



PIANO
STRATEGICO
2021 - 2023

GRAN SASSO
SCIENCE INSTITUTE

INTRODUCTION

Knowledge for a better future

2021 represents the beginning of a new phase for the GSSI. With the November 2020 visit by the Evaluation Committee appointed by ANVUR, we entered a process that will shortly lead to the initial accreditation of our Institute and to our official entry into the ordinary funding system of Italian universities. The preliminary feedback received from the Committee has filled us with pride for the work done so far and made us confident in the work lying ahead.

We begin the new year, as we draft this new strategic plan, being aware of having reached a critical mass in professors and researchers and of our increased financial resources. This awareness leads us to take key decisions for our future in terms of investments and acquisitions of new spaces for training and research activities. The planned investments will allow the GSSI to strengthen its ability to attract new talents; we expect that those new talents will result in further external resources for GSSI stemming from our increased capacity of competing for research projects.

Another reason for confidence in our future is the strengthening of relations within the "team" constituted by the six Italian schools of excellence (Normale, Sant'Anna, Iuss, IMT, Sissa, GSSI). Together, we participate in an ecosystem of scientific research and higher education of international level.

Aware of the new phase reached by the GSSI, we have structured this new Strategic Plan in two parts. The first part outlines the GSSI strategy on the 2030 timescale, defining our identity and mission, as well as our intended impact on the international scientific community, on the local economy, and on society at large. The second part translates this long-term strategy into concrete steps for the next three years by providing specific objectives and indicators.

The vision that guides us is strong and simple at the same time: knowledge must be free and open, and lead to a better future for everyone. A future characterized by respect for the person and by economic, social and environmental sustainability of all human activities. We want to contribute with our skills and our passion to the construction of this new world.

The Rector
Eugenio Coccia

GSSI 2030

We present here the long-term vision of the Gran Sasso Science Institute on the 2030 horizon. In this imaginary "journey" into the future, our aim is to answer the fundamental question: "who do we really want to become?", in order to clarify our identity, mission, and intended impact on the academic community, the local economy, and society at large.

GSSI was established as a curiosity-driven science centre, delivering research and training activities in innovative and highly promising fields. In the coming years we will keep pursuing our core mission of excellence, expanding our international faculty, producing scientific research of the highest caliber, developing our training and educational capacity, leveraging the best assets already present in our region and connecting them with international resources.

We aim at being recognized in 2030 as one of the leading international research institutions – in the fields of astroparticle physics, mathematics applied to natural, social and life sciences, computer science with a focus on multi-agent systems, regional science and economic geography – and renowned for outstanding interdisciplinary projects, for bridging innovative research and industry and for our social impact.

A world class curiosity-driven science centre

The decision to establish the GSSI in L'Aquila was motivated by the desire of contributing to the rebirth of the city after the 2009 earthquake, following a model of 'City of Knowledge' supported by the Organisation for Economic Cooperation and Development (OECD)¹.

The first tangible sign of GSSI's contribution to this model is the presence today of hundreds of international students and young researchers, mentored by renowned scientists who have chosen to live and work in L'Aquila, animating the city with their projects and dreams. In just a few years of existence, and with a limited staff, GSSI already achieved outstanding scientific results in all its four areas (Physics, Mathematics, Computer Science and Social Sciences).

We selected our fields of study and research based on the highest potential for scientific discovery, technological transfer and foreseeable impact on our life and society in the years to come, also taking into account the excellent scientific assets already existing in L'Aquila.

Focusing on Astroparticle physics we sought to leverage a research infrastructure, the Laboratori Nazionali del Gran Sasso (LNGS) of the Italian Institute for Nuclear Physics (INFN), which is the largest underground research center in the world. Establishing a doctoral school tightly connected with the LNGS (and with other INFN centers) creates a powerful synergy capable of multiplying both volume and quality of scientific research. The disciplines of Mathematics and Computer Science were also already well established at the University of L'Aquila. These two research fields, properly declined, were thought to compose a defined scientific core, together with Physics, with natural overlapping interests and exciting perspectives. Finally, our Social Sciences area stemmed from the explicit desire to be instrumental to the social and economic development of L'Aquila and its surrounding area, following the 2009 earthquake.

Our initial approach was supported by a report from ERAWATCH, the European Commission's information platform on European, national and regional research systems and policies. ERAWATCH identified the GSSI as one of the most promising innovative initiatives in the Italian university landscape, spearheading a doctoral reform that "significantly increased the attractiveness of the Italian R&I system for students and young

¹ www.oecd.org/regional/regional-policy/laquilaearthquakere-launchingtheeconomy.htm

researchers.”² This positive evaluation was recently confirmed by the Italian Government, as it stated in his “Piano Sud 2030” (a plan for national cohesion and development for the next decade) that “the Gran Sasso Science Institute has grown into a centre of scientific excellence and international attraction, also thanks to specialized skills present in the area, including those of the National Institute of Nuclear Physics (INFN) laboratories.”³

The GSSI, despite its recent foundation, has already obtained a successful record of both managing and participating in important European and international projects, with all four research areas participating in European H2020 projects. Results from our training activities have been equally encouraging, and the many applications to our doctoral programs are of growing quality at a national and international level. Our students continue to receive important awards and practically all of them are employed shortly after graduation, mostly as post-docs or researchers, often in leading international research institutions.

Despite early success, several challenges, both endogenous and exogenous - as the CoViD19 pandemic- still lay ahead of us on our path to be a fully established world-class institution. As we continue in our effort to attract highly qualified faculty and researchers, we will suffer from salary caps required for Italian public universities, which are considerably lower compared to what can be offered by other international institutions. However, what we cannot offer in terms of salary, we will try to compensate in terms of trust, adequate funding for research activity and opportunities for career development. We do not give *positions of privilege* to senior faculty and we offer to our younger colleagues the same support that other institutions reserve for scholars with already well-established careers.

The academic evaluation system run by the Italian Government could present us with additional challenges. For example, the so-called third mission (public engagement) in Italy was traditionally measured in terms of a few numeric indicators, such as number of patents filed each year. As discussed in detail in the following sections, our view of the third mission has a wider scope, including broader knowledge transfer, social impact and the promotion of open knowledge. Rather than trying to maximize patent filings, we embraced a longer time frame and worked to build deeper partnerships with local stakeholders. Recent changes introduced in academic evaluation by the new Minister of University and Research give us hope that our approach to the third mission was “ahead of the curve” and that we will be evaluated and rewarded with public funding on the basis of our true social impact.

To increase our attractiveness, we will support institutional partners that are part of our local scientific “ecosystem”. One example is our current dialogue with INFN to establish a technology hub that could help to expand the role of the LNGS as a key infrastructure also for space-based scientific programs.

As the GSSI grows, it will be important to maintain the specific focus of its research areas, throughout their evolution, to distinguish them from programs in other universities. As an example of this, the Area of Social Sciences recently underwent a profound restructuring in order to better target an innovative niche in post-graduate education and renamed its doctoral program as “Regional Science and Economic Geography”.

As a young institution, we need to secure adequate funding to support all our activities. In 2020 we made a decisive progress on this front, as the Italian government increased GSSI’s yearly funding to a level that assures our long term financial sustainability. We will also need to expand our campus in the L’Aquila centre by acquiring new space and real estate nearby to host our growing activities. Finally, all our institutional missions will require full support from a lean and effective administration, capable of accommodating our international ambitions.

Our advancement, characterized by an open knowledge attitude, will be guided by three overarching principles that distinguish the GSSI from other schools for advanced studies and that will further the ethos of its founding:

² ERAWATCH Country Reports 2013: Italy

³ Presidenza del Consiglio dei Ministri. 2020. Piano Sud 2030, sviluppo e coesione per l'Italia. p.24

1. inter- and cross- disciplinarity;
2. bridging cutting-edge research and industry; and
3. leveraging knowledge to improve social justice.

We expect such principles not only to inform the activities within our own institution, but especially to serve as a guide for positioning the GSSI within collaborations with external partners. We thus expect the GSSI to act as a catalyst capable of precipitating important scientific, economic, and social impact. In the following sections we will discuss further and illustrate, also through the use of practical examples, why we selected those principles, what has been achieved so far, how we plan to overcome the obstacles ahead of us, and what systemic changes we are planning to put in place, in order to implement our vision.

The choice of our fields of research and of our principles seems especially appropriate as humankind is facing a global crisis triggered by the COVID-19 pandemic, perhaps the biggest crisis of our generation. The whole world must now find an answer to the question: do we go back to the situation the world was in before the pandemic, or do we accept the challenge of redesigning it towards social and environmental sustainability?

Before this crisis we were counting years until large areas of our planet become uninhabitable because of climate change. We worried that the rise of artificial intelligence could result in mass unemployment, while the concentration of wealth in a few hands could reach explosive levels. Those concerns are even more urgent now and the aftermath of this pandemic will make impossible to ignore them any longer. As the world approaches a difficult reconstruction, we need to preserve human liberty, to open knowledge access to everybody and to exploit citizen empowerment.

The role of a young, free research institution is more important today than it ever was.

Inter- and Cross- disciplinarity

Looking back at the history of science we can appreciate how revolutionary scientific progress was often driven by contamination among different scientific disciplines. Today, there is a growing consensus that interdisciplinary collaboration is required to develop tools and methods that lead to further advances in research programs. In fact, some of the world's leading universities have already established cross-disciplinary programs. Despite disincentives coming from the Italian academic evaluation system, interdisciplinary research can steer curiosity and inquisitiveness and boost progresses in each specific discipline. The specific combination of the scientific areas of the GSSI and their contained size facilitate fostering close relations among faculty members, as well as among students and postdocs. As will be shown below, interdisciplinarity can be found even within each individual area. Astroparticle physics, for instance, studying the connections between the Big Bang Model of cosmologists with the Standard Model of particle physicists, combines the advanced instrumentation harnessed by particle physicists with the highest standard of imaging of the cosmos undertaken by astronomers. Similarly, within Social Sciences, regional science and economic geography complement their respective theoretical paradigms and analytical tools to approach the issue of local development in a novel, overarching and systematic manner.

During its first years of operation as an independent University, GSSI already took significant steps to foster interdisciplinarity, focusing on research topics where excellence can only result from collaborative cross-disciplinary efforts, such as data science and smart communities. System modelling and analysis provide common frameworks for joint research projects in widely different fields such as cultural heritage, complex networks and smart cities, new mathematical modelling of economic systems (e.g., local labour markets), and numerical simulations of earthquakes and seismic safety. The Computer Science and Social Sciences

areas are already working together to detect and analyse emerging social phenomena and they have organized joint seminars, produced co-authored papers, and submitted successfully joint grant proposals. Funding from the Minister of Research has recently been exploited to hire, by “attraction” (from relatively more developed regions) and “mobility”, four new researchers who are about to start working on the topic of Smart Cities and Communities and Cultural Heritage.

Joint postdoctoral programs are being put in place and will represent a common practice in the future. There is also ongoing collaboration between the Mathematics and Computer Science areas on the study of complex networks and of behavioural models. Data mining and big data solutions will soon provide a benefit for research carried out by every GSSI area, from the analysis of Internet of Things data to the separation of gravitational wave signals from noise.

To support the development of cross-disciplinary activities, GSSI created the *Centre for Urban Informatics and Modelling* (CUIM), which integrates contributions from all four scientific areas into research projects focused on the L’Aquila territory. Thanks to these research activities, GSSI became a member of the CINI National Laboratory on Smart Cities and of the CINI Cybersecurity National Lab. GSSI is also a co-founder of the REDI Consortium (*REsilience after Disasters*), together with the University of Camerino and two major national research institutions, INFN (Fundamental Physics) and INGV (Geophysics). This initiative involves GSSI’s role as a competence centre in a region that is prone to earthquakes and it represents a commitment towards the issue of social and economic resilience after a natural disaster.

We are already looking for researchers who have both a deep expertise in their core discipline and the desire and capacity to collaborate with researchers from other disciplines. As we develop this interdisciplinary spirit we are aware that within the Italian academic accreditation system there are no incentives for young researchers to publish on interdisciplinary topics and that the professional networks of our researchers outside of the GSSI are generally confined to traditional disciplines. Therefore, we started a discussion across GSSI’s areas to identify a viable set of internal incentives, such as internal prizes for joint publications that feature authors from more than one research area. We are also planning to stabilize CUIM as an “interdisciplinary research centre” within GSSI.

The dialogue among different scientists is often difficult because of differences in approach and language. To build a common language, the GSSI already started to offer courses on interdisciplinary topics, such as those on Machine Learning and Blockchain in 2019 and on Reinforcement Learning and Cybersecurity in 2020, and we hosted the “Smart City Looks Like” summer school in the summer of 2019. To systematically embed interdisciplinarity into the GSSI’ educational offering, each area will offer each year one or more courses on topics that are of potential interest for students of all areas. Topics will range from artificial intelligence to elements of economic theories and to applications of quantum mechanics and will cross different scientific domains. In the coming years, interdisciplinary courses across the four scientific areas will become compulsory within the four PhD programs, and all PhD students will be required to attend them. We are also currently discussing the design of new interdisciplinary activities, possibly shaped as Master’s degrees, workshops and courses with contributions from GSSI research areas, CUIM, Open Polis Foundation (see below) and other partners.

Bridging cutting-edge research and industry

Innovation has emerged as the leading factor supporting the competitiveness, growth and development, and academic research can provide a precious contribution to innovation. Because of this, research and teaching are no longer considered as sufficient to define a successful university. The so-called “third mission” of universities (the first two being education and research) took centre stage and it is becoming increasingly important. The famous “triple helix” model developed in the 1990s by Etzkowitz⁴, and recently enriched by the insertion of the civil society “fourth helix”⁵, recognized explicitly the need for effective university-industry-government relationships to spur innovation and economic development in a knowledge-based society. To better play such a role, leading universities worldwide have established technology transfer structures and incubators. In addition to spurring innovation, applied research programs can create qualified human resources for the economy and guarantee alternative career paths for PhD students and researchers. A strong program of applied research could be especially beneficial in a place like L’Aquila, considering that the Italian industrial system is composed mainly of small and medium sized industries that often lack resources to support dedicated research and development activities.

Most of the research activity carried out at the GSSI is curiosity driven and our curiosity driven projects, in particular those related to large physics projects, have already demonstrated their potential to seed new technological developments. This aspect is crucial for the success of the developments described in this section. For the INFN Darkside project and for the Nuses project, GSSI staff are collaborating with L’Foundry and Thales Alenia Space Italia (TASI) in the development of innovative silicon-based sensors and satellite payloads. These technologies could be employed for a wide range of industrial applications, such as positron emission tomography, advanced driver-assistance systems, and earthquake-precursor monitoring from space. GSSI is actively engaged also with Small and Medium Enterprises (SME): CUIM, for instance, is currently developing innovative sensors for environmental monitoring and smart cities in collaboration with small-sized local companies.

A recent extraordinary example of interdisciplinary industrial effort has been possible thanks to the know-how matured within the INFN Darkside project. This effort, led by GSSI physicists and supported by medical doctors and engineers, consists in the realization of a novel mechanical ventilator designed for rapid mass production in response to the COVID-19 pandemic to address the urgent shortage of intensive therapy ventilators in many countries. The ventilator (named MVM for Milano Ventilatore Meccanico) is now a certified medical device.

Methodologies and software tools developed by faculty and students in computer science and mathematics are also suitable for industrial adoption and for establishing spin-offs. Gunpwwer S.r.l., a start-up that provides companies with services and applications based on cloud computing, IoT, Big Data analysis and Artificial Intelligence, was recently recognized as the first spin-off of the Gran Sasso Science Institute. The Computer Science Area is currently exploring a collaboration with TASI for the development of tools to ensure safety of satellites’ software. A local start-up, Dante Labs, is already funding a 4-years PhD scholarship in Computer Science to work on the “development of efficient techniques and tools for the analysis of large genomic data”. In 2020 the GSSI registered its first patent in the medical diagnostic sector. At the end of 2019 we signed a memorandum of understanding with the Hubruzzo Foundation aimed at supporting professional training, entrepreneurial development, and the transfer of GSSI research to industrial innovations. We are

⁴ Etzkowitz, Henry and Loet Leydesdorff. 1995. The Triple Helix -- University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development. *EASST Review*, Vol. 14, No. 1, pp. 14-19.

⁵ Borkowska, K., Osborne, M. Locating the fourth helix: Rethinking the role of civil society in developing smart learning cities. *Int Rev Educ* 64, 355–372 (2018). <https://doi.org/10.1007/s11159-018-9723-0>

also actively engaged in knowledge transfer towards offices of national and local government through several agreements signed in the last two years.

The Gran Sasso Science Institute's role within an "innovation ecosystem" was recognized in 2020 by the Italian Government in the already quoted "Piano Sud 2030", which included GSSI as a virtuous example of "policies for establishing innovative companies, for attracting talent, and for technology transfer."⁶

In order to incentivize the development of new technologies, we have recently signed a memorandum of understanding with INFN, LFoundry and TASI to design a joint lab for applied research that will foster innovation while training industry technicians, PhD students and academic researchers. The presence in the Abruzzo Region of important industries, research institutions and innovative clusters provides a unique opportunity to create a technological hub of international level in L'Aquila. The joint lab establishes the base of infrastructures and human capital that could be leveraged to create a new institution: a technological hub (which we would like to call Gran Sasso Tech) with its own legal identity, that is independent, open to other partners (e.g., UNIVAQ, ASI, Telespazio, Leonardo, ZTE, FCA, etc..), and which could provide support to small local industries. Establishing a technological hub, modelled on the Fraunhofer Institute in Germany and adapted to the Italian landscape, capable of operating with a lean, effective and business-oriented culture, could provide the GSSI with an important instrument to interface with the private sector and with venture capital.

We are aware that applied research and collaboration with the private sector may not be always perceived as valuable by researchers working in purely curiosity-driven science. For this reason, in parallel with the establishment of the hub, we will implement internal activities to inform GSSI faculty of the benefits and opportunities resulting from our partnership with local industry.

By 2030, the hub will become the first cell of an institute for applied research that will support the creation and development of local industries, as the Fraunhofer-Gesellschaft has been doing in Germany already for several decades. By then, all GSSI researchers will have aligned with and adopted a common framework of rules and procedures for IP protection and exploitation. Thanks to the hub, GSSI will benefit from additional "industrial" PhD students. Internships of GSSI students in industries and SMEs will be promoted as well. A number of technologists based in the hub will also provide expertise and support for research and development (R&D) activities of the GSSI. IP resulting from GSSI faculty and students research will be exploited through spin-offs incubated in the hub, providing new revenue streams to our university while contributing to the economic revitalization of our region.

The implementation of the bridging principle will require substantial improvement in the administrative capacity of the GSSI. In Italy the process of universities establishing Technology Transfer Offices (TTOs) is still under way and some doubts have been raised on their effectiveness within the Italian context. However, on average, Italian TTOs are younger and smaller compared to other countries, and this might explain some of the differences. We plan to mitigate the potential drawbacks connected with the limited size of GSSI's staff by joining networks of Technology Transfer resources. In 2019 we decided to join NETVAL, the Italian association for the valorisation of results from public research, which provides technology transfer training and tools, as well as an interface with Technology Transfer Offices of other universities, Technology Ministries and local administrations, industrial associations and industries, venture capitalists and financial bodies, and international organizations. Additionally, GSSI is in the process of joining JoTTO, the Joint Technology Transfer Office shared by School IMT Advanced Studies Lucca, IUSS, Scuola Normale Superiore, and Scuola Superiore Sant'Anna of Pisa. In 2020 we approved an official internal regulation for GSSI's spin-off companies and we nominated a commission on technology transfer, which oversees and advises on all matters related to IP

⁶ Presidenza del Consiglio dei Ministri. 2020. Piano Sud 2030, sviluppo e coesione per l'Italia. p.24

protection and valorisation. Finally, GSSI adopted a formal set of internal Intellectual Property (IP) policies to better guide our KTT activities.

Leveraging knowledge to improve social justice

As mentioned in the previous section, research has become the motor of economic growth. Today, IP generated by research (mostly publicly funded) accounts for a majority of assets owned by Standard & Poor's 500 companies. Even though taxpayer money is a primary driver behind this wealth, economic inequality has increased progressively in developed economies, rising questions on who the ultimate beneficiary of publicly funded research should be. Moreover, the introduction of new technologies (e.g., artificial intelligence, big data) has the potential to produce benefits for the whole society but also to damage vulnerable groups of people. Scientists are often the first to see the emergence of new technologies, so they are in a privileged position to evaluate from the outset their social potential and to monitor and influence their use. We therefore feel responsible to engage in an open debate on the effects of innovation and technology transfer on social justice. This is in conformity with the concern for social welfare that was a key motivation for the foundation of GSSI. Our Institute was established after the 2009 earthquake in L'Aquila, with an explicit intention of supporting the recovery of the local social structure. We believe that respect for ethical principles and diversity characterizing the plural society of the 21st century is a driver of value creation for people, and a source of new opportunities and choices for individuals and groups. The principle of social justice has been given greater relevance within the strategy of the new European Commission, with potential important consequences for the allocation of resources that could be leveraged to support GSSI's actions in this area.

From the foundation of the GSSI, we took concrete steps to pursue social engagement. GSSI is a co-founder of Openpolis, a foundation dedicated to open-government campaigns through the publication and analysis of data concerning politics, migrations and public policies in general. At the end of 2016, GSSI created *OpenDataRicostruzione*, a free online portal that supports public accountability by featuring granular data relative to all publicly funded reconstruction works for damages caused by the 2009 L'Aquila earthquake. In 2019 CUIM created *OpenData L'Aquila*, a free online portal featuring extensive smart city data relative to numerous areas, such as environment, commerce, culture, energy, mobility, public safety, government budgets, tourism, etc... A participatory framework is already embedded in activities of the CUIM that involve local citizens in the identification of needs, in providing services, and in predicting/preventing crises. GSSI is also a partner of *Forum Diseguaglianze Diversità* (Forum D/D), which aims to design public policies and collective actions to reduce inequalities and enhance everyone's freedom. Through our engagement with the Forum D/D we began developing a model of technology transfer that could integrate an evaluation of social impact. In 2019 we signed a memorandum of collaboration with the Forum D/D for evaluating GSSI's socially mindful model of technology transfer and for establishing a participative process for our initiatives around urban monitoring, urban revitalization through student housing, and open data.

A non-profit foundation, named after Ferrante d'Aragona and comprising the GSSI, the University of L'Aquila and the Municipality of L'Aquila, is being created to manage a large group of apartments, owned by the Municipality and mainly located in the city centre, which were restructured after the 2009 earthquake. The Foundation aims to rent these apartments at moderate cost to students, staff and visitors of academic and cultural institutions to prevent real estate speculation, accelerate the recovery of the urban centre, and increase the attractiveness of the city of L'Aquila for qualified human capital.

Forecasting possible effects of innovation and technology on people's inequalities and opportunities is a difficult task, as illustrated by Collingridge's dilemma⁷. On one hand the impact of technologies cannot be easily predicted until they are extensively developed and widely used. On the other hand, control of technologies becomes more difficult as technology is developed and becomes entrenched. However, there are examples of "social investing due diligence" already used by international investment funds, and the European Parliamentary Technology Assessment (EPTA) network regularly publishes new approaches and relevant data. More importantly, GSSI's Social Sciences and Computer Science groups could develop innovative methods and internal know-how on how to measure the social impact of research, leveraging ongoing work on networks and algorithmic game theory. In the coming years, GSSI will launch also a discussion on how research on Computer Science can respond to the challenges of the article 22 of the EU GDPR concerning "decisions based solely on automated processes".

We are mindful that adding an evaluative process of social impact to research projects could create an additional burden for researchers. A widespread commitment within GSSI will be necessary to ensure our capacity to direct knowledge towards an improvement of social justice. Establishing sound participatory mechanisms is also a difficult task. Effective participation requires two-ways processes: educating the public to the implications of new technologies and collecting their feedback to evaluate and direct applied research. A strong collaboration will be required in this field between social science researchers, administration (e.g. communication office, KTT, etc.), and external partners such as the Forum D/D.

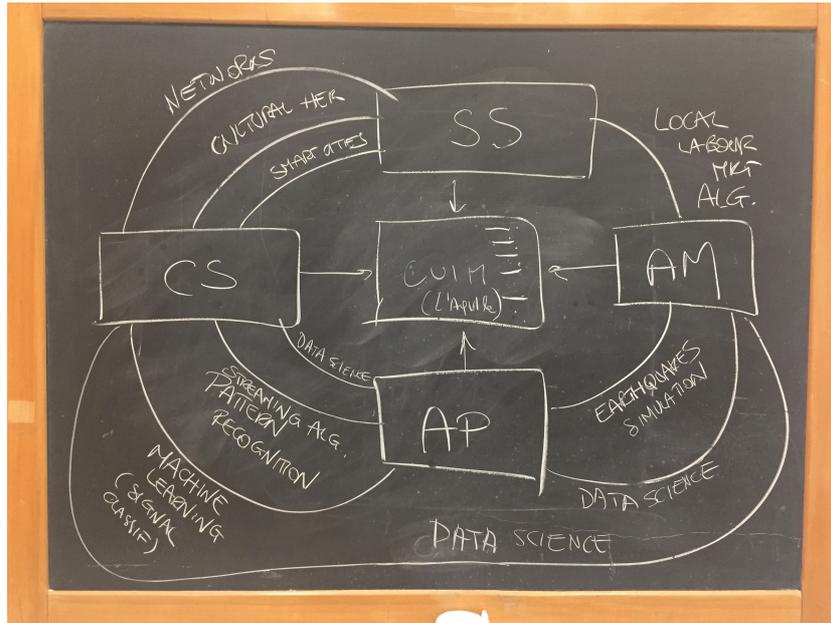
By 2030 GSSI will have developed a long-term strategy for social impact evaluation activities. Whenever possible, we will have developed amendments to GSSI regulations and administrative procedures to make them compatible with practices that improve social justice. At a higher level, we will disseminate GSSI's approach to social impact as a model for other universities and we could lobby, if necessary, for specific changes to national regulations. We will regularly organize workshops with civil organizations, discussing the social impact of current and future technological advances as well as new ways to organize society, thus leveraging the new GSSI's investments in behavioural and experimental economics. These workshops will strengthen also implementation of the interdisciplinary principle.

GSSI is also a partner of the Italian Alliance for Sustainable Development (ASviS), which has the aim to increase awareness of the importance of the 2030 Agenda for Sustainable Development of the United Nations in Italian society, economic stakeholders and institutions, and to mobilise them in order to pursue the 17 goals defined within it.

By 2030 we will have trained a new generation of students and researchers motivated to embrace a framework of increased social responsibility as a counterbalance to the economic and social inequalities that characterize today's world at all scales. Where appropriate, applied research projects will be empowered to produce estimates of social impact at their outset. Leveraging the IP developed by the GSSI will help us to negotiate favourable industrial partnerships that will reduce, not increase, economic inequalities. When licensing our IP we will favour partners that are local, small, and that pursue goals of social impact in addition to mere profit. Similar criteria will be considered for our various activities of procurement.

Finally, we will disseminate the results of our research to the widest possible audience, by means of public lectures, blogs, social media, and activities involving the general public, embracing open data standards for information that could be directly used and exploited by the public at large. GSSI will offer a course on measuring social impact of research that will be open to PhD students and researchers and we will leverage our internal expertise for educating managers from industries and public administrations.

⁷ Collingridge, D. 1980. *The Social Control of Technology*. New York: St. Martin's Press



The blackboard illustrates a collective discussion at GSSI on common interests. SS=Social Sciences, AM=Applied Maths, AP=Astroparticle Physics, CS=Computer Science

Specific contributions of individual areas

The long-term vision for the institute outlined above is based on strategic plans elaborated for each of the four Areas of the GSSI. We briefly describe these plans in the following sections.

Physics

The physics area of GSSI focuses its research and training program on astroparticle physics, the interdisciplinary field merging astrophysics, cosmology, and particle physics.

This strategic choice was motivated by two considerations: the geographical and cultural proximity of the largest laboratory in the world dedicated to this topic, the Gran Sasso National Laboratory (LNGS) of INFN, and the vision that this field of research has the highest potential for discovery and for technological transfer in the years to come. We are confident that this choice will place GSSI high in the international rankings in the 2030 horizon.

The open questions that will shape the fate of astroparticle physics in the next decade and that will forge a new vision of the universe concern the nature of dark matter and dark energy, the quantum representation of neutrinos, the origin of cosmic rays and the exploration of the universe through gravitational waves. Notably, two of these questions can be addressed with experiments located at the LNGS.

Our various research lines are intimately connected to each other. For instance, the search for dark matter (DM) has been increasingly more constrained by observations of DM signals in cosmic rays (CRs) (indirect

searches), as well as from searches for DM candidates in accelerators. Extremely high precision measurements of the fluxes and mass composition of CRs from space is leading to put extremely strong constraints on several DM candidate particles, and at same time it is opening unprecedented possibilities of understanding the cosmic radiation, especially in its nuclear component and in its antimatter component.

The detection of gravitational waves has made it possible to probe the properties of binary systems of stellar mass black holes and neutron stars. This discovery triggered a large campaign of observations using traditional astronomical telescopes, which led to the detection of multi-wavelength electromagnetic signals for a binary neutron-star merger connecting this catastrophic event to the most energetic astrophysical transients in the Universe, gamma ray bursts. On the other hand, the detection of gravitational waves also triggered increasing interest in primordial black holes as potential dark matter candidates.

Observational and theoretical efforts are bound to lead to major developments in the years to come, and the GSSI has to be ready to catch such challenges and optimize the potential for discovery.

We live in an interesting time, in which major results are being presented to the public every day. Yet, some trends are clear as well: no candidate particle for DM has been identified in the range of energies accessible to LHC. Indirect search for DM signals in cosmic rays and in high energy astrophysical environments has also led us nowhere. Direct searches of DM in underground laboratories, such as the LNGS, have a potential for discovery and led so far to continuously improve the upper limits. GSSI supports the most important new experimental effort of this kind, which also has a strong technology transfer program: DarkSide. It is being built at LNGS with a GSSI professor as the PI. GSSI also supports new promising approaches also at LNGS with GSSI leadership.

Observation of the Universe through gravitational waves will open doors for new discoveries and will establish a new representation of the cosmos. GSSI plays an important role in the astrophysics community and in the Virgo/LIGO Collaboration both in the detector science and technology, and in the data analyses and modelling, with particular focus on multi-messengers signals. GSSI has access to the best observational resources for the electromagnetic follow-up of gravitational-wave sources (including ESO, ESA and NASA telescopes) with a coordinating role in the European scenario. Moreover, GSSI will be a crucial contributor to the Italian bid to establish the new generation observatory Einstein Telescope (possibly located in Sardinia).

In the next few years, the international community (APPEC in Europe, DOE/NSF in the USA) will select the leading technologies for investigating the fundamental questions of the neutrino mass and nature and will define the programs of discovery of the neutrinoless double beta decay, which is the only way to settle the question of the quantum representation of neutrinos. It is imperative that GSSI establishes a leading effort to shape the LNGS program.

Finally, the GSSI plays an important role in the search for the origin of high energy cosmic radiation, which in the next decade will lead to an impressive experimental effort aimed at measuring the properties of cosmic rays with unprecedented accuracy and will unveil information that is crucial for understanding the acceleration and transport of those very high energy particles in the universe, all topics in which GSSI is heavily investing.

Both in the perspective of helping the identification of DM particles and of maximizing our chances of discovering new pieces of physics and astrophysics, space sticks out as a very promising frontier. Building upon current interests in space enterprises in which GSSI has engaged, we have a plan to build the already mentioned infrastructures. The leading activity in the short term will regard space research in tight collaboration with INFN, through the creation of a hub for this type of research in Italy in the short term, and at international level in the long term. A stimulus to this project came from the leadership of GSSI in the project for the realization of the NUSES satellite, involving Thales Alenia Space, and aimed at both a technological advancement in detection of astrophysical neutrinos from space and the search for seismic

precursors in the Earth magnetosphere. The presence of major industries in Abruzzo adds to the value of this plan, both in terms of credibility and of impact on the local economy.

The inspiration to invest in space came also from underground: the DarkSide experiment makes use of a large number of Silicon Photo Multipliers (SiPM), the same devices that are essential for a possible use in space in next generation CR experiments – which will see the active participation of GSSI - such as HERD and POEMMA. One of the payloads of NUSES is in fact aimed at the space certification of SiPM for adoption in future space missions. The production of SiPM for DarkSide is going to take place at L-foundry (Avezzano), while being assembled at a planned and already funded INFN infrastructure (called NOA). In addition to the potential benefit of establishing a technology capable of identifying seismic precursors, this new hub will embed, within all stages of technology development and commercialization, specific procedures and evaluation mechanisms to assure that its operations will result in a reduction of social and economic inequality. The goals of the GSSI hub are threefold:

- 1) Developing innovative technologies for spatial payloads
- 2) Developing techniques based on new materials and additive manufacturing
- 3) Providing suitable tools for numerical simulations and modelling for the investigation of the universe and the Earth and the analyses of large amounts of data associated with future space-based experiments

As a result of all the choices outlined above, by 2030 we aim at becoming a leading centre for the investigation of Astroparticle Physics in all possible environments: underground, on the Earth surface and in space.

Mathematics

The mathematics of the GSSI has already reached its distinctive personality which allows it to develop strategic choices on long time scales, looking at the challenges of the next 10 years, with the awareness of having laid the foundations in the right directions.

The choice, not to be delimited by rigid disciplinary boundaries, is intended to go in search of a significant cross-fertilization with the contiguous areas, which has immediately proved to be a winning direction.

In the current GSSI, these pillars have been laid by extending the usual bases of applied mathematics also to other sectors like computational fluid dynamics and statistical physics.

The 2020-2030 decade now opens with a huge challenge due to the construction of new paradigms for the development of a society that must face the monstrous criticalities created by the Covid pandemic disaster. For mathematicians, this opens up challenges that add to those that already exist in science and technology.

In particular, the development of a new approach to human health problems becomes more and more relevant. This will have to range from an increasingly accurate description of human physiology to models for the spread of epidemic diseases. Furthermore, research in system biology and pharmacology becomes of great importance in this area.

This coexists and intersects with fundamental research objectives that are set by new frontiers in Science and Technology, such as artificial intelligence, machine learning, high performance and quantum computing, robotics, communications technology, biotechnology, genomics, synthetic and computational biology, computer security, energy, materials science.

The mathematical models of collective behaviours are now a tool that cannot be renounced as seen in the problems of epidemiology, highlighted by the pandemic emergency. They play an essential role in the study of network relational systems. The functioning of social aggregators such as Google, Netflix, people dating apps, etc. are based on sophisticated algorithms built on the top mathematical models.

Mathematics plays also a fundamental role in the analysis and design strategies of disaster recovery.

Since the beginning of the GSSI's activities, the Mathematics area declared its field of interest to be mathematics applied to natural, social and life sciences, and structured its research around four core pillars:

- a) Stochastic analysis and statistical mechanics, statistics and data analysis, uncertainty quantification.
- b) Analysis of partial differential equations, in the spirit of infinite dimensional dynamical systems, applied to different fields such as mathematical physics, engineering, biology and social sciences.
- c) Numerical methods for differential and functional equations, with particular emphasis to dynamical systems and evolution equations. Matrix theory and numerics for linear algebra, with application to control theory and to the analysis of large networks and graphs. Novel tools for stability analysis and synthesis of switched and discontinuous systems.
- d) Continuum mechanics, modelling and scientific computing, numerical simulations of turbulence, fluid mechanics of human body, bio-fluids mechanics, fine scale analysis in fluid dynamics, turbulence, quantum mechanics, quantum many body problems.

On the basis of previous considerations, this strongly suggests to focus primarily on the consolidation and further development of the current research lines.

Being mathematics per se the common language of any quantitative science, we end with the words of Galileo Galilei: "Nature's great book is written in mathematical language".

Computer Science

Information and communication technology evolve rapidly and it is difficult to predict the specific research issues we will be facing in 2030. However, it is foreseeable that future computing systems will consist of large-scale, physically distributed, autonomous and heterogeneous agents, where different kinds of data-collection sensors supply information used to manage assets and resources efficiently. These agents will take context-dependent decisions autonomously, will pursue local goals and cooperate to achieve global tasks while maximizing their individual utility. They will interact with humans and their environment in ways that will have to be monitored, planned and understood to ensure that they behave as expected and that their impact on the environment they affect will be "positive".

Our overarching scientific goal for 2030 is to become one of the best-known research institutes in computer science addressing the challenges behind the development of multi-agent systems, going from the design of suitable abstractions and efficient algorithms to their implementation in trustworthy systems. On the algorithmic side, in 2030 we will be in a position to achieve international recognition for contributions to algorithmic game theory, whose techniques allow one to model and analyse the consequences of autonomous, and possibly selfish, agent behaviour on system quality and performance, and to provide efficient solutions and mechanisms coping with the effect of non-cooperative behaviour on resource allocation, cost sharing, communication, and spontaneous network and community formation, amongst

others. Moreover, we aim to be a leading group in computational social choice, a related area of research at the interface of Computer Science and Economics, that is concerned with the design and analysis of methods for collective decision making, and in particular on how to fairly aggregate the individual points of view of several agents, so as to arrive at a reasonable compromise. Addressing those issues in the setting of huge multi-agents systems will need significant advances in the design of fast algorithms for finding optimal or approximate solutions and research on algorithm engineering, focussing on developing algorithms having good performance in practice. Since much of the decision making in such autonomous systems will affect society at all levels, this research effort will have to take into account also aspects related to algorithmic fairness and the impact that our algorithmic solutions will have on “social justice”, broadly construed.

The principled construction of large-scale multi-agent systems will also require the development of model-based techniques for their design, implementation and validation, supported by automated tools. Hence, we also aim at achieving excellence and high international visibility in the establishment of model-based, software engineering methods and tools that will allow for the development of systems that are efficient, reliable, predictable, scalable and modular, and thus easier to program and maintain. In particular, we will strive to produce software tools supporting the development and automated analysis of systems that are mature enough to impact both academic and industrial settings. An example of a grand challenge in this field--and one that the computer science group is well positioned to address---is represented by autonomous agents that interact with the physical world, and will increasingly use machine-learning algorithms and other techniques from artificial intelligence to make decisions influencing their emergent behaviour; ideally, such decisions should be perspicuous to the other agents with which they interact, be they humans or machines.

Achieving the above-mentioned scientific goals will require a careful and timely recruitment of permanent and tenure-track faculty in the areas of specific interest for the computer science area. Despite the positive responses to our calls for “expressions of interest” for a variety of positions, attracting top-class, computer-science faculty to the GSSI has proven to be a difficult task over the last three years and will most likely remain so in the foreseeable future. Indeed, the vast majority of Computer Science departments in the world is hiring at all academic levels in response to the growing number of students who wish to enrol in computer-science degrees. The competition for talent will be fierce and building an aura of scientific excellence in our selected research areas will be crucial in attracting a good number of high-class computer scientists to the GSSI. The recent success of computer-science researchers in grant winning (three Italian PRIN grants, two European projects, two grants from the Icelandic Research Fund, a joint PON project the area of Social Sciences for funding 2 assistant professor positions, and contracts with the Municipality of L’Aquila and the Dante Labs local company) on topics related to the aforementioned scientific challenges, the publications by group members in very selective and coveted outlets, the successful international conferences, workshops and summer schools we organized at the GSSI, and the awards and honours bestowed on our students, postdocs and faculty have put our research in the spotlight and have contributed to increasing the visibility of the GSSI within the computer-science community. Since achieving critical mass and visibility are important for future successful hires, we plan to double the size of the group within the coming three years and to continue attracting top-class visiting researchers to the GSSI.

Increasing the number of computer-science researchers at the GSSI will also be necessary to make the group be a prime mover in the implementation of the three strategic pillars in the long-term vision for the GSSI. By 2030, the computer-science area will have taken full advantage of the interdisciplinary opportunities arising from the presence of the different areas at the GSSI and will be the hub of many cross-disciplinary research projects. We foresee this development along the following main directions, amongst others. The first concerns the development of strategies supporting data-driven decision making for the national strategy on inner areas. In particular, we have already started a long-term collaboration with the area of Social Sciences in the application of models and tools from computer science to detect and analyse emerging social phenomena, with the goal of helping policymakers to build inclusive and smart communities. Some of the

preliminary results in this interdisciplinary research have been reported in two jointly-authored papers (at the time of writing) and have formed the basis for joint grant proposals (both at the national and European level). In cooperation with the mathematics area, we started a research project on behavioural models of people and entities, to predict emerging dynamics and collective behaviour or to test public policies (applications span from traffic networks to the allocation of public goods and the organization of tender procedures). Collaboration with the Mathematics area also deals with algorithmic problems concerning specific settings of common interest, such as the study of complex networks and the coordination of swarms of mobile robots, in upcoming joint projects.

Data science is a strategic interest of the Institute that cuts across all the research groups at the GSSI. The computer-science group will play a central role in the design of efficient and certified solutions to problems in data mining and big data. Such solutions might be exploited in smart-city services starting from data generated by sensors and smart devices (collaboration with social sciences), in the automatic classification of cosmic particles on the basis of their generated signals, and in the automated separation of gravitational noise from particle signals. Algorithm engineering techniques might help in devising real-time algorithms that can be exploited in future experiments in Astroparticle Physics.

Given the increasing importance of data science and machine learning, the computer-science group is also considering the establishment of those fields as a fourth research pillar that would complement the existing ones, namely algorithmics, formal methods and software engineering.

Attracting suitable academic personnel to reach the critical mass needed to achieve our goals related to interdisciplinary research will be a challenge. However, as mentioned above, the groups in computer science and social sciences have already attracted funding for jointly hiring five researchers. The Computer Science and Physics groups are involved in a COST action, whose objective is to create a network of scientists from four different areas of expertise, namely gravitational-wave physics, geophysics, computing science and robotics, with the goal of tackling challenges in data science.

The growth and pervasiveness of digital technologies provides the computer-science group with many opportunities to impact local government and economy in a positive fashion. Partly embracing Shneiderman's "Twin-Win Model"⁸, our basic-research efforts will be accompanied by a problem-oriented approach leading to publishable research results as well as to solutions that are ready for wide dissemination and application by local government and/or industry. By 2030, we foresee the development of a number of spin-off companies in Abruzzo and surrounding regions founded by researchers and (former) students in computer science at the GSSI. The group already has agreements and strong ties with local and national industry, and several other agreements are being finalized. In particular, the CS group attracted a PhD scholarship fully funded by Dante Labs, a start-up specialized in sequencing genomic data, and started a research collaboration on software verification with Thales Alenia Space, that is a leading company in the systems for space telecommunications and collaborates with the most prestigious institutions such as NASA and the European/Italian Space Agency. Moreover, one of the members of the group has founded a start-up which will be the first spin-off of GSSI and currently employs more than 50 people, most of which graduates and students in Computer Science from the University of L'Aquila. We also collaborate with the Municipality of L'Aquila on topics such as real-time tracking and travel planning in public transport, and in the handling of environmental disasters. This range of collaborations contributes to connecting our international outlook in research and graduate-student education with the development of the local community that hosts the GSSI. Having said so, as stated in the Vienna Manifesto for Digital Humanism⁹, while digitalization provides

⁸ <https://www.pnas.org/content/pnas/early/2018/12/05/1802918115.full.pdf>

⁹ <https://www.informatik.tuwien.ac.at/dighum/wp-content/uploads/2019/05/manifesto.pdf>

unprecedented opportunities for growth, it also challenges scientists and technologists to use the power of computing for the common good: “Technological innovation demands social innovation, and social innovation requires broad societal engagement.” Even though achieving social innovation and justice are tasks that are far beyond what an institute like the GSSI can do, we will strive to ask ourselves the question “cui prodest?” (“who benefits?”) when our research can impact society and to disseminate the basic knowledge needed to appreciate the benefits and pitfalls of digitalization for society at large, starting from L’Aquila and Abruzzo as a whole. To this end, we are organizing and we will organize a variety of events in which our best communicators will present research results to the general public, to the whole of the GSSI and to policymakers in an accessible way, highlighting both opportunities they offer and dangers they may pose. In particular, during the COVID-19 emergency we started the joint ICE-TCS @ Reykjavik / GSSI virtual seminars, which brought together world-renowned scholars from different corners of the globe, and are continuing even after the abolition of the restrictive measures. Interdisciplinary talks were given by famous world-wide scientists such as Moshe Vardi, concerning the ethical crisis of computing, and Edward Lee, on his celebrated book on the coevolution of humans and machines.

Social Sciences

The last 3 years, since 2017, were characterized by a profound restructuring of the Social Sciences Area to better match the overarching goals inspiring the GSSI and the “mega-trends” that are shaping the world. This restructuring has involved both the education and research domains, setting them along trajectories whose pursuing will continue in the next decade, but which will have to be “adjusted” to face the new challenges posed by the Covid19 crisis.

As far as education is concerned, the new doctoral program, initially named “Urban Studies and Regional Science”, has been renamed “Regional Science and Economic Geography”. This re-labelling is intended to mark and signal a prospective re-positioning of the doctoral program that, while continuing to keep interdisciplinarity as its core essence, aims at better fine-tuning its inspiring idea of differentiating the GSSI from other competitors by targeting an innovative niche in the post-graduate international education “market”. Such a repositioning aims at providing a wider scope combining economic geography with regional science to foster a handier contamination of the program with other neighbouring disciplines like sociology, innovation, international, health and environmental studies. In so doing, the interdisciplinarity breadth of the doctoral programme has been widened. This also provides the students with an overarching training, adequate to investigate the pervasive consequences, threats and opportunities that the Covid19 pandemic is posing to regional and local economies. In order to pursue this training objective more directly, the Area is in the process of establishing a partnership with the University Bicocca of Milan, aimed at offering co-funded PhD and postdoc scholarships to research the medium and long-term impact of Covid19 on regions and local economies.

So far, the initially designed niche strategy followed by “Urban Studies and Regional Science” has paid off with a large number of applications, a growing interest from researchers worldwide (testified also by the successful international conferences we organized and hosted in the last couple of years), and with an effective selection of very talented students and young postdoctoral researchers. If the period 2017-2019 was our “sowing time” – marked by a re-organization and initial recruiting – and the time of the first “harvesting”, the next three-year period 2020-2022, will be crucial for the newly “Regional Science and Economic Geography” PhD to bear its fruits and consolidate our position worldwide. In the short-run, turning the difficulties posed by covid-19 (especially in limiting international student and faculty mobility) into an

opportunity, the Area started offering blended learning and activated a new Webinar series in “Regional Science and Economic Geography”, which also serves the purpose to extend and stimulate our research networking (the videos are all recorded and will be posted on our webpage).

As for the research domains in which the area operates, going forward to 2030, we envisage the strategic choices made so far to pay high dividends. However, we also realize that the Covid19 crisis has come to “interfere” with the “mega-trends” recently mapped by the OECD for the prospected decade and this requires the area to integrate and amend some of its initial domains.

Starting with the “demography and migration” mega-trend, certainly one of most pressing before the Covid19 crisis, the area of Social Sciences is well positioned worldwide in the study of migration flows (both voluntary and forced). On the one hand, our skills and expertise have already been recognized through joint projects with key players (e.g. the OECD) and several projects under way (H2020 proposals, connections with the European Commission and OECD). On the other hand, the increasing intersection of the migration trend with those of “economy, jobs and productivity”, “role of governments” and, because of the Covid19 scenario, with that of “health, inequality and well-being”, urges the development of further research to tackle a series of issues that will shape the future, including: the new patterns and routes of migration that the pandemic will create at the international level; the impact that social distancing and tele/smart working will possibly have on individual preferences for peripheral vs. metropolitan areas and on their respective populating/migration processes; the new needs of skill-matching that tele/smart working and learning will pose to migrants; the governments’ ability to gain the trust of their citizens also, and above all, in implementing/following the stringency measures that the Covid19 requires. In dealing with these and other related issues, particular attention will be given to the structural needs of peripheral areas, and to the threats the Covid19 has been posing to them – also, and above all, because of the digital divide. The Social Sciences Area will further expand its research activities on regional inequalities in the next decade by continuing the close collaboration with the SNAI initiative (National Strategy for Inner Areas) and by the new “Riabitare l’Italia” (“Repopulate Italy”) initiative that sees researchers at the GSSI among the funding members.

The key issues that marked the previous decade, along with those raised by the unprecedented shock caused by the pandemic, require continuing, expanding and adapting existing research on regional resilience. Indeed, the length and depth of the “Covid19 shock” demands reconsidering the standard conceptual and methodological framework of the field, to address the regional capacity to be resilient in an unprecedented “transformative” way. In this research domain, the Area is about to join three separate initiatives: 1. a network to respond to a call by the Volkswagen Foundation, with a comparative research project between Italy, Germany, and the UK; 2. a research project with the USA and Germany to study the behavioural responses of people to the covid19 crisis (including their attitudes towards environmental issues); 3. a consortium led by ENEA - with partners from Spain, Romania, Denmark, France and Belgium, among others - to participate in the newly released H2020 call on the socio-economic effects of covid19.

Research will also continue and intensify on topics with substantial spill overs on the development perspectives of the territory in which the GSSI is embedded, like cultural heritage and tourism. These two sectors have been particularly hit by the Covid19 crisis. On the one hand, the direction that the studies on the topic had taken from the recently won Horizon 2020 DISCE project (with UK and Finnish partners), had to be re-oriented, exploiting the extraordinary flexibility that the European Commission is allowing in dealing with the current crisis. On the other hand, the research activities that the Area had already undertaken in supporting recent policy initiatives about the cultural heritage of the city (like the candidacy of L’Aquila to become the next Italian capital of culture) have had, and will still have, to adjust in order to consider the threats and impact of Covid19. In this last respect, the Social Sciences area has come to recognize that, for the decade to come, more attention will have to be dedicated to policy and project evaluation, also and above all of policies and projects in the recovery phase. Despite its importance, this is a field that did not see

major advancements in regional science in the last 20 years. Performing a successful and meaningful project and policy evaluation is not a trivial task and much needs to be done. However, developing an expertise in this area is crucial and really requires to increase available resources and to pull together experts from different fields. In order to face these needs, the Social Sciences area is now collaborating with a group of institutions including INFN, the University of Milan and Sant'Anna in Pisa.

Still, in the attempt of increasing the alignment between the competencies of the area and the research implications of the mega-trends in the Covid19 scenario, the Social Sciences group is also planning to extend its domain of topics in the near future. Urgent attention is required, for instance, on the implications of the development of new technologies - like artificial intelligence and robotics - which are now fundamental in managing and restarting economic activities during and after the Covid19 crisis. The "new-technology" megatrend crucially intersects with those under the (OECD) headings of "globalization", "climate change and environment", and "natural resources and energy", which the Covid19 is also reshaping. The so-called 4th Industrial Revolution, which was unfolding before the shock arrived, is enabled by a series of technological advancements with pervasive socio-economic implications, especially at the regional level. This makes the research on the economics and geography of innovation a necessary extension of the GSSI current portfolio of activities.

A further enlargement of the GSSI research portfolio appears motivated by two connected considerations. Firstly, like the majority of the economic activities nowadays, technological advances occur in a global scenario, within which multinational actors and operations pose new challenges to regions and local systems, but also offer new opportunities. The classical interest that the tension between local and global forces has always stimulated, needs now to be revisited by retaining the processes of structural changes that Covid19 has been entailing, especially in reshaping and shortening both local and global value chains. In both respects, international business appears an important field of research with which to complement regional science and economic geography.

Secondly, technologies and innovation also have crucial environmental implications, to the extent that eco-innovations can help regions in facing crucial environmental challenges (like climate change), in mastering environmentally sustainable socio-technical regimes and in accomplishing what has been recognized as a necessary "green transition". The urgency of such a green transition emerges under a different light from the dramatic shadow of the Covid19. While the carbon-fossil-based paradigm might regain momentum in the aftermath of the recessionist fall-down in oil/carbon prices, the restarting of economic activities (almost "from-scratch") that cross-country lock-down measures are imposing, represents a fundamental opportunity to set the centrality of "the new green deal". This is a fundamental issue also, and above all, at the regional level, at which environmental sustainability might come to clash with social sustainability and inequality, making environmental regional studies another field of research to invest in for the future.

As an important prodromal effort to embrace these (relatively) new fields of research, the Social Sciences area has recently hired a new senior (full professor) and a new junior (tenure-track, from April 2020) faculty, and is planning to take on a new associate professor, through whose competencies and networking it aims at placing among the research centres of international excellence in the next decade.

In concluding, it should be emphasized that, both for education and research, interdisciplinarity is key for the Social Sciences Area. Regional science, by its own nature, is already a complex and cross-disciplinary field combining economists and geographers, but our aim is to push the boundary further. Our "cross-disciplinary 2.0" strategy requires the collaboration with other fields in the social sciences realm such as, as we said, innovation, international and environmental studies. Important trans-disciplinary knowledge for the development of regional science can also be obtained by spanning its boundaries towards sociology studies and planning. The former has already been implemented by including territorial sociologists in the PhD teaching board, the latter by being part of the REDI consortium led by planners at the University of Camerino.

Going one step forward, we are also developing a “cross-disciplinary 3.0” strategy collaborating with hard sciences at the GSSI. As social sciences area we need to join the new era of data, not as passive receivers (like most do), but rather as pro-active seekers. Last year, we started a collaboration with Computer Science with a joint postdoc in the area of big data and joint publications in the area of smart cities. This year we recruited four assistant professors (non-tenured) funded by the PON-MIUR grants we jointly won on “smart cities” and on “cultural heritage”. Furthermore, the Social Sciences area has recently started working on the environmental implications of Artificial Intelligence at the regional level, which could also benefit from a collaborative interaction with the Computer Science Area. We often have good theories but bad data and, in this respect, the collaboration with the other areas of GSSI, along the strategic line of data science, will be very advantageous and put us at the forefront of cutting-edge research following the example of world leaders such as Harvard.

GSSI at a glance

- **4 Ph.D. Courses (4 years)**
- **130 Ph.D. Students currently enrolled**
- **52 Professors and Researchers**
- **40 Post-Docs**
- **40% International Ph.D. Students and Post-Docs**
- **143 Ph.D. degrees awarded**

GSSI research projects

<u>Project</u>	<u>Scientific Area</u>	<u>Funding Body</u>	<u>Programme</u>	<u>GSSI Grant</u>	<u>Role</u>	<u>GSSI P.I.</u>	<u>Starting from</u>	<u>Duration</u>
DISCE - Developing Inclusive & Sustainable Creative Economies	Social Science	European Commission	Horizon 2020	457.900 €	Linke d	Alessandra Faggian	01/01/2019	36 months
GrowBot - Towards a new generation of plant-inspired growing artefacts	Mathematics	European Commission	Horizon 2020	600.000 €	Linke d	Pierangelo Marcati	01/01/2019	48 months
INITIUM - an Innovative Negative Ion Time projection chamber for Underground dark Matter searches	Physics	European Commission	Horizon 2020	1.109.705 €	Coor dinat or	Elisabetta Baracchini	01/03/2019	60 months
AHEAD2020 - Integrated activities for the High Energy Astrophysics Domain	Physics	European Commission	Horizon 2020	211.875 €	Linke d	Marica Branchesi	02/03/2020	48 months
Novel technologies for dark matter search and frontier astroparticle physics experiments' — 'DarkWave'	Physics	European Commission	Horizon 2020	46.828 €	Linke d	Cristiano Galbiati	01/10/2020	36 months
COST - QG - MM - Quantum gravity phenomenology in the multi-messenger approach	Physics	European Commission	Horizon 2020	/	Linke d	Roberto Aloisio	13/11/2018	48 months
COST - G2net - A network for Gravitational Waves, Geophysics and Machine Learning	Physics	European Commission	Horizon 2020	/	Linke d	Jan Harms	18/10/2018	48 months
BEHAPI - Behavioural Application Program Interfaces	Computer Science	European Commission	Horizon 2020	/	Linke d	Emilio Tuosto	01/03/2018	48 months
ESGI-COST-MI-NET - European Study Group with Industry	Mathematics	European Commission	Horizon 2020	6.554 €	Linke d	Pierangelo Marcati	14/05/2018	5 days
GRAPES - Galactic cosmic Ray Propagation: an extensive study	Physics	European Commission	Horizon 2020	180.277 €	Coor dinat or	Carmelo Evoli	01/10/2017	24 months
SHARPER - SHaring Researchers' Passions for Evidences and Resilience	Inter-disciplinary	European Commission	Horizon 2020	/	Partn er	/	15/05/2020	9 months
DarkWave - Novel technologies for dark matter search and frontier astroparticle physics experiments	Physics	European Commission	Horizon 2020	46.828 €	Linke d	Cristiano Galbiati	01/10/2020	36 months
IT MATTERS - Methods and Tools for Trustworthy Smart Systems	Computer Science	MUR - Ministry of Education, Universities and Research	PRIN 2017	128.000 €	Linke d	Luca Aceto	29/08/2019	36 months
ALGADIMAR - Algorithms, Games and Digital Markets	Computer Science	MUR	PRIN 2017	122.220 €	Linke d	Gianlorenzo D'angelo	29/08/2019	36 months

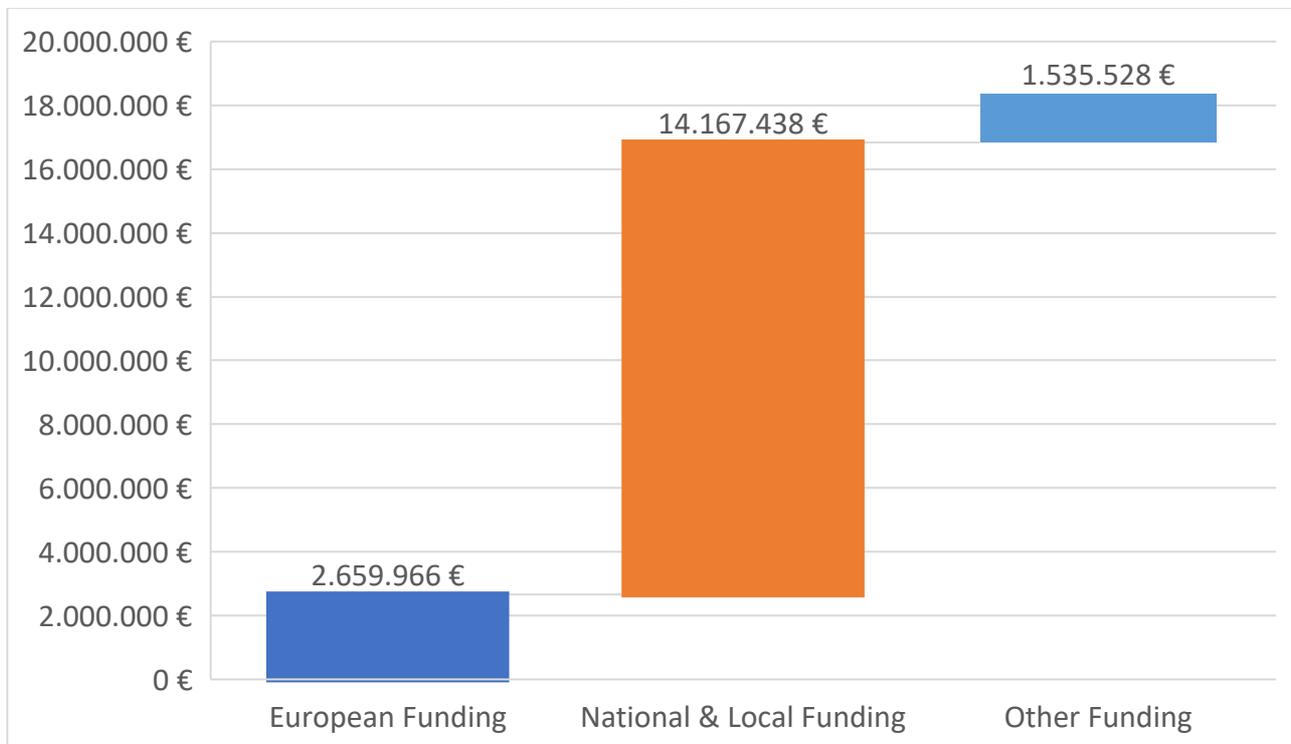
SEDUCE - Designing Spatially Distributed Cyber-Physical Systems under Uncertainty	Computer Science	MUR - Ministry of Education, Universities and Research	PRIN 2017	142.000 €	Linked	Catia Trubiani	29/08/2019	36 months
Discontinuous dynamical systems: theory, numerics and applications	Mathematics	MUR - Ministry of Education, Universities and Research	PRIN 2017	49.190 €	Coordinator	Nicola Guglielmi	19/08/2019	36 months
Advanced techniques for a next generation cryogenic Double Beta Decay experiment	Physics	MUR - Ministry of Education, Universities and Research	PRIN 2017	249.000 €	Coordinator	Fernando Ferroni	29/08/2019	36 months
NAT-NET - Neutrino and Astroparticle Theory Network	Physics	MUR - Ministry of Education, Universities and Research	PRIN 2017	83.427 €	Linked	Giulia Pagliaroli	29/08/2019	36 months
Zero radioactivity in future experiments	Physics	MUR - Ministry of Education, Universities and Research	PRIN 2017	143.676 €	Linked	Elisabetta Baracchini	29/08/2019	36 months
Characterization of the Sos Enattos mine in Sardinia as the site for the Einstein Telescope GW observatory	Physics	MUR - Ministry of Education, Universities and Research	PRIN 2017	268.270 €	Coordinator	Eugenio Coccia	03/11/2019	36 months
The new frontier of Multi-Messenger Astrophysics: follow-up of electromagnetic transient counterparts of gravitational wave sources	Physics	MUR - Ministry of Education, Universities and Research	PRIN 2017	85.700 €	Linked	Marica Branchesi	03/11/2019	36 months
CUIM - Center for Urban informatics and Modelling	Inter-disciplinary	CIPE - Inter-ministerial Committee for the Economic Planning	RESTART	4.500.000 €	Coordinator	Roberto Aloisio	01/01/2018	36 months
NUSES - A pathfinder for studying astrophysical neutrinos and electromagnetic signals of seismic origin from space	Inter-disciplinary	CIPE - Inter-ministerial Committee for the Economic Planning	RESTART	7.000.000 €	Coordinator	Roberto Aloisio	20/05/2020	24 months

REDI - Reducing risks of natural Disaster	Inter-disciplinary	MUR - Ministry of Education, Universities and Research	FOE	230.000 €	Consortium	Alessandra Faggian	03/08/2020	/
REDI - Reducing risks of natural Disaster	Inter-disciplinary	MUR - Ministry of Education, Universities and Research	FOE	70.000 €	Consortium	Pasquale Blasi	24/11/2020	/
NGS - New Satellites Generation components	Physics	MUR - Ministry of Education, Universities and Research	PON Ricerca e Innovazione 2014-2020	237.500 €	Linked	Ivan De Mitri Roberto Aloisio	19/03/2019	30 months
PON Ricerca e Innovazione 2014-2020 Azione I.2, AIM – Attrazione e Mobilità Internazionale”, Linea 1 (Mobilità dei ricercatori dei ricercatori)	Social Science	MUR - Ministry of Education, Universities and Research	PON Ricerca e Innovazione 2014-2020	381.060 €	/	Alessandra Faggian	01/06/2020	36 months
PON Ricerca e Innovazione 2014-2020 Azione I.2, AIM – Attrazione e Mobilità Internazionale”, Linea 2 (Attrazione dei ricercatori)	Computer Science	MUR - Ministry of Education, Universities and Research	PON Ricerca e Innovazione 2014-2020	377.396 €	/	Michele Flammini	01/06/2020	36 months
Sviluppo di una piattaforma integrata di servizi web e mobile	Computer Science	Municipality of L'Aquila	POR-FESR	95.000 €	/	Michele Flammini	01/12/2018	72 months
Sviluppo locale, aree interne e città intermedie: studio di casi e metodi per la rilevazione degli effetti e per l'orientamento della policy a livello locale	Social Science	Municipality of L'Aquila	/	5.000 €	/	Alessandra Faggian	04/02/2020	/
Esistenza, limiti singolari e comportamento asintotico per equazioni Eulero/Navier-Stokes-Korteweg	Mathematics	INDAM - GNAMPA	GNAMPA 2019	4.000 €	/	Paolo Antonelli	11/03/2019	12 months
Progetto Giovani GNFM - Derivation of effective theories for large quantum systems	Mathematics	INDAM - GNAMPA	GNAMPA 2019	3.000 €	/	Serena Cenatiempo	26/07/2019	12 months
Progetto Giovani GNFM	Mathematics	INDAM - GNAMPA	GNAMPA 2019	1.200 €	/	Francesco Tudisco	27/09/2019	12 months
XXI Congresso dell'Unione Matematica Italiana	Mathematics	INDAM - GNAMPA	GNAMPA 2019	400 €	/	Cristian Mendico	02/09/2019	6 days
Modelling Camp	Mathematics	INDAM - GNAMPA	GNAMPA 2019	150 €	/	Silvia Lombardi	26/07/2019	5 days
QMath14: Mathematical Results in Quantum Physics	Mathematics	INDAM - GNAMPA	GNAMPA 2019	350 €	/	Cristina Caraci	12/08/2019	5 days

Progetto DarkSide-20k	Physics	INFN - National Institute for Nuclear Physics	/	760.000 €		Cristiano Galbiati	01/12/2017	/
Progetto premiale FIGARO - Fostering Italian Leadership in the Field of Gravitational Wave Astrophysics	Physics	INFN - National Institute for Nuclear Physics	Progetti premiali FOE 2015	150.000 €		Marica Branchesi	02/03/2020	36 months
Analisi dati, teoria e simulazioni dello studio di Astrofisica delle Alte Energie e di Fisica Astroparticellare	Physics	INAF - National Institute for Astrophysics	/	49.400 €	/	Pasquale Blasi	01/09/2019	18 months
Surface brightness fluctuations distance, cosmology and gravitational waves	Physics	INAF-OAAb National Institute for Astrophysics - Osservatorio Astronomico d'Abruzzo	/	42.777 €	/	Pasquale Blasi	01/01/2019	48 months
A modern approach to cosmic rays	Physics	INAF - National Institute for Astrophysics	/	33.000 €	/	Pasquale Blasi	01/03/2018	18 months
Convenzione tra GSSI e INAF per il co-finanziamento di una collaborazione di ricerca	Physics	INAF - National Institute for Astrophysics	/	10.000 €	/	Marica Branchesi	20/07/2020	36 months
Partnership strategica tra SISSA e GSSI per lo sviluppo del progetto di ricerca "fisica e matematica dei dati"	Physics and Mathematics	SISSA - International School for Advanced Studies	/	135.632 €	/	Eugenio Coccia	10/12/2018	/
Progetto e implementazione di algoritmi e strutture dati efficienti per l'analisi di dati genomici	Computer Science	Dante Labs	/	109.841 €	/	Michele Flammini	01/11/2019	48 months
PhD Scholarship in "Mathematics in Natural, Social and Life Science"	Mathematics	IIT - Istituto Italiano di Tecnologia	/	82.381 €	/	Pierangelo Marcati	01/11/2016	36 months
Advanced Virgo Plus Newtonian Noise Cancellation	Physics	EGO - European Gravitational Observatory	/	60.000 €	/	Jan Harms	05/06/2020	24 months

Study and Design of the matching optics for the Advanced Virgo Squeezer	Physics	EGO - European Gravitational Observatory	/	18.000 €	/	Eugenio Coccia	23/08/2017	6 months
Squeezed states of light generation for shot noise limited interferometric	Physics	EGO - European Gravitational Observatory	/	6.000 €	/	Pasquale Blasi	01/02/2019	3 months
Gravitational wave transients search and characterization of signal features without model	Physics	EGO - European Gravitational Observatory	/	7.500 €	/	Claudia Lazzaro	01/03/2019	6 months
PhD Scholarship in "Urban Studies and Regional Science"	Social Science	The European House – Ambrosetti	/	58.897 €	/	Alessandra Faggian	01/11/2016	36 months
La sostenibilità di un evento sportivo: Case history della Mezza Maratona dell' Aquila - Città del Mondo	Social Science	ASD Atleticom	/	3.000 €	/	Alessandra Faggian	10/04/2020	12 months

Total funding from projects: € 18.362.932



2021 – 2023 STRATEGIC GOALS

A. RESEARCH & EDUCATION

1. Being a world class curiosity-driven science and graduate education centre

<u>OBJECTIVES</u>	<u>YEARLY GOALS</u>	<u>TERM</u>	<u>INDICATORS</u>
Attracting highly qualified faculty and researchers	Hiring highly qualified faculty and researchers	Each year through 2023	<ul style="list-style-type: none"> • % of new faculty and researchers arriving to GSSI from universities with high international ranking
Attracting world-class Ph.D. students to GSSI and preparing them for successful careers	Attracting highly qualified international Ph.D. Students	Each year through 2023	<ul style="list-style-type: none"> • % of new Ph.D. students arriving to GSSI from universities with high international ranking • % of international Ph.D. students
	Successfully placing GSSI students after graduation	Each year through 2023	<ul style="list-style-type: none"> • % of GSSI Ph.D. students hired 9 months after graduation • % of GSSI Ph.D. hired in academic or research positions
Maintaining the specific focus of GSSI's scientific areas to distinguish them from programs in other universities	Drafting statements for each area detailing its unique scientific and educational focus, how they compare and contrast with competing universities, and what are the key actions for growth	End of 2021	<ul style="list-style-type: none"> • Areas' statements approved by GSSI's Scientific Committee
	Strengthening research and education in focus topics	End of Academic Years 2021-22 and 2022-23	<ul style="list-style-type: none"> • # of new hires in focus topics for each scientific area • # publications in high-impact journals in focus topics for each scientific area • # specific courses in focus topics for each scientific area

Financing collaborative research through competitive grants	Increasing GSSI's use of funding for collaborative research from national and international calls	Each year through 2023	• Amount of funding received
Expanding GSSI's campus in the L'Aquila historic centre	Completing the acquisition of new real estate	End of year 2021	• Real estate acquisition completed
	Planning and implementing the reorganization of office, research, and educational spaces	End of year 2022	• Re-organization completed
Strengthening a lean and effective administration, capable of supporting GSSI's international ambitions	Completing formalization of major administrative processes	End of year 2021	• Processes formalization completed
	Drafting a new plan identifying functions and personnel needs	End of year 2022	• Administrative functions and personnel plan approved
	Completing new personnel hiring	End of year 2023	• # of hired personnel
	Updating the GSSI's institutional website to support research, education, third mission and administration	End of year 2022	• New institutional website online and fully functional

2. Fostering inter- and cross- disciplinarity

<u>OBJECTIVES</u>	<u>YEARLY GOALS</u>	<u>TERM</u>	<u>INDICATORS</u>
Developing outstanding interdisciplinary research projects	Identifying a viable set of internal incentives for interdisciplinary research and publications	End of year 2021	<ul style="list-style-type: none"> • Implementation of incentives
	Producing scientific publications co-authored by researchers from different scientific areas	Each year through 2023	<ul style="list-style-type: none"> • # publications
	Submitting successful interdisciplinary grant proposals	Each year through 2023	<ul style="list-style-type: none"> • # of successful interdisciplinary grant proposals featuring GSSI researchers from at least two scientific areas
	Stabilizing CUIM as an “interdisciplinary research centre” within GSSI.	End of year 2022	<ul style="list-style-type: none"> • CUIM stabilized
Embedding interdisciplinarity into GSSI’s education	Offering courses on interdisciplinary topics	Each year through 2023	<ul style="list-style-type: none"> • # interdisciplinary courses offered
	Making interdisciplinary courses across the four scientific areas compulsory within the four PhD programs	End of year 2021	<ul style="list-style-type: none"> • All PhD students formally required to attend interdisciplinary courses
Including specifically interdisciplinary focus among the different GSSI's educational offering	Establishing joint interdisciplinary postdoctoral programs	End of year 2022	<ul style="list-style-type: none"> • # of joint PhD programs established
	Design interdisciplinary Master’s degrees	End of year 2023	<ul style="list-style-type: none"> • # of interdisciplinary Master's degrees designed and ready to start.

B. GSSI & SOCIETY ("TERZA MISSIONE")

3. Bridging cutting-edge research and industry

<u>OBJECTIVES</u>	<u>YEARLY GOALS</u>	<u>TERM</u>	<u>INDICATORS</u>
Creating a public/private technology hub to strengthen competitiveness and innovation of local and national industry	Establishing a Foundation to develop and manage the Technology Hub	End of year 2021	• Foundation established
	Supporting the creation of specialized activities for technology development and prototyping	Each year through 2023	• # of activities established
	Supporting the Foundation in hiring highly qualified technologists	Each year through 2023	• # of technologists hired
Increasing cooperation in applied research and KTT with the other five "Scuole a Statuto Speciale"	Developing joint projects and initiatives within JoTTO	Each year through 2023	• # of projects and initiatives
Supporting innovation in local industries while developing human resources	Establishing industrial Ph.D. fellowships with local industries	Each year through 2023	• # of Industrial Ph.D. fellowships
Valorising GSSI's IP and know how	Developing a communication plan and materials aimed at promoting GSSI's applied research with private industries	End of year 2021	• Plan and materials completed
	Establishing agreements with private industries and public administration to develop and transfer innovation	Each year through 2023	• # of agreements signed
	Licensing GSSI's IP	End of year 2023	• # of licensing agreements signed
	Incubating spin-offs and start-ups	End of year 2023	• # of spin-off recognized

4. Leveraging knowledge to improve social justice

<u>OBJECTIVES</u>	<u>YEARLY GOALS</u>	<u>TERM</u>	<u>INDICATORS</u>
Developing and implementing a long-term strategy for social impact evaluation and management	Developing first impact cases of GSSI's projects	End of 2021	<ul style="list-style-type: none"> • Impact case submitted to VQR
	Adopting an official internal Regulation for managing and evaluating the social impact of GSSI's activities	End of year 2022	<ul style="list-style-type: none"> • Regulation adopted
	Organizing participatory workshops with stakeholders and civil organizations to discuss the social impact of technological advances and of major GSSI activities	End of year 2023	<ul style="list-style-type: none"> • % major GSSI projects and activities with participatory workshops in place
Developing and disseminating innovative methods and know-how on how to measure the social impact of research	Offering courses on measuring social impact of research for PhD students and researchers as well as managers from industries and public administrations	End of Academic Year 2021/2022	<ul style="list-style-type: none"> • # of courses offered • # of attendance
	Publishing interdisciplinary works in scientific journals on the evaluation and management of social impact	Each year through 2023	<ul style="list-style-type: none"> • # of publications on topic
Preventing real estate speculation, accelerating the recovery of the urban centre, and increasing the attractiveness of the city of L'Aquila for young talents	Establishing a new Foundation together with the City of L'Aquila and the Università degli Studi dell'Aquila to manage real estate for talented students and researchers	Spring 2021	<ul style="list-style-type: none"> • Foundation established

Promoting outreach and social engagement	Organizing events to share GSSI's research with the broad public and to engage it	Each year through 2023	• # of events organized
Promoting transparency and public accountability	Develop open-data projects and initiatives	Each year through 2023	• # of projects and initiatives
Promoting environmental sustainability	Identifying administrative goals relative to environmental sustainability	End of 2021	• List of administrative goals approved
	Approving a comprehensive plan for environmental sustainability	End of 2022	• Environmental sustainability plan approved
Promoting gender equality	Drafting a gender equality report	End of year 2021	• Report completed