PhD PROGRAMME IN RISK, ENVIRONMENTAL, TERRITORIAL AND BUILDING DEVELOPMENT

Department: Department of Civil, Environmental, Land, Building Engineering and Chemistry
Coordinator: Prof. Vito Iacobellis (vito.iacobellis@poliba.it)

Places available:

- "Innovation" macro-area: 3 places
- "Sustainability" macro-area: 3 places

Candidates are advised that there are separate application calls for each macro-area. Candidates who intend to apply for both programmes must submit two different applications for each macro-area,

The current document includes attachments regarding specific details for research topic fields for each macro-area.

Admission Requirements

Applicants to the PhD programme in Risk, Environmental, Territorial and Building Development must hold a second level (specialized) degree as follows:

- Degree diploma awarded by an Italian university prior to Ministerial Decree 509/99;
- Specialist Degree (as per Ministerial Decree 509/99);
- Master's Degree (as per Ministerial Decree 270/04);
- Degree qualifications awarded by foreign universities officially recognised as equivalent to the above.

The Selection Board will decide upon the eligibility of qualifications as part of the assessment procedure.

Application Instructions:

Please note that the information provided in this paragraph **complements and does not substitute** that contained in arts. 2 and 3 of the Call for Applications document.

REQUIRED DOCUMENTATION

Candidates **must** upload the following documentation to their online application. **Failure to do so will result in their exclusion from the selection procedure**:

1. A **CV** following the layout of the **example** provided by Politecnico di Bari on the Politecnico website www.poliba.it in the *Ricerca/Dottorati di Ricerca* section. This file should be named "01.CV";

2. **A signed, valid identification document.** This file should be named *"02.Documento riconoscimento".* Only the following documents will be considered; failure to comply will result in exclusion from the selection process*;*

   - ID cards, only if issued by an EU member state;
   - Driving licence, only if issued by an EU member state;
   - In all other cases, a fully valid passport (also non-EU citizens, including the UK);

3. **Degree qualification certification for first (Bachelor) degrees and second (specialization/Master's) degrees (or 5-year Single Cycle degrees)**. A list of all exams taken with their relative marks in both degree courses (or the Single Cycle course) should also be included, following the example provided by Politecnico di Bari which is available from the Politecnico website in the *Ricerca/Dottorati di Ricerca* section. This file should be named "03.Titoli di laurea".

DOCTORATE RESEARCH PROGRAMMES ON SUSTAINABILITY / INNOVATION-RELATED TOPICS
Attachment 3

Candidates with **a degree qualification awarded by a non-Italian university** must attach the following documents to their application, prepared by the academic institute which issued them. This supersedes any form of self-declaration:

- Degree certificate or diploma showing relative final mark;
- Official transcript of exams taken during all university study programmes, showing relative results;
- Any other relevant documentation which demonstrates the equivalence of qualifications with those required in this application call (Supplementary Diploma, *Dichiarazione di Valore* (statement of value) issued locally).

These documents must be in Italian, French or English or translated into Italian or English and verified by an official Italian diplomatic or consular representative under the responsibility of the candidate. These should follow the guidelines set out in the document "*PROCEDURES FOR ENTRY, RESIDENCY AND ENROLMENT OF INTERNATIONAL STUDENTS AND THE RESPECTIVE RECOGNITION OF QUALIFICATIONS, FOR HIGHER EDUCATION COURSES IN ITALY FOR THE ACADEMIC YEAR 2021/22*" available at the link www.studiare-in-italia.it/studentistranieri;

4. **A summary / abstract of the thesis topic for specialist/Master's degree (or five-year Single Cycle degree),** stating the title and name of thesis supervisor(s) (max 3,000 characters); this file should be named "04.Abstract tesi";

5. **Research project proposal,** which must be completed in the format provided by the Politecnico di Bari; this is available at www.poliba.it/it/dottorati-di-ricerca. The proposal must include:

    - research project criteria in line with art.3 of Ministerial Decree 16061/2021 and art.5 of the call for applications document;
    - research topics in accordance with the PhD programme selected and relevant macro-area topic (Sustainability/Innovation, refer to attached macro-area details).

    Proposals are assessed purely as part of the selection procedure and are not necessarily those which candidates will develop during the programme. This file should be named "05.Proposta di Ricerca".

OPTIONAL DOCUMENTATION

6. **A self-certification declaration for any other qualification deemed suitable for evaluation** which must be signed and dated and follow the layout of the example provided by Politecnico di Bari on the Politecnico website www.poliba.it in the *Ricerca/Dottorati di Ricerca* section. In accordance with art. 46 (Statements in lieu of Certification) and art. 47 (Self-Drafted Affidavits) of Presidential Decree 445/2000 (pursuant to art. 15 of Stability Law 183/2011), candidates may not submit certificates and affidavits issued by public administrations or providers of public services for qualifications that are to be assessed. These certificates should be replaced by statements as per arts. 46 and 47 of Presidential Decree n. 445/2000). This file should be named *"06. Dichiarazione altri titoli".*

7. (Additional, optional) **Two letters of presentation from teaching staff** who have supervised the candidate during their university studies. These files should be named "07.Lettere presentazione 1" and "07.Lettere presentazione 2".

8. **Language certification** demonstrating a knowledge of English which corresponds to at least B2 level. Only non-Italian citizens may attach certification which demonstrates knowledge of the Italian language. This file should be named "08.Certificazione linguistica 1" (2, 3 etc);

9. **Any publications** related to activity carried out and shown on the candidate's CV. This file should be named "9. Pubblicazione 1" (2, 3 etc.).

All documentation must be in either Italian or English or translated into Italian or English, under the responsibility of the applicant.

DOCTORATE RESEARCH PROGRAMMES ON SUSTAINABILITY / INNOVATION-RELATED TOPICS
Attachment 3

In cases of large documents unavailable as electronic files or which exceed the number of MB permitted for documents, applicants may submit these separately (in paper format or as a CD or DVD-ROM), accompanied by a detailed list of contents, <u>by 2 p.m. of the deadline date for admission applications</u>.

Any publications submitted on paper or digital support must be sent in a closed envelope, signed along the seal, to the following address:

Magnifico Rettore del Politecnico di Bari – Direzione Gestione Risorse e Servizi Istituzionali-Settore Ricerca, Relazioni Internazionali e Post-Lauream - Ufficio Protocollo – Via Amendola 126/B, 70126 BARI (Italy)

Envelopes must display the name and surname of the candidate together with the following text: "*Concorso di Ammissione al Corso di Dottorato in*… (name of the PhD programme)". The delivery of the envelope containing publications to Politecnico di Bari - by postal service, private courier or shipping agency – is at the exclusive risk of the candidate.

<u>Admission examination</u>

The admission examination is based on:

1. **an assessment of qualifications held** (average exam marks, final degree mark, theses, Master's degrees, post-graduate courses, language certification, publications, etc.);

2. **an interview** to ensure a complete evaluation of the candidate and to verify the applicant's aptitude for research and willingness to undertake experience abroad, as well as areas of research interest.

The Selection Board will assess candidates' qualifications and interview with a mark out of 100 (maximum mark for qualifications 40 and interview 60). Candidates obtaining less than 10 marks for the qualification evaluation will not be admitted to the interview.

The results of the Board's assessment for qualifications and project proposals will be published on the ESSE3 portal in the private area of each candidate.

No other notification will be sent directly to candidates.

At the end of the examination procedure, the Board will carry out an overall assessment and draw up an admission rankings list on the basis of the marks obtained by candidates in each part of the examination.

The assessment criteria for qualifications will be established by each Selection Board.

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National Operational Programme 2014-2020
PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

SUSTAINABILITY-BASED TOPICS (ACTION IV.5)

SCHOLARSHIP N. 26

A. RESEARCH PROPOSAL

a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and overlap of knowledge and skills to promote the development of innovative products and services with reduced environmental impact, focusing on topics such as:
- protection of the ecosystem;
- biodiversity;
- reduction of climate change impact;
- enhancement of sustainable development

in order to promote green recovery and overcome the effects of the Covid-19 pandemic crisis.

Italy is the European country with the highest landslide risk (Salvati *et al.*, 2016; Froude M.J. & Petley D.N., 2018), which is expected to get more severe due to climate change in the next future. In particular, for the hilly and mountainous inner areas, landslide hazard is related to widespread damage on buildings and infrastructures, hence jeopardising their socioeconomic development and worsening the ongoing depopulation.
On the other hand, the COVID-19 pandemic pointed out the need for a sustainable development model in which those areas that are currently marginalised counterbalance the congestion of urban centres and highly industrialised areas. Hence, it is mandatory to contrast the landslide susceptibility that contributes to the marginalization of wide areas of the country by improving the resilience of the slopes through mitigation measures with a low impact on economy,

landscape and environment, as required by the PNRR (M2C4) by means of the European funds RRF and REACT-EU, as a response to the socioeconomic crisis.

On the contrary, as a consequence of overlooking the hydro-mechanical causes of the processes, the current monitoring and mitigation interventions are often ineffective, causing further economic loss. In this context, the proposed PhD study aims at producing the prototype of an informative platform for the widespread surveillance of landslides, assisting the accountable authorities in their land management activity. At the slope scale, this platform will allow to manage landsliding on the basis of the knowledge of the geo-hydro-mechanical context (GHM) and of the causes of failure. As a consequence, it will be cost-effective and repeatable, in a variety of GHM contexts.

The resulting mitigation of landslide risk will contribute to the revamping of wide areas of the country, promoting their landscape, historic and cultural heritage and allowing to take advantage of their potential for sustainable tourism and agricultural production, thanks to stable and safe infrastructures, as requested by the PNRR (M1C3, M3C1, M5C3).

The proposed research involves the interaction with companies operating in the fields of monitoring and surveying, that will share their hardware and knowledge with the PhD student, receiving in return the skills needed for the development of the devised monitoring platform and for the management of its data. Being focused on low-impact risk mitigation, the research follows Action IV.5 of the Green doctorates. It is also innovative and multidisciplinary (SSD: ICAR07, GEO05, ICAR02, ICAR06), hence enforcing the interaction with research groups in Information Engineering.

b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students and grant funding to Sustainability-based research projects.

Scope of the research is the creation of a Smart Land Monitoring Platform (PMI) for surveying and analysing landslide phenomena aimed at a sustainable risk management, particularly for those areas marginalised due to landslide hazard. Moving from the digitalisation of the subsoil of landsliding slopes based on I-level knowledge of landslide processes in the region for which the PMI is conceived, the latter will allow: 1) to validate I-level hypotheses about active processes in the slope; 2) finalising the diagnosis of the causes of instability; 3) the monitoring of the evolution of processes, as a warning system in the transient phase of selection and subsequent implementation of the mitigation measure; 4) the choice of the most sustainable mitigation strategy, founded on the knowledge-base provided by the PMI itself. The outcome of point 4) might consist of an early warning system, which will include the existing PMI as a part. It is important to stress that, differently from the current common practice, the PMI will be deeply rooted into the knowledge of the landslide phenomena in the region.

Therefore, the study will move from the diagnosis of landslide phenomena widely developed in the past ten years in various GHM contexts of the Apennines, of the Fossa Bradanica and of some areas of the Alps (Cotecchia et al., 2021). Then, the research will focus on the optimization of the monitoring systems for the selected pilot GHM context, in terms of type of

instruments, spatial layout, space-time correlation of the recorded variables, timespan and frequency of acquisition, and transmission for further processing and analysis.

As a land-wise knowledge incubator, supporting the authorities in the management of landslide risk, the PMI involves the computerisation of surveying and monitoring systems at the regional scale, hence leading to the adoption of mitigation measures more effective than in the past, also allowing a significant cost reduction due to the optimization and repeatability of the systems. This follows the sustainable management of risk requested by the Sendai Framework for Disaster Risk Reduction of 2015-2030 of the UN (GAR-2019, coauthored by the Proponent) and by the Italian PNR 2021-27.

By deploying Internet-connected innovative monitoring instruments, the PMI allows the real-time acquisition of data that, in turn, will be processed by the platform, so as to be readily transferred to predictive numerical models. This makes the proposed research fully consistent with the aims of the Italian SNSI and PNR 2021-27.

c. Research activity proposal, methods and contents

For the GHM contexts of reference, i.e. the Southeastern Apennines and the Fossa Bradanica, previous studies collected the representative landslide mechanisms M_i, and the associated slope factors, into a Regional Landslide Manual (RLM). In these contexts, two pilot slopes were selected, in the towns of Bovino and Chieuti (FG), whose local administrations expressed interest for the research presented hereby. In the areas of both towns, the selected partner company already carried out survey and monitoring activities in the past, as required by the regional authority for risk mitigation. In particular, for both slopes, hosting landslides with different depth, the company will provide all the available data to the PhD candidate, aimed at building the PMI.

For both pilot slopes, following the Multilevel Approach developed by the Proponent, all the available data concerning both internal (predisposing) and external (triggering) factors of instability will be georeferenced. All existing data of multi-time aerial photo and of damage to buildings and infrastructures will also be collected in the same informative system. Based on the RLM, the mechanics of slopes, and with the aid of the purposedly built informative system, a phenomenological model of the possible M_is active in the selected slopes will be conceived. Then, the development of the PMI will follow, partly working in the offices of the partner company, by selecting both the site and laboratory tests required to complete the diagnosis of the landslide mechanism and the most suitable monitoring instruments to install. The combination of ground investigations and monitoring will allow to build in three dimensions the evolution of the variables of the process, and hence of the slope stability. The resulting GHM model should be readily implementable in calculation tools for simultaneously running numerical predictions of the same evolution.

By cooperating with companies and R&D centres devoted to the development of advanced slope monitoring instruments, the PMI will become an efficient and advanced prototype of a continuous surveying system of slope stability, to the aid of the accountable authorities in selecting the most adequate and sustainable risk mitigation strategies. Furthermore, the

research will provide a breakthrough in surveying, storage and processing of data, thanks to advanced sensors, real-time continuous acquisition, background use of pre- and post-processing software. The PMI will be replicable for other slopes hosting similar landslide mechanisms. At the same time, the research will devise a methodology for designing PMIs for different M_is, being deeply rooted in the physics and mathematics underlying the development of landslide mechanisms.

B. COMPANY-BASED ACTIVITIES within the Italian territory

a. Research activity to carry out with the company

The interaction with companies working in the fields of geotechnical investigations, (both laboratory and field) geotechnical and environmental monitoring, geophysical investigations, topographic survey (either surface or remote sensing), plays a central role in the development of the proposed PMI. In particular, the PhD student will carry out a 6-month internship at a company working in geotechnical and geophysical investigation and monitoring, and will also cooperate with a company owning a certified geotechnical laboratory, and with a company working on continuous monitoring of Earth surface and infrastructures with satellite data, as well as on design and development of informative systems for environmental data.

The researcher will work on: 1) integration of data from different types of investigation; 2) technological development of monitoring operations. The latter, in particular, will involve an improvement of continuous measurement of: 1) displacements at depth, through fixed inclinometers or fibre optic; 2) pore water pressure, suction, water content and underground seepage velocity; 3) normal and tangential stress through earth pressure cells; 4) displacements of building and infrastructures. The student will devise the optimisation of the procedures for acquisition and remote transmission of data. The measurement of climate-related variables in time (temperature, rainfall, relative humidity, wind, etc.) will support mesoclimatic models for predicting the variation of climatic boundary conditions, to be subsequently implemented in quantitative analyses of climate-slope interaction.

b. Period of company-based study and research

6 months

C. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU):
quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.

SCHOLARSHIP N. 26

This research project is aimed at changing the approach currently adopted when dealing with landsliding, both within the public administrations for safety and land planning, as well as in the engineering practice. This project is aimed at addressing to the establishment of a state-of-the-art landslide observatory, able to conjugate the scientific knowledge in the diagnosis of natural phenomena together with the most recent and advanced digital technology of non-invasive probes for continuous monitoring.

Such landslide observatory provides a widespread and digitally-based network of the underground (Internet of Soil), which would configure a highly innovative strategy in a country which suffers the most from landsliding hazard, as Italy does.

Since the project is aimed at defining strategies for the digital transition with specific reference to two different slopes, it provides highly innovative quantifiable targets, as it is expected from the 'PON Green' action; those targets are even more coherent with the PON since the digital transaction is aimed at a sustainable landslide risk mitigation.

As such, the PMI proposal is based on the deterministic interpretation of the landslide mechanism, which makes the proposal suitable for providing an exhaustive and clear picture of the slope processes and the related causes.

This would make the PMI a useful platform for defining landslide risk mitigation strategies acting on the causes (i.e. reducing the piezometric levels, varying the geometry, etc.), being therefore, much more effective and sustainable in maximizing the resilience of the slope if compared to localized structural interventions. It is worth mentioning that monitoring the slope processes in progress configures itself as a mitigation strategy, being based on the observational method. Furthermore, when dealing with climate-induced landslides, the PMI becomes a tool able to monitor the slope-vegetation-atmosphere interaction, providing useful data to build numerical models for forecasting the climate-change effects.

The results achieved during the PhD and their coherence with the project are measurable, given the nature of the project. The verification of the higher efficiency of the PMI compared to conventional slope monitoring methods is part of the research; this can be quantified in terms of: i) reduction of both the economic cost and time of the interventions; ii) increase in the amount and accuracy of the database on which the PMI is based, which could ease both the diagnosis of the landslide mechanism and the numerical modelling of the slope processes. The benefits of the PMI will also be deduced by comparison with interventions on other slopes where similar landslide mechanisms to those here of reference are found. Finally, the higher efficacy and the smaller cost of the risk mitigation interventions derived from the use of the PMI will both be verified by comparison with those implemented for similar mechanisms.

C. ACTIVITIES ABROAD

a. Research activity abroad

The PhD candidate will carry out part of his research activity abroad, with the aim of validating the PMI prototype and verifying the replicability of the approach adopted in different GHM contexts, a collaboration will be activated with the Municipality of Osilnica (260 m a.s.l.) in

the valley of the Kolpa river, located in the extreme south of Slovenia; this territory is known for its naturalistic heritage and marginal position, which justify its strong tourist vocation. At the municipality of reference, the PhD student will acquire knowledge and data about the management of hydrogeological risk and GHM contexts of Osilnica. Such analyses will be the basis for the validation of both the results already acquired and the SME prototype under construction, with reference to a different GHM context. In particular, the PhD student will carry out the acquisition and selection of existing data to be digitalized in the PMI platform and, with the guide of a local tutor, he will select a pilot slope, whose landslide mechanism can be described according to a I-level approach. For the selected slope, the PhD student will acquire all the territorial data regarding the structural geology, geomorphology, hydro-mechanical parameters of the soil, surface hydrography, and hydrogeology. In addition, he will collaborate with the companies involved in the research project to define the monitoring tools and sensors, verifying their suitability also by interacting with local companies.

This collaboration will clearly continue when the PhD student will come back to the Polytechnic of Bari, where he will receive support for the completion of the numerical modelling part, calibrated on the data about the foreign municipality. In this regard, he will be able to verify the effectiveness of the numerical models of slope-atmosphere-buildings-infrastructures interaction, which must implement the GHM coupling and also take into account the interaction with the climate, for the scenarios of the slopes of the area.

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National Operational Programme 2014-2020
PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

SUSTAINABILITY-BASED TOPICS (ACTION IV.5)

SCHOLARSHIP N. 27

A. RESEARCH PROPOSAL **Preparation of high-quality biofuels from waste vegetable oils**	
a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and overlap of knowledge and skills to promote the development of innovative products and services with reduced environmental impact, focusing on topics such as; **- protection of the ecosystem;** **- biodiversity;** **- reduction of climate change impact;** **- enhancement of sustainable development** **in order to promote green recovery and overcome the effects of the Covid-19 pandemic crisis.**	Substituting fossil fuels with biofuels is fundamental to reduce greenhouse gas emissions from auto-vehicles. Biofuels used by motors are generally composed of fatty acid methyl esters (FAMEs) obtained mainly from edible vegetable oils, including palm oil. After the ban on palm oil imposed by the EU within 2030, many oil companies are seeking sustainable alternatives to produce biodiesel. With the recent approval of the Renewable Energy Directive, the so-called RED II, the European Union set for 2030 the goal of 14% of energy resources from renewable sources to be used in the transportation area. The document also provides for the drastic reduction of palm oil in the production of biodiesel. This is a measure that tries to limit the deforestation in tropical countries (Malaysia and Indonesia above all) where palms are cultivated, and to regulate the use of food resources in the production of biofuels. Starting from 2021, EU States are not allowed to increase the amount of imported palm oil with respect to 2019 for biofuel preparation. In addition, starting from 2023 EU States should gradually decrease the quantity of imported palm oil until 2030, when they will be not allowed anymore to use palm oil for biodiesel production.

	However, France and Norway established regulations to ban the use of palm oil in biofuels as early as 2020 and some of the major fuel companies are working to find valid substitutes. Every year, in Italy, about 280 thousand tons of waste vegetable oils are produced, and, for example in 2018, only 23% (75 thousand tons) of them was recovered. A large amount of the recycled waste oil derives from catering and food industry, and only a marginal part of it belongs to citizens kitchens. The remaining 205 thousand tons of waste oil is produced daily after cooking and it is often disposed directly in domestic trash. This practice causes serious environmental damage, because a single liter of oil poured into a water body creates a pollution film as large as a football field and it contaminates 1 million liters of water. Waste oil also damages domestic pipes and purification systems: 1 liter of oil produces up to 4 kg of sludge, increasing the maintenance costs of the whole system. From a sustainability point of view based on a circular economy, being able to convert waste cooking oil (WCO) into high quality biodiesel remains a very interesting goal to achieve, considering that recent studies have shown that using biodiesel instead of petrol diesel also reduces pollutant emissions.
b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students and grant funding to Sustainability-based research projects.	The research topic aims at developing a sustainable process involving the conversion of waste cooking oil from food waste into high quality biodiesel. In this context, the proposed doctoral course project complies with the SNSI associated to the Green Chemistry area, which is known to be characterized as a "biobased industry", and refers to the transformation of biomass, deriving from agriculture, food waste, organic waste, algae and microorganisms, into substances, chemicals and biofuels through biorefineries. The use of biomass as a raw material allows to reduce the use of fossils and to mitigate the release of CO_2 associated with the life cycle of the generated products with a positive impact on human health and on the environment. Furthermore, this research topic complies with the NRP 2021-2027, relating to the "Large Area of Research and Innovation" called "Food Products, Bioeconomy, Natural Resources, Agriculture, Environment". In particular, the research theme is consistent with the sub-area relating to "Green Technologies", and the associated Cluster 5 (Climate, energy and mobility), dedicated

	to an integrated development of solutions for the production and sustainable use of energy, both in consolidated and in innovative fields (biofuel production). According to this cluster, the strategies for biomass production and management as well as the development of conversion processes typical of regenerative chemistry and biotechnologies (biocatalysis, metabolic engineering, development of advanced bioreactors) will be privileged subjects of future investments. The creation of synergies between the fields of bioenergy and biofuels, biochemicals and bioproducts and the areas of basic and fine chemicals are strategically important to establish alternative supply chains for the source of raw materials.
	Finally, the proposed research topic falls within the L240 / 2010 and the Ministerial Decree 45/2013, since it is part of a consolidated PhD course, accredited by the MIUR.
c. Research activity proposal, methods and contents	The research activities will be focused to the development of a procedure able to convert waste cooking oil (WCO) into biofuel. The whole process will be made by two steps:
	1) Transesterification of WCO in methanol in the presence of potassium hydroxide to give fatty acid methyl esters (FAMEs), *i. e.* biodiesel, and glycerin (by-product);
	2) Subsequent upgrading of biodiesel by partial hydrogenation. In fact, the high quantity of carbon-carbon double bonds present in the mixture of the obtained FAMEs renders the biodiesel highly oxidizable, polymerizable and perishable. Generally, the upgrading occurs by partial hydrogenation, aiming to yield a high quantity of monounsaturated products (C 18:1 mainly, methyl oleate), which is a right compromise between fluidity and stability. Total hydrogenation products (methyl stearate) are avoided because they are solid and not useful for fuel purposes. Partial hydrogenation is generally carried out in the presence of hydrogen gas under high pressure with a noble metal catalyst. The proposed research project involves the use of glycerin (or a its derivative) as a reducing agent instead of dihydrogen, which is a flammable and potentially dangerous gas. Glycerin, on the other hand, is a by-product obtained in the transesterification step; therefore, it is an optimal reagent from the circular economy point of view. The reaction requires a

	catalyst based on Pd or Ni; therefore, both commercial catalysts and recyclable materials synthesized *ad hoc* in our laboratories will be used. The upgrading process will be carried out in a microwave reactor, which allows a uniform heating of the reaction mixture and shorter conversion times than conventional heating.
	Since the transesterification reaction is a rather standardized process, the research activity of the PhD student will be focused on: *i)* the synthesis of heterogeneous potentially recyclable catalysts based on non-precious metals (such as Ni) able to promote the partial hydrogenation of FAMEs with high yield towards monounsaturated products; *ii)* the optimization of the microwave-assisted reaction conditions for the upgrade of biodiesel into high performance biofuel.
B. COMPANY-BASED ACTIVITIES within the Italian territory	
a. Research activity to carry out with the company	The research activity in the chosen local company involves the microwave-assisted upgrading reaction of biodiesel obtained by the transesterification of WCO. Once the PhD student has developed the upgrading reaction in a batch microwave reactor used in the Chemistry laboratories of DICATECh, he/she will design a methodology to convert the batch reaction into a continuous flow one, more attractive from an industrial point of view. In practice, the PhD student will acquire both chemical and engineering skills, aiming at setting up a continuous flow microwave reactor that allows to obtain the continuous upgrading of FAMEs in the presence of glycerin (or its derivative, such as propyl alcohol) and a recyclable catalyst, under sustainable conditions, since the use of hydrogen gas, which is notoriously a flammable gas and difficult to store, will be avoided. Specifically, the work of the PhD student in the local firm will be: a) Reproducing in a large microwave reactor present in the company the biodiesel upgrading reaction previously optimized in the DICATECh chemistry labs. In this way, the biodiesel partial hydrogenation reaction will be scaled-up, and its effectiveness will be tested on a large scale and close to industrial production by modifying some parameters (concentration, quantity of catalyst, power, temperature, etc.) in order to optimize the yield in the desired product even when the quantities of

	reagents will be much higher than those used in the DICATECh lab. b) Modifying a microwave reactor of the company, transforming it into a continuous flow microwave oven, which would make the process more attractive and economically advantageous from an industrial point of view.
b. Period of company-based study and research	8 months
c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): **quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.**	The REACT-EU initiative - conceived by the European institutions in the summer of 2020 - represents an increase in the effectiveness of the 2014-2020 community cohesion programming to continue interventions to mitigate the health, economic and social effects of the pandemic and to build a bridge towards the operational start of the 2021-2027 cycle, in particular in supporting the interventions for the so-called "double transition", green and digital. In terms of supporting the green, digital, and resilient transition of the socio-economic system, REACT-EU provides for various interventions to stimulate companies to adopt production models based on green and digital competitiveness, and funding for research and higher education projects aimed at innovative and ecological skills. In this context, the proposed doctoral path is totally consistent with the REACT-EU guidelines. Quantifiable and measurable targets in the proposed doctoral program will be: 1) Annual achievement by the PhD student of the credits required by the training plan of the PhD Cycle in Risk, Environmental, Territorial and Construction Development. 2) Participation of the PhD student in Conferences concerning the valorization of biomass. 3) Drafting of scientific papers indexed by Scopus and/or WOS concerning the proposed research topics, in which the name of the doctoral student appears among the co-authors. 4) Application for patents.
C. ACTIVITIES ABROAD	
a. Research activity abroad	The research activity abroad will concern the issues of sustainable chemistry, and in particular the use of recyclable catalysts and innovative and

	environmentally friendly solvents, within three areas of interest: 1) Enhancement of biomass. 2) Use of catalytic processes in continuous flow reactors. 3) Catalysis applied to environmental issues and to the abatement of NOx from exhaust gases. Depending on the problems encountered during his/her training, the PhD student will deepen one of the three aspects mentioned, during his/her research activity abroad.

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SUSTAINABILITY-BASED TOPICS (ACTION IV.5)

SCHOLARSHIP N. 28

A. RESEARCH PROPOSAL	
a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and overlap of knowledge and skills to promote the development of innovative products and services with reduced environmental impact, focusing on topics such as; **- protection of the ecosystem;** **- biodiversity;** **- reduction of climate change impact;** **- enhancement of sustainable development** **in order to promote green recovery and overcome the effects of the Covid-19 pandemic crisis.**	The proposed doctoral, named *Green technologies for sustainable management of the WEEE cycle*, focuses on the management of Waste from Electrical and Electronic Equipment (WEEE). WEEE encompasses a wide range of electrical equipment including all components and materials that are an integral part of it. WEEE generated globally in 2019 alone is equivalent to 53.6 million tonnes, about 7.3 kg per inhabitant, an exponential increase (+21%) over the previous year. However, in 2019 only 17.4% was recycled globally, and despite the improvement over the past five years, the annual growth rate (+2 million tonnes) was higher than the recycling rate (+0.4 million tonnes). Of the total WEEE collected, the most significant proportion is represented by large white goods (labelled R2), followed by cooling and climate (R1) and small household appliances, consumer electronics, and photovoltaic panels (R4). Literature reports that WEEE contains potentially recoverable raw materials, hazardous components, and substances such as polyurethane and ozone-depleting substances. The EU strategy aims to

	promote forms of recovery and recycling of WEEE plays a key role in this, allowing the recovery of Secondary Raw Materials (SRMs) while reducing the amount of WEEE going to landfill. Based on the above estimates, this proposal focuses on the most extensive grouping (R2), large white goods (washing machines, dishwashers, dryers or heating appliances, etc). The state of the art is that, after dismantling the hazardous and non-hazardous components, the carcasses are shredded and subjected to magnetic separation and manual sorting for ferrous metals and miscellaneous materials, respectively. The non-recoverable fractions are finally destined for landfills. Such a scheme allows for iron, plastics, aluminium, copper, glass, and wood recovery. In order to increase the recovery of existing fractions and their quality and promote the recovery of new ones (e.g. valuable metals), the proposal aims to test the technical feasibility of a new treatment scheme inspired by circularity in waste management. The proposed new WEEE management model will be able to exceed the minimum recovery target for group R2, minimise the amount of non-recoverable fractions to be landfilled, and reduce environmental impacts. The technologies to be investigated are all characterised by a medium-high Technology Readiness Level (TRL 6-7) and as such are able to favour replicability and rapid technology transfer to industry.
b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students and grant funding to Sustainability-based research projects.	The proposed doctoral pathway aims to develop a new model for WEEE management that has reached the end of its life cycle. The new model is based on established technologies and innovative technologies with a medium-high Technology Readiness Level. The aim is to create a new value chain that starts with research and development and leads to the generation of innovative products (e.g. materials recovered from WEEE) and services and to the development of enabling technologies (e.g. ultra-grinding, tribo-electrostatic separation, pyrolysis, and pyrolytic oil dehalogenation). The proposal is consistent with the National Strategy for Intelligent Specialisation (SNSI) since, about the thematic area "Intelligent and sustainable industry, energy and environment", there is a development trajectory called "Systems

	and technologies for water and waste treatment" utterly focused on waste management.
	The proposal is also consistent with the National Research Programme (NRP) 2021-2027, since the topic of waste recovery is an integral part of the large research and innovation area "Food, bioeconomy, natural resources, agriculture, environment". The field mentioned above includes among its main keywords "reuse, recycling, recovery, green chemistry, circular, green technologies", which are the basis for the development of the proposed doctoral programme, as detailed below.
	Finally, the proposal is consistent with Law 240/2010 and Ministerial Decree 45/2013 on the funding of doctorates in Greenfield. In fact, the proposed topic, aimed at developing a new management model for post-consumer WEEE, focused on maximising the recovery of materials and energy, with a reduced impact on the environment and minimising the disposal of residual waste in landfills, is perfectly in line with the issues of ecosystem conservation and the reduction of the impacts of climate change and the promotion of sustainable development (objectives of the measure on the funding of additional PhD scholarships on Green topics, Action IV.5).
c. Research activity proposal, methods and contents	WEEE in group R2 is currently managed according to a scheme that includes dismantling operations for material recovery/bonification of hazardous compounds, shredding, separation of ferrous, manual separation of other materials, separation of non-ferrous from plastics and landfilling of non-recoverable fractions. Although flattering, the recovery targets set by the Ministry of the Environment have not yet been fully achieved, precisely because of the presence of a significant amount of waste disposed of in landfills.
	In order to (i) increase the percentage of recovered materials, (ii) favour the recovery of specific materials and (iii) reduce the disposal of non-recoverable fractions in landfills, this research proposes to investigate, experimentally, a new treatment scheme that, starting from the eddy current of the conventional scheme described above, envisages the following combination of technologies separation of aluminium from copper by means of a densimetric table; milling of the

	post-eddy current plastics in high-energy mills; tribo-electrostatic separation of the milled plastics aimed at obtaining polymers with high purity and characteristics equal to those of virgin polymers; pyrolysis in a rotating drum reactor of the fractions not otherwise recoverable; characterisation of the pyrolysis products (char, pyrolytic oils and gas) and dehalogenation of the pyrolytic oils.
	The pilot plants for ultra-milling, tribo-electrostatic separation and pyrolysis are already available at the DICATECh Laboratory of Environmental Chemistry and Technologies.
	The PhD course will last 36 months and will be organised according to the following methodological steps: (i) Characterisation of WEEE; (ii) Pre-experimental and preparatory activities characterised by shredding of WEEE, separation of ferrous, any other recoverable materials, non-ferrous and plastics; (iii) Separation of aluminium from copper with densimetric table and their recovery; (iv) ultra-grinding of post-eddy current plastics by means of a Hicom 15 H/E nutation mill; (v) tribo-electrostatic separation; (vi) pyrolysis of non-recoverable fractions in a Lenton reactor; (vii) dehalogenation of pyrolytic oils and their recovery; (viii) technical, economic and environmental assessments of the investigated process cycle.
	The research foresees the involvement of a company already authorised to manage the waste of this proposal and of the research group in the field of sustainable resources and waste management.
	The results will be used to assess the strengths and weaknesses of the proposed concept note.

B. COMPANY-BASED ACTIVITIES within the Italian territory

a. Research activity to carry out with the company	In line with the above methodological approach, the following activities will be carried out at the company: (i) characterisation of WEEE that is the subject of the proposal, (ii) pre-experimental and preparatory to the actual research activities on pilot plants, and (iii) separation of aluminium from copper by means of a densimetric table.
	Concerning to the first group of activities, the objective is to characterise the WEEE entering the proposed treatment scheme, which has already been classified according to the current legislation. Dismantling and separation of hazardous and non-

	hazardous parts, identification of materials for material recovery and reclamation will be carried out, followed by the following analytical determinations: particle size analysis; basic chemical/physical characterisation; determination of calorific value; thermogravimetric analysis; sink-float analysis (sample density); release test. The above operations will be carried out within the company in accordance with a jointly defined operating protocol that takes into account, among other things, workplace safety and health and hygiene aspects.
	In relation to the second group of activities, the objective is to subject the WEEE under study - after dismantling operations - to the treatments that they normally undergo in a commercial plant. The required process operations (shredding; separation of ferrous metals by magnet; manual separation of any other recoverable materials; separation of non-ferrous metals and plastics by eddy current) will be supervised by the company staff, as well as being carried out at their already authorised facilities. Each resulting waste stream will be subject to characterisation.
	With reference to the third group of activities, the objective is to verify the technical feasibility of separating aluminium from copper, both present in the non-ferrous metals stream, the latter obtained following separation by eddy currents. For this purpose, it will be used a densimetric table already in possession of the company, appropriately calibrated. On the outgoing flows, their purity will be determined.
	The above activities will be carried out in the first and (part of) the second semester of the second year, and will last 9 months.
	After this period, the doctoral student will have acquired knowledge on the technologies and procedures normally adopted for the management of WEEE, as well as acquiring a strong background on the characterisation activities imposed by the current law. The knowledge of the technological status quo will be the starting point for a better understanding of the results that will be obtained later, as a result of the technological/experimental activities.
b. Period of company-based study and research	9 months

c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): **quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.**	REACT-EU will provide additional funding for the most important sectors as well as for maintaining employment and job creation. Resources will also be used to invest in the European Green Deal, and common keywords include green technologies, circular waste management and green transition. According to the Utilitatis Foundation, the entire waste sector has a turnover of more than EUR 10 billion and over 95,000 employees. In spite of the criticalities emerged from the COVID emergency, the waste sector can be a driving force for the relaunch of the national economy. In fact, the Utilitatis Foundation estimates an investment requirement of around €8 billion, primarily for the construction of new plants. These plants should recover materials and energy from waste and minimise landfill disposal. WEEE is characterised by considerable amounts of recoverable material such as plastics, ferrous and non-ferrous materials. The market for non-ferrous metals is growing steadily and, above all, is strongly encouraged by the EU, which aims at self-sufficiency by reducing imports from China. Similarly, it is the case for plastics, where growth is mainly driven by the rising cost of virgin polymer. The value of granulated plastics from separate collection is about 300 €/tonne while virgin polymer can be up to 1000 €/tonne. The proposed treatment scheme would produce a material with dimensional and purity characteristics comparable to those of virgin polymer. Already in 2005, it was shown that the treatment cost of tribo-electrostatic separation alone on a 1 ton/hour plant was less than 40 €/ton including plant depreciation. Although to this cost (40 €/tonne) the cost of milling and pre-treatment to remove the metal components must also be added, it is clear that there is ample scope for the technology to be competitive, particularly if the aim is to produce a high quality niche material comparable to virgin polymer. With regard to non-recoverable WEEE residues, pyrolysis would avoid their disposal in landfills, with a major environmental benefit. Pyrolysis, working at low temperatures (350-550 °C), would avoid the typical impacts of combustion.

	From the above, the high impact of the proposal on the production system, consistent with the aims of REACT-EU, is evident. With regard to the monitoring of the doctoral programme, measurable physical indicators will be defined, the results of which will be compared with the expected values.
C. ACTIVITIES ABROAD	
a. Research activity abroad	The research group in Sustainable Resources and Waste Management consists of more than 25 researchers. The group addresses all issues concerning the circular economy by focusing on waste resources such as plastics, metals or organic waste, energy system analysis, renewable energies, anaerobic system analysis and the bio-economy. In the first semester of the third year, the PhD student will deal with the technical, economic and environmental assessments of the investigated process cycle. Activities will be carried out first of all to determine the mass and energy balances, as well as to identify the operational criticalities emerged during the investigated treatment cycle. Subsequently, an economic and an environmental assessment will be carried out. The environmental assessment will be carried out using the established Life Cycle Assessment (LCA) methodology. The assessments will require the definition of the system boundary, which in this study will correspond to the physical boundary of the company. The technical, economic and environmental results will be compared with similar results from the current WEEE treatment scheme under investigation, in order to highlight the advantages and disadvantages of the proposed scheme. These activities, lasting min/max 3/6 months, will be carried out by the PhD student under the supervision of the staff.

National Operational Programme 2014-2020
PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

INNOVATION-BASED TOPICS (ACTION IV.4)

SCHOLARSHIP N. 29

A. RESEARCH PROPOSAL	
a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and the formation of professional profiles as a response to the requirements of the business sector for innovation and competitiveness. **A development of research on topics of innovation, digital advancement and enabling technology while supporting the enhancement of human capital, determining factors in the progress of research and innovation in Italy.**	The research project aims to define research models on road safety with the introduction of new automation technologies in the vehicle fleet. This objective is in line with the requests to create a high added value in the country, as it intends to implement scientific crash models, it aims to create a high level of professionalism in the field of technology and road engineering for all individuals involved in this research. The creation of such models creates new perspectives in the field of national research and leads to the definition of a new professional figure in the field of modeling, technology, road safety and design and planning. In other words, it aims at creating a professional research figure who knows how to combine "classic" knowledge on road safety with the automation needs in terms of traffic safety. It is a change of vision where the classic cultural know-how of traffic safety must be integrated with the knowledge related to information engineering and mechanical engineering.
b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and	The possibility of having automatic and interconnected vehicles can significantly change the idea of conceiving roads. In parallel, the idea

PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students, with the aim of fostering innovation and exchange between the field of research and world of manufacturing and the certification of research project contributions within the sector of innovation (Law 240/2010, art. 24, section 3 and subsequent modifications and additions).	of road safety can also be completely reformulated. The specific objective of the research is aimed at defining safety performance functions (SPFs) that can help decision makers and companies to understand the road safety implications, based on the different degrees of penetration of automatic vehicles in the vehicle fleet. In addition, the research intends to provide a comparative tool to assess road safety by contemplating the changes brought by the introduction and development of the technology. In particular, the research will focus on verifying the geometric characteristics of road layouts, in order to make the infrastructure more understandable by intelligent vehicles, and assess the impact on road safety, in terms of reduction of the expected average crash rate. This aspect will play a major role for future road design. A further aspect of the research is aimed at understanding the interactions between traditional vehicles and automatic vehicles, as the degree of automation and penetration of the latter vary, as well as the characteristics and technologies present on board of new vehicles. The study involves two phases of safety performance investigation, one related to the simulation of scenarios, using traffic simulators, and one related to the validation/calibration of traffic simulator outputs through driving simulators. Through the driving simulator, it will also be possible to verify the intelligibility of the road layout and the behavior of drivers in mixed traffic conditions. This double level of analysis has the function of defining the driving scenarios, both evaluating them in the complexity of the surrounding conditions and focusing on the single automatic vehicle immersed in the ordinary driving environment, to be able to assess both the microscopic and macroscopic level. The research results will also bring significant benefits to the development of traffic simulation and driving software in implementing new scenarios that are as realistic and faithful to technological innovations in the road and transport sector.
c. Research activity proposal, methods and contents	Having obtained the first crash forecasts with the tools available today, it is necessary to verify the validity with specific SPFs. However, simulation

	methods must be used, since specific SPFs are not currently available, whose results must be validated through driving simulators. The test scenario must be implemented on a statistically significant number of road sections and intersections, for which a reliable crash dataset is available. The scenarios must be implemented on microsimulation software and the results obtained must be compared with the input data, to define the crash frequency and severity that can actually be reproduced with traffic simulations. Once the scenarios for the case study have been validated, it is possible to proceed with the definition of different automation scenarios of the vehicle fleet, proposing a sigmoidal penetration of automatic vehicles. The results of the simulations can be further verified through driving simulators, which will also be useful in defining the impact of road geometry on the safe driving of vehicles and the behavior of users in presence of mixed traffic.
B. COMPANY-BASED ACTIVITIES within the Italian territory	
a. Research activity to carry out with the company	The research activity to be conducted at the Company, therefore, will focus on two main issues: 1) study and analysis of the interaction between AV and CV with electric micro-mobility devices and with bicycles, to optimize the technological components of the same vehicles; 2) evaluation of road safety in urban areas, based on the degree of penetration of both AVs and CVs, and electric micro-mobility devices and bicycles. The dual value of the research carried out at the Company will tend to actualize the knowledge that the researcher has acquired in the context of the traffic analysis. At the same time, it could be useful for the company itself for a continuous technological updating and a greater degree of competitiveness. In fact, only with a holistic approach to the various types of vehicles circulating on the road is it possible to predict the various future scenarios in an analytically reliable way and to grasp their potential and risks.
b. Period of company-based study and	10 months

research	
c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): **quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.**	The first results obtained from the use of CMFs, currently existing in the literature, appear to be promising as regards the reduction in crashes linked to the presence of AVs and CVs. In fact, the more their level of automation and penetration is pushed, the more effective is the optimization of road safety. The research aims to obtain models for more precise and accurate crash estimates through the use of specially designed SPFs. These forecasting tools may be useful in the evaluation of crashes in the near future, when it will be necessary to carry out specific forecast studies in the absence of an adequate number of crash data. Likewise, it will be possible to study the behavior of drivers in the presence of mixed traffic, laying the foundations for eventually modifying the current road design criteria that considers only human behavior when driving traditional vehicles. This research aims to provide a first analytical and technical tool that gives concrete answers to a problem, such as road crashes, for different market penetration rates of automatic vehicles. It intends to develop more robust SPFs in light of the growing fleet automation, and, at the same time, to verify the possible effects on the driving behavior of "traditional" drivers in presence of automatic vehicles. The results of the research thus obtained may also tend to the definition of new design criteria for road infrastructures, which take into account the changes that the vehicle fleet will undergo in the short-medium period.
C. ACTIVITIES ABROAD	
a. Research activity abroad	The study of the interactions between vehicles, designed to validate the behavior of road users in a mixed environment, requires the use of driving simulators, as well as road tests on layouts made for this purpose, in order to avoid putting users into risk. The presence of driving simulators with scenarios already implemented for road safety analysis in a mixed environment and the presence of road layouts dedicated to the research of AVs

	and CVs are the discriminating elements for the choice of the foreign Research Center that can significantly contribute to scientific and applicative research training. During the period of staying there, the researcher will acquire further know-how related to computer and engineering, completing his training and making it highly appealing to the university world and applied research.

SCHOLARSHIP N. 30

National Operational Programme 2014-2020
PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

INNOVATION-BASED TOPICS (ACTION IV.4)

SCHOLARSHIP N. 30

A. RESEARCH PROPOSAL **DEVELOPMENT OF AN AUTOMATIC SYSTEM FOR THE EARLY WARNING AND MONITORING OF THE STRUCTURAL SAFETY OF BRIDGES AND VIADUCTS BY DIFFERENTIAL SAR SATELLITE INTERFEROMETRY AND DATA ENRICHMENT TECHNIQUES.**	
a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and the formation of professional profiles as a response to the requirements of the business sector for innovation and competitiveness. **A development of research on topics of innovation, digital advancement and enabling technology while supporting the enhancement of human capital, determining factors in the progress of research and innovation in Italy.**	The research proposal, in coherence with the SNSI, connects the themes of safety of the urban environment, environmental monitoring, prevention of critical events and risk in transport infrastructures with those of Digital Agendas, Smart Communities and Big Data, realizing a significant degree of innovation in the fields of Civil and Structural Engineering. In recent years, these sectors have recognized the need to ineract with the most innovative and frontier issues such as the analysis of big spatial data and data enrichment to achieve the objectives of recovery, development and growth of competitiveness. The real challenge that will generate a paradigm shift in Structural Engineering redesigning its role and centrality - currently in crisis - is played on the ability to exploit information from heterogeneous sources through data enrichment, obtaining high levels of

	accuracy and developing interactive digital systems for evaluation, monitoring and control of safety.
	Methods and algorithms for the assessment of structural vulnerability of bridges and viaducts have been widely developed at various scales of detail, but a significant leap in knowledge and innovation is related to the retrieval and processing of data, whose lack, incompleteness and uncertainty represent the great limitation in the effectiveness of structural assessment procedures. The use of multi-source data and innovative treatment techniques is an alternative to the current monitoring procedures of existing bridges (based on periodic in situ inspections, often with long times and unsuitable to identify critical issues in a timely manner) and is therefore a significant element of innovation in the field of intervention.
	The training path within the Doctoral School of the Polytechnic University of Bari is oriented to the formation of figures with extensive technical knowledge and specialized disciplines and high digital skills, able to manage systems and problems characterized by high complexity and multi-disciplinarity. The specific training and research plan will draw further effectiveness from the synergistic organization of activities between the proposing university, the company and the foreign university.
b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students, with the aim of fostering innovation and exchange between the field of research and world of manufacturing and the certification of research project contributions within the sector of innovation (Law 240/2010, art. 24, section 3 and subsequent modifications and additions).	Recently, in Italy many catastrophic events have involved strategic infrastructures (bridges on the Polcevera river in Genoa and on the Magra river in Massa Carrara, viaduct on the Turin-Savona) with significant loss of human lives and of the functionality of road networks. In fact, Italian and European infrastructure networks are often characterized by age, inadequacy and degradation, in addition to geomorphological, seismic and hydraulic hazards that may lead to further damage or collapse. The monitoring and evaluation of existing bridges and viaducts are usually entrusted to private companies that, however, having to manage a large number of works in a short time and with limited economic and human resources, often fail to deal with them effectively and timely. It is therefore strongly felt the need for adequate digital and IT tools that make these operations more efficient and above all economically sustainable, and more generally that support decision-making processes to improve the safety and robustness of infrastructure.

	With reference to this theme, the objective of the proposed research is the design of a Decision Support System based on the analysis and management of satellite/interferometric data and multi-source data, and the development of multi-scale algorithms for the prediction of local and global structural vulnerability scenarios of bridges and viaducts. This tool, mainly addressed to public or private bodies managing infrastructure networks, will be able to support the activity of operators and inspectors in the automated identification of major sources of vulnerability and risk. The project is part of the general theme "Digital Agenda, Smart Communities, Intelligent Mobility Systems" of SNSI, and in particular of the development trajectory "Systems for the safety of the urban environment, environmental monitoring and prevention of critical events or risk" dedicated to the strategic elements of land transport infrastructure networks. In addition, the project fits into the "Security for Social Systems" theme of the NRP, as well as into the subgroup of "Security of Structures, Infrastructure and Networks". In summary, the research will focus on the study and analysis of interferometric/satellite data integrated with on-site data (cartographies, maps, GPS data, hydro-geomorphological and seismic hazard and other discrete geolocalized data) that will allow the remote monitoring of infrastructures by recording and processing displacements, velocities and particular movements related to situations of vulnerability and risk for bridges and viaducts. This process involves typical geospatial big data issues and involves the use of advanced geospatial information extraction tools to significantly improve geolocation and precise recognition of spatial features.
c. Research activity proposal, methods and contents	The proposed research activities refers to the scientific field of Structural Design - ICAR/09, and in particular to some of its most recent and innovative research topics. The objective is to create a prototype of computer platform and Decision Support System for the continuous monitoring of the structural safety of bridges and viaducts through the use of integrated satellite data. The system will include algorithms for automatic processing of geospatial and satellite data and

computerized procedures for interpretation and management of data by the user (e.g. reporting of "alerts"). The structure of the prototype will be organized in a modular and scalable way in order to incorporate new types of data, manage a different number of infrastructures, include all possible critical events (geomorphological hazard, structural degradation, obsolescence and malfunctioning, ...).

4 WPs are foreseen with the collaboration of all the actors involved.

WP1(Poliba - external company)

Remote Sensing techniques based on the use of satellite imagery: study of SAR differential satellite interferometry techniques and of the potential and limitations in the use of output data on infrastructures in order to identify the types of sensitive attributes/parameters that can be derived, the levels of resolution-cost-reliability, operational limits, data management/correction techniques.

WP2 (Poliba- external company)

Study and development of algorithms for interferometric data management and integration of other geo-referenced multi-source data (optical data, mapping of geomorphological and seismic hazard phenomena and traffic data), in order to validate satellite data through specific application to an area consisting of several pilot cases. To this end, after having carried out a preliminary study on the categories of infrastructure under investigation (typological, constructional and structural characteristics), the major sources of vulnerability will be identified by proposing algorithms for the calculation of structural vulnerability differentiated according to the scale of analysis.

WP3 (Foreign university)

Numerical simulation of the bridges and viaducts falling in the study area by means of FEM structural calculation software, numerical evaluation of the effects (displacements, strains, deformations, stresses) detected by the interferometric data previously processed and validated, in order to evaluate different scenarios of vulnerability and risk (local and global). Calibration, of alert thresholds that will guide the user to define potential criticalities, with reference also to scientific literature and regulatory texts.

WP4

Design of the prototype of digital platform for the analysis and presentation of the results of the

	analysis, risk scenarios and priority lists for interventions.
B. COMPANY-BASED ACTIVITIES within the Italian territory	
a. Research activity to carry out with the company	The activities at the company will aim to verify the strategy of application of interferometric satellite measurements to the control of infrastructures such as bridges and viaducts testing at experimental level the strategy defined with the research work for the definition of the level of vulnerability of the same. In particular, the company will provide the necessary data and the PhD student, supported by a team of experts in the field, will carry out an analysis of the results of the processing of massive radar data (e.g. Sentinel-1) obtained through advanced algorithms of differential multi-temporal interferometry on a study area characterized by pilot cases in order to validate experimentally the theoretical approach defined in the initial stages of research for the assessment of structural vulnerability of bridges and viaducts. In view of an enhancement of the services already provided by the company, the objective of the work carried out in this phase will be to test and validate the approach with respect to the objectives of the project also with the application to case studies within the company's proprietary platforms. Throughout the course of the research, moreover, the focus will be on sharing and updating the results developed and the tools to be used in order to enhance the training and skills of the PhD student.
b. Period of company-based study and research	12 months
c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for Cohesion and the Territories of Europe programme (REACT-EU): **quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.**	This research proposal addresses the issue of innovation and digital transition in structural engineering. With reference to the management of the built heritage, the current procedures for monitoring the safety of existing bridges are based on periodic in-situ inspections, and as a result, the timeframes often become long and unsuitable for the timely identification of critical issues in networks and infrastructures. Moreover, the recent pandemic has severely constrained the construction industry highlighting how the techniques of management, maintenance and adaptation of infrastructure need

	new social and working models based on digital means.
	The objective of the proposed research is precisely to develop an innovative tool for analysis and monitoring, taking advantage of the latest advances in research in the field, which can automate the acquisition, management and processing of data streams by continuously updating information and events related to the works, and thus offer a system of decision support for managers and operators in the sector, whose primary need is to manage large infrastructure assets by optimizing available resources and time.
	The prototype of a digital decision support platform for monitoring and interactive multi-scale management of structures and early warning will be developed and will allow to update and innovate the current technical and operational framework.
	The effectiveness and impact of the tool will be assessed through a series of performance indicators, according to the most common indicators of achievement and result. In particular, the reliability and accuracy of the evaluations obtained with the data enrichment procedures will be measured, considering a value of 90% acceptable in relation to the pilot cases investigated.
	It will be evaluated the usability of the platform, as well as the processing time to obtain the desired result where, for each work, the evaluation time will amount to about 1 minute.
	Further indicators will be: the capability of the system, considering the implementation of a minimum number of 20 works, extendable in the path of technological upgrade; the scalability, which ensures the perfect functioning of the system as the computational load increases; the modularity, which ensures a comprehensive response to the needs to modify/improve the algorithms at the base of the procedure.
C. ACTIVITIES ABROAD	
a. Research activity abroad	During the stay and training abroad, a leading university center in the field of Structural Engineering, with a specific excellence in diagnostic applications and in the most advanced monitoring technologies, the PhD student will carry out the research activities related to the numerical

	simulation methodologies of bridges and viaducts constituting the pilot cases considered, using finite element software, and application of interferometric data previously processed and validated. The purpose of this period will be twofold: on the one hand, the more traditional issues of numerical modeling of infrastructures with detailed approaches (e.g. fiber models in opensource codes) will be addressed, and on the other hand, a brand new analysis of the effects related to the application of interferometric input data of displacement and velocity, aimed at assessing with accurate and innovative evaluations the possible scenarios of structural vulnerability and risk related to monitoring and control of events considered critical.

SCHOLARSHIP N. 31

National Operational Programme 2014-2020
PhD programmes for sustainability and innovation-related subjects

Ministerial DECREE N. 1061 (10 Aug 2021)
Academic Year 2021/2022 – XXXVII CYCLE

INNOVATION-BASED TOPICS (ACTION IV.4)

SCHOLARSHIP N. 31

A. RESEARCH PROPOSAL	
a. Relevance of doctorate research project in creating high added value in terms of scientific, social and economic impact on Italy, fostering appropriate research models and the formation of professional profiles as a response to the requirements of the business sector for innovation and competitiveness. **A development of research on topics of innovation, digital advancement and enabling technology while supporting the enhancement of human capital, determining factors in the progress of research and innovation in Italy.**	Within the risk assessment and mitigation for the built environment, one of the founding axes of the PhD Programme in "Risk And Environmental, Territorial and Building Development" (DICATECh - Poliba), the vulnerability of strategic civil structures and public real estate assets, widespread on a territorial scale, has specific relevance, with respect to phenomena of physical, technological and normative obsolescence. These phenomena, in fact, albeit of a slow cumulative type, can compromise the safety of use in operating conditions, as well as the overall resilience in the event of immediate catastrophic events. In particular, the need to have tools and techniques for evaluating and controlling works and artefacts, comparable to nodes of complex networks, requires integrated research models to address distinct and complementary aspects: from the structuring of knowledge deriving from variegated and heterogeneous data to the acquisition of information from complex systems of sensors and devices, from the involvement of a plurality of stakeholders, experts and non-experts, to the optimization of intervention procedures according to a systemic approach.

	All the aforementioned areas can widely benefit from the most recent innovations related to enabling technologies, such as big data, data platforms, high-performance computing systems and artificial intelligence. Nonetheless, they require careful analysis of the specific application domain, requiring the close synergy of academic research and industrial development in the construction sector to guide the design and performance validation of the most appropriate ICT systems.
	In this perspective, the project aims to direct the training of highly specialized professional figures, with a highly interdisciplinary profile and capable of guiding the digital transition processes of small and medium-sized enterprises and local administrations, enhancing human capital as an engine of industrial innovation and the advancement of technical-scientific knowledge.
	Furthermore, the issue of enabling technologies applied to the diagnosis and maintenance of civil works and building structures implies a high added value with repercussions at different levels: scientific, for the interdisciplinary vision underlying the application of tools of information technology and electronics to the sector of civil, construction and territorial engineering and for the extension of the 4.0 building approach to existing buildings; economic, in terms of increased competitiveness of the construction business system, typically characterized by a low and slow ability to incorporate innovation, and the development of transversal professional profiles capable of understanding procedures and tools of the digital transition; social, for the application of enabling technologies to collaborative processes between technicians, administrations, companies and users.
b. Adherence of doctorate research project to National Strategies of Intelligent Specialisations (SNSI) and PNR and applicability to Law 240/2010 and Ministerial Decree 45/2013 regarding PhD students, with the aim of fostering innovation and exchange between the field of research and world of manufacturing and the certification of research project contributions within the sector of innovation (Law 240/2010, art. 24, section 3 and	The research aims at the performance design and performance of an integrated digital environment for the documentation, diagnosis and management of strategic civil structures and public real estate assets, distributed on a territorial scale. For this purpose, the definition and development of a methodological workflow is envisaged, namely guidelines, operational protocols and best practices, which might explicit areas, purposes and requirements for ICT enabling technologies to build information repositories and decision support tools in the phases

subsequent modifications and additions).	of knowledge, evaluation and control of the existing assets. The general theme is strongly consistent with the thematic areas and the technological trajectories contained in the SNSI, for which "*Digital Agenda*" and "*Smart Communities*" find a meeting point in the implementation of technologies that are able to make structures and infrastructures in the territory safe, intelligent and sustainable, also in the prevention of critical or risk events. Similarly, it finds full correspondence in the PNR vision of synergy between "*Digital*" and "*Industry*" in which the "*Digital Transition - i4.0*" can "*systematize and fully exploit the potential of digital innovation for the benefit of different needs and perspectives that emerge […] at the level of the community and of the country system* ". In particular, the PNR recalls some "*articulations*", which converge in the approach and objectives of the research proposal, including: (i) "*High performing computing and big data*" for an "*economy based on dynamic attractive and secure data and on agile data management and use*" in particular for sustainable development and resilience, through cloud platforms and services for communities, SMEs, professionals and citizens and (ii)" *Artificial Intelligence for environment and critical infrastructures* ", also through" *multimodal and multimedia data, multispectral images and data from distributed sensor networks* ". Furthermore, more generally, the PNR underlines the need for a human-centric approach to enabling technologies, which, without prejudice to their reliability and robustness, must be designed to interact with the individual in the most effective and intuitive way possible, by means of, among others, "*human / computer interaction systems [...], egocentric vision collaborative intelligence systems, augmented / virtual reality systems*".
c. Research activity proposal, methods and contents	The research project addresses some distinct and complementary aspects in the context of performance control, scheduled maintenance and participatory management including: - Structured and integrated documentation of all information useful to define the current performance level on the basis of documentary sources,

	experimental measurements, analytical processing and direct surveys; - Availability of advanced diagnostic techniques and methods, based on supervised procedures with a view to expeditiousness, replicability and reliability; - Implementation of planned maintenance and management strategies for the prediction and prevention of pathologies, anomalies and defects. In detail, the research activities must concern: - Geographic Information Systems (GIS) and Building Information Modeling (BIM) data processing and management platforms for the systematization and integration of documentary, instrumental and analytical data at different scales of analysis and intervention, also with reference to monitoring plans and control over time and early warning systems; - Photorealistic 3D models from laser scanner / photogrammetric acquisitions and multispectral 3D models for mapping, segmentation and annotation supervised by reverse engineering, image processing and machine learning techniques and for the guided formulation of expert judgments through logical inference algorithms; - Virtual Reality (VR) environments for the construction of collaborative paths between the professional, institutional and entrepreneurial subjects involved, with respect to both the construction of knowledge and the communication of control and intervention actions; - Products and digital contents usable in Augmented Reality (AR) for inspection and maintenance activities toward technical operators and training activities toward non-expert users. - Tools for the acquisition and management of data from user reporting using innovative Natural Language Processing (NLP) techniques in anomalous situations for the conservation state and safety of the places. The expected final result is the definition of the conceptual structure - information flows, contents and relationship logics - of the aforementioned integrated digital platform, based on the verification of correlation and interoperability of the aforementioned tools / products, to be tested and validated on case studies representative of strategic civil structures (hospitals and health facilities, public administration offices, emergency management offices, ...) and public real estate assets (state-owned buildings, post offices, economic-social housing, ...)

	in order to guarantee the replicability and scalability of the results achievable.

B. COMPANY-BASED ACTIVITIES within the Italian territory	
a. Research activity to carry out with the company	The PhD student will carry out part of his/her research activity at the company Boviar srl, with decades of experience in the creation and supply of hardware and software tools for diagnostics and monitoring in civil, construction, geotechnical and environmental engineering, using non- destructive techniques and versatile and innovative detection and control systems. In particular, the company will be able to offer support to the general framework of research topics, also in the light of its recent participation, together with the Polytechnic of Bari, represented by members of the PhD teaching staff to the project " VERBUM. Virtual Enhanced Reality for Building Modeling "(Program of the Puglia Region" INNONETWORK), in which the study and experimentation of immersive digital environments, usable in augmented / virtual reality, for the documentation and use of phases and contents of the recovery process was addressed for historic buildings. Nonetheless, doctoral student will be able to tackle some specific aspects of research, related to the company's know-how, with particular attention to: - Monitoring networks integrated into GIS / BIM data management platforms for the control over time of significant environmental and structural parameters and the activation of early warning protocols - 3D multispectral models for the extraction and processing of diagnostic information relating to performance levels and the presence of symptomatic manifestations of degradation - BIM / AR environments for the assessment and control of the state of conservation of the structures.
b. Period of company-based study and research	6 months
c. Measurable nature of expected results and potential impact of implemented actions with reference to the aims of the Recovery Assistance for	The proposed research, in line with the aims of the REACT EU of job creation, in particular for young people, aims to create the basis for the education of highly specialized professional profiles, which can

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Cohesion and the Territories of Europe programme (REACT-EU): quantifiable and measurable targets in doctoral research project in line with indicators set out in NOP reference of actions.	guide technological innovation processes of small and medium-sized and digital transition enterprises of public administrations and private entities related to the management and maintenance chain of civil constructions and building assets. Moreover, this orientation is fully consistent with the PhD course, traditionally devoted to the development of knowledge and skills that meet the needs of universities, research bodies and territorial bodies for management of environment, territory and buildings and those of the freelancer individually, associated or as an employee of a company. In fact, the employment data of research doctors show how the convergence of the educational objectives of the doctorate with the needs and demands of the territory, the world of work and profession, as well as the academic ones, was very satisfactory, testifying to the good effectiveness organization, courses and activities carried out. Nonetheless, it is highlighted that the potential for integration of PhDs can be further enhanced by some distinctive features of the research proposal, such as interdisciplinary, synergy with the business world and internationalization.
C. ACTIVITIES ABROAD	
a. Research activity abroad	The research activities to be carried out in collaboration with the Escuela Técnica Superior de Ingeniería De Edificación must concern the themes and areas in which the research group of Prof. Moyano has developed experience in recent years, as a support to the review of the state of the art on the topics of reality-based modelling (aerial and terrestrial digital photogrammetric techniques and laser scanner surveys) and computer-based (CAD and BIM modelling), as well as methods and techniques for instrumental investigation aimed at material-constructive and performance qualification of structural components. In particular, on the basis of the experimental applications conducted by the members of the research group, activities related to photorealistic 3D models for information modelling and semantic interpretation of the building stock; collaborative design processes based on digital technologies; instrumental monitoring techniques; criticality reporting systems; building pathology analysis for the development of maintenance and management strategies and quality control procedures for building components.