sem+ Inc.[1][19]	N/A	3,44	2013	LifeTech	USA	3
SmartMicroOptics Srl	5	476	2016	LifeTech	Italy, Genoa	1
Transine Therapeutics Limited	N/A	N/A	2020	LifeTech	UK	1

Note: Data provided by the companies and elaborated by the Technology Transfer Directorate.

Table 5: IIT start-ups details.

[19] Closed in 2019. Value in US dollars.

Appendix 5: Academic network

IIT has established 11 Centers at Italian Universities and Institutes and two outstations in the USA. Center infrastructure is fully provided by IIT on Universities' premises or in independent buildings close to Universities. Centers are run by IIT personnel with IIT budgets, rules, and evaluation procedures. Each Center has an IIT coordinator (a PI-equivalent role). New tenure-track positions were recently launched in several Centers to strengthen their structure. IIT appoint additional PIs to bring all Centers to a stable configuration. Scientific staff of the hosting/companion University are typically associated with IIT's research programs and Scientific Initiatives to foster interinstitutional collaborations and PhD training.

The 11 Centers are:

- **Center for Sustainable Future Technologies (CSFT) - Turin** (in association with the Polytechnic University of Turin): studying and developing low-carbon processes and technologies, sustainable materials, and energy storage.

- **Center for Nanoscience and Technologies (CNST) - Milan** (in association with the Polytechnic University of Milan): materials science and nanotechnologies, printable electronics, advanced photovoltaic devices, soft materials, nanoimaging.

- **Center for Genomic Sciences (CGS) - Milan** (in association with IEO – the European Institute of Oncology and IFOM – the FIRC Institute of Molecular Oncology): genomic studies in oncology and bioinformatics.

- **Center for Neuroscience and Cognitive Systems (CNCS) - Trento** (in association with the University of Trento): functional NMR imaging, vision and brain algorithms.

- **Center for Translational Neurophysiology of Speech and Communication (CTNSC) - Ferrara** (in association with the University of Ferrara): speech, natural-language processing human-brain interface, and organic bioelectronics for neurosciences.

- **Center for Nanotechnology Innovation (CNI) - Pisa** (in association with Scuola Normale Superiore): graphene and 2D materials, structural studies of organic and inorganic materials, nanomedicine.

- **Center for Microbiorobotics (CMBR) - Pontedera** (in association with Scuola Superiore S. Anna): soft robotics and responsive materials. From January 2021, renamed as **Center for Materials Interfaces - CMI** (in association with Scuola Superiore S. Anna): responsive (nano)materials and smart interfaces.

- **Center for Life Nanoscience (CLNS) - Rome** (in association with the Sapienza University of Rome): imaging, biophysics, genomics, and neuroscience. From January 2021, renamed as **Center for Life Nano- & Neuro- Science (CLN2S)** (in association with the Sapienza University of Rome).

- **Center for Advanced Biomaterials and Healthcare (CABH) - Naples** (in association with the University of Naples Federico II): tissue engineering, cell-instructive materials, bionanotechnologies.

- **Center for Biomolecular Nanotechnologies (CBN) - Lecce** (in association with the University of Salento): nanotechnologies for human health, including energy harvesting, wearable sensors, nanodevices for brain interfaces, and nanostructure modeling.

- **Center for Cultural Heritage Technology (CCHT) - Venice** (in association with Ca' Foscari University): new technologies to analyze and preserve cultural heritage.

- **Center for Nanotech for Brain (CNB) - Boston, USA** (in association with Harvard Medical School): neurobiology and in vivo optogenetics based on IIT technologies.

- **Center for Computational and Statistical Learning (CCSL) - Cambridge, USA** (in association with MIT): machine-learning models and algorithms.

Appendix 6: Acronyms

2D: Bidimensional materials
AD: Alzheimer's Disease
AI: Artificial Intelligence
ASD: Autism Spectrum Disorders
BBB: Blood Brain Barrier
CABHC: Center for Advanced Biomaterials and Healthcare, Naples
CBN: Center for Molecular Biotechnologies, Lecce
CCSL: Center for Computational and Statistical Learning, Cambridge (USA)
CGS: Center for Genomic Sciences, Milan
CHT: Center for Human Technologies
CINECA: Italian Supercomputing Center
CLNS: Center for Life Nanoscience, Rome
CMBR: Center for Microbiorobotics, Pontedera (PI), effective until December 2020
CMI: Center for Materials Interfaces, Pontedera (PI), effective from January 2021
CNB: Center for Nanotech for Brain, Boston (USA)
CNCS: Center for Neuroscience and Cognitive Systems, Trento
CNI: Center for Nanotechnology Innovation, Pisa
CNST: Center for Nanoscience and Technology, Milan
COMPUNET: Computational Sciences
CRL: Central Research Laboratory, Genoa
CSFT: Center for Sustainable Future Technologies, Turin
CTNSC: Center for Translational Neurophysiology of Speech and Communication, Ferrara

DS: Down Syndrome
DTI: Diffusion Tensor Imaging
EEG: Electroencephalogram
EM: Electron Microscopy
ERC: European Research Council
EU: European Union
FET: Future and Emerging Technologies
fMRI: Functional Magnetic Resonance Imaging
HD: Huntington's Disease
HPC: High Performance Computing
HRC: Human-Robot Collaboration
IEO: European Institute of Oncology
IFOM: The FIRC Institute of Molecular Oncology
INAIL: Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro (National Institute for Insurance against Accidents at Work)
IP: Intellectual Property
IRCCS: Istituti di Ricovero e Cura a Carattere Scientifico (Scientific Institutes for Research and Care)
ISS: Istituto Superiore di Sanità (National Institute of Health)
LifeTech: Technologies for Life Science
ML: Machine Learning
Moog@IIT: IIT-Moog Joint Lab
MTDLs: Multitarget-directed Ligands
NANOMATERIALS: Nanotechnology and Materials
NCs: Nanocrystals
NDGDs: Neurodegenerative Diseases
NDVDs: Neurodevelopmental Disorders
NIC@IIT: IIT-Nikon Joint Lab
NLP: Natural Language Processing
NSYN@Unige: Center for Synaptic Neuroscience, Genoa
PD: Parkinson's Disease
PET: Positron Emission Tomography
PI: Principal Investigator
RM: Robotic Models
RD: Research Domain
SPTs: Single-Particle Tracking Techniques
TT: Technology Transfer
WHO: World Health Organization

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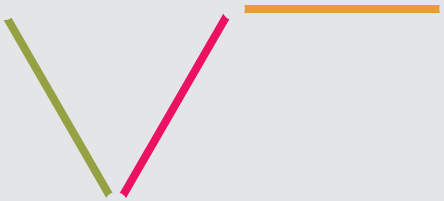

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