Research subjects proposed for the 33rd cycle

Curriculum A: Civil and Environmental Engineering, Agricultural Technologies

1 *(ref. A1 – for topic of reserved scholarships – UNITN and Edmund Mach Foundation scholarship)*

Fine spatial scale modelling of Trentino past forest landscape and future change scenarios to study ecosystem services through the years (TRENTINOLAND)

P.I.: Marco Ciolli (UNITN), Nicola La Porta (Fondazione Edmund Mach)

Participants UNITN: Maria Giulia Cantiani, Duccio Rocchini, Clara Tattoni

Over recent decades, forest land cover is dramatically changing in European mountains and in the Alps in particular. Since the 1950s the progressive urbanization of the valleys and the abandonment of mountain and rural dwellers has intensified. More than 60% of the Trentino land, is covered by forest and mainly by high forest. This human migration have brought to a progressive shrinking of meadows and pastures due to the natural forest expansion causing a dramatic change in the landscape, the consequences of which affect biodiversity, social and cultural dynamics and landscape perception as well as ecosystem services.

The objective of this research focuses on the application and experimentation of advanced GIS and modeling techniques to compare aerial imagery, historical maps and data and remote sensed images to understand the past landscape changes and their dynamics in Trentino and to build future scenarios based on long-term set of observations. These analyses and models will be integrated with i) forest assessment plan datasets, historical floristic geodatabase and and ii) ecosystem service analysis of past and future landscapes. The research will produce a fine scale dataset representing past landscape changes as well as a set of future forest Trentino landscape scenarios at a detailed scale (3-5 m).

The work herein proposed will realize the first systematic approach of synthesis for the whole Trentino forest landscape changes since 1859, with the valuable outcome of its dynamical scenarios in relation to intensity of different pressures and drivers. The results will be useful for researchers and decision makers and will allow unprecedented analysis of ecological and territorial dynamics.

Expected results will be to fostering a significant early-career researcher in a transdisciplinary landscape context and to publish scientific, technical and popular papers. The new multidisciplinary competences and skills acquired by the student at the end of the PhD course, like advanced geographical data manipulation combined with GIS and R technology, will give him/her the possibility to work in research bodies like: Universities, CNR, CREA, ENEA, ISPRA, FAO or in professional fields like: urban greening, parks, agriculture. The main scientific outcomes of the project will be three scientific papers on peer reviewed (ISI) journals about reconstruction of the dynamisms of the forest landscapes in Trentino, future landscape scenarios, comparison of Ecosystem services of the Trentino and Alpine forests along the years and an open geodatabase accessible by a Webgis with the dataset.

2

Use of hardwood-based structural elements for a short supply chain in timber constructions
P.I.: Maurizio Piazza (UNITN)
Participants: Ivan Giongo (UNITN)
The project falls within the framework of the PRIN 2015 program, as part of the research "*The short supply chain in the biomass-based and wood sector: supply, traceability, certification, carbon capture and storage. Innovations for green building and energy efficiency*". The project idea was prompted by the rapid increase in demand for wood based products in constructions, both for structural and non-structural use. In Italy however, most of the timber products that are sold today, are imported from abroad, resulting in decreased quality of the original wood assortments, loss of know-how and craftsmanship in regional and local areas. Objective of the project is therefore to enhance the concept of local chain-wood biomass, promoting the definition of good practice for the mobilization of wood biomass and developing technological solutions for sustainable building and energy efficiency, by means of product innovation. Project outcomes should: (i) verify the possibility of mobilization and the sustainability of short supply chains of wood biomass; (ii) promote new models of environmental certification and energy efficiency analysis; (iii) create innovative products for the bio-building (XLAM laminated panels, plywood panels) with wood species never before used for this type of applications; (iv) characterize the architectural function of wood products, by taking into account material degradation and studying effective solutions for preserving it. Particular attention will be given to the most common types of hardwood in Italy such as chestnut, beech and deciduous oaks. Currently, use of hardwood in timber constructions is hindered by the performance of mechanical connections which were originally developed for softwood material. Therefore, it is fundamental to the project success that hardwood connection systems are thoroughly investigated and sound analytical formulations to predict their behavior are developed. The possibility of producing beams and panels with domestic timber will boost forest enhancing and help rethink forest management models with criteria of sustainability and multi-functionality. The increase in local demand for timber will cause, as indirect consequence, an increase in the national forest area, a greater articulation of the wood-processing industry with a decrease in unemployment and abandonment of inland areas, often depressed.

3

Modelling water flows under phase transitions
P.I.: Riccardo Rigon (UNITN)
Participants: Vincenzo Casulli (UNITN), Stephan Gruber (Carleton University)

This study starts from a pore scale view of flow in soil and aggregate it at the representative elementary volume, (REV) scale according to statistical assumptions, to obtain new forms of the Richards equation. Flows are assumed to happen under normal and/or freezing conditions and under evapotranspiration demand and transitions from unsaturated to saturated conditions will be properly accounted in all types of flow. The theoretical work at the basis of this proposal is contained in Dall'Amico et al. 2011 and Tubini, 2017. At the beginning the system will be modeled by coupling the water budget equation and the energy budget equation, neglecting vapor mass budget, as usually done. The candidate should take care of integrating the equations with appropriate and sound numerical methods that guarantee mass and energy conservation, as Casulli and Zanolli (2010) and its possible extensions.
There are various possible further development of this research path. One is to couple the water and energy budget with surface waters simultaneously solved, another is to deal with water vapor explicitly. Others developments will come with the development of research.
The informatics behind the code will follow (and, in case co-develops) the developments pursued by dott. Serafin, Ph.D. work inside the Object Modelling System version 3 or subsequent (OMS3, David et al., 2013), that will take care implicitly of parallelism and provide various services to computation (e.g. Serafin, 2016).
All the code developed will be done in Github (or similar platform), inside the GEOframe community and will be Open Source according to the GPL v3 license.
The candidate will take care of implementing, besides the code, the appropriate procedures for continuous integration of the evolving source code, and s/he will be also asked to maintain a regular rate of commits to the common open platform. Despite these conditions, and being free and open source, the code will be intellectual property by the coders, which will be guaranteed also by the components-based infrastructure offered by OMS3.
The implementation part will be followed, accompanied by testing activities, either for mathematical consistency, than for physical consistency with experiments and field measurements made especially by Dr. Stephan Gruber group at Carleton University, where the candidate will be asked to spend some periods od his/her doctorate. Thought participation to experimental activities will not be intended to be purely passive, but s/he will be asked to actively participate as much as feasible and reasonable.
The Ph.D. student is intended to produce, besides working and tested codes, also at least three papers in major journals, of which, at least one as first Author.

This project can enter either the curriculum C or the curriculum A of our doctoral school.

Essential References:

Casulli, V., & Zanolli (2010). A nested newton-type algorithm for finite colume methods solving Richards' equation in mixed form. SIAM J. SCI. Comput., 32(4), 2225–2273.

Dall'Amico, M., Endrizzi, S., Gruber, S., & Rigon, R. (2011). A robust and energy-conserving model of freezing variably-saturated soil. The Cryosphere, 5(2), 469–484. http://doi.org/10.5194/tc-5-469-2011

David, O., Ascough, J. C., II, Lloyd, W., Green, T. R., Rojas, K. W., Leavesley, G. H., & Ahuja, L. R. (2012). A software engineering perspective on environmental modeling framework design: The Object Modeling System. Environmental Modelling and Software, 39, 1–13. http://doi.org/10.1016/j.envsoft.2012.03.006

Serafin, F., About graphs, DSL and replicable research, 2016, http://abouthydrology.blogspot.co.at/2016/11/about-graphs-dsl-and-replicable.html

Tubini, N. (2017, March 31). Theoretical Progress in freezing-thawing process studies. (R. Rigon, F. Serafin, & S. Gruber, Advisors.).

4

Environmental granular flows

P.I.: Aronne Armanini (UNITN)

Debris flows, rock avalanches and snow avalanches are natural catastrophic phenomena that affect many mountainous regions around the world and are considered *environmental granular flows driven by gravity*.
A simplified approach is to treat them as two-phase flows: the liquid phase is water or air, while the granular material represents the solid phase.
The rheology of granular phase depends on the type of interactions among particles: if the contacts are binary and instantaneous, the regime of the granular flow is dominated by interparticle *collisions. I*f the contacts become long lasting and involve more particles at the same time, the flow regime becomes frictional.
The collisional regime is well described by the kinetic theory of dense gases while with respect to the frictional regime there is not yet a complete theory.
Recently a rheological model (heuristic model) based on the experimental evidences that the two regime coexist along the flow depth (Armanini et al. 2009) and that at the boundary with the loose static bed the rheology reduces to the Coulomb's condition (Armanini 2010) has been proposed by Armanini et al. (2014).
The proposed of this PhD thesis is to better investigate the interactions between the two phases and to extend the results on the rheology to non permanent granular flows such as debris flows and snow avalanches.

5

Sediment transport in vegetated water courses

P.I.: Aronne Armanini (UNITN)

The importance of vegetation as a factor in improvement of the environmental quality of rivers is widely recognized. Hence hydrophilous riparian plants are not only naturally present on banks and floodplains, but their use in restoring regulated rivers is encouraged. In recent decades, understanding of the hydrodynamic interaction between plants and flow has significantly improved thanks to the increasing number of researchers interested in this topic and the consequent proliferation of theoretical and experimental studies.
One of the aspects of the interaction between vegetation and flow that is still

unknown is represented by the influence of vegetation on the processes of morphological evolution of watercourses. In particular, the effect of vegetation in mobile bed mathematical modeling.
In this case, there is a lack of literature on the definition of the sediment transport capacity suitable for the depth integrated mathematical models (closure relation).
Armanini et al. (2005), through their research study in a stationary and homogeneous vegetated channel flow, have demonstrated that in case of emerging vegetation traditional solid transport formulas can be used, as long as the dimensionless solid discharge and the mobility parameter are properly modified on the base of vegetation characteristics.
We would like to extend the analysis to the case of submerged vegetation.
The research is made up of an experimental laboratory part where we intend to simulate in equilibrium condition different scenarios of sediment transport in the presence of submerged vegetation.
Based on the experimental results, we will try to construct an interpretative model.
The ultimate goal is to obtain saddle closure relationships to be used in depth integrated mathematical models.

6

High-resolution simulations of boundary-layer processes and urban-scale phenomena over complex terrain

P.I.: Lorenzo Giovannini (UNITN)

Participants: Dino Zardi (UNITN)

The research activity proposed will focus on the evaluation of atmospheric processes over urban areas in complex terrain, and in particular on the interactions between built-up areas and boundary-layer phenomena typical of mountain valleys. The study of local climatic alterations induced by the presence of urban areas is a topic of growing interest in the scientific community, due to the fact that most human activities are concentrated inside urban areas: therefore the attention focuses on the specific climate which an increasing number of citizens experiences every day.
The research activity will be carried out by means of high-resolution numerical simulations with state-of-the-art meteorological models, coupled with parameterizations which take into account the effects of urban areas on atmospheric boundary-layer climatic conditions. In fact, in the last few years the implementation of advanced surface parameterizations inside meteorological models allowed a more realistic representation of urban effects. The research activity will include also the extensive test and the possible improvement of these parameterization schemes.
The study of the urban climate of a city in complex terrain must take into account the interactions between the built-up area and the peculiar phenomena typical of these contexts, as for example valley winds or thermal inversions. Valley wind circulations, which develop mainly on clear-sky days during the warm season, are distinguishing features of mountain valleys. They significantly mark the local wind climatology with a pronounced daily periodicity, as their direction regularly reverses between day and night. Therefore, the research activity will focus also on the evaluation of the mechanisms driving thermally-driven circulations, in order to better understand their interaction with urban areas. In particular high-resolution numerical simulations are expected to provide insights on the physical processes responsible

for the development of temperature and pressure contrasts between different segments of the valley driving the valley wind system, both at ground level and in the valley core. On the other hand, considering thermal inversion, numerical simulations may be used to evaluate also the influence of urbanization on the inversion breakup, and the consequent effects on air quality.
The expected research outcome of the present project comprises both a better understanding and representation of climatic conditions in cities located in complex terrain, including the interactions with local boundary-layer processes, and the improvement of surface parameterization schemes to describe the effects of urban areas inside meteorological models. More precise simulations of processes controlling the boundary layer structure over a city in complex terrain are expected to provide better forecasting results on key parameters affecting air quality in the area, energy consumption in buildings and thermal comfort conditions. Moreover, the modeling strategy adopted might be used to build possible future scenarios, in order to test strategies to improve thermal comfort and life quality and to minimize energy consumption inside urban areas.
Results from the present project are expected to be published in peer-reviewed high-ranked international journals.

7 (ref. A2 – for topic of reserved scholarships – UNITN and Edmund Mach Foundation scholarship)

Ecological connectivity in the Alpine anthropic matrix: natural reserves and corridors for the conservation of brown bear in the Alps (ABC - AlpBearConnect)
P.I.: Marco Ciolli (UNITN), Francesca Cagnacci (Fondazione Edmund Mach), Luca Pedrotti (Parco Nazionale dello Stelvio)
Participants: Annapaola Rizzoli (Fondazione Edmund Mach), the BearConnect consortium
If current times are defined as 'Anthropocene' era, Europe is among the most anthropized areas of the planet. Primeval habitats are hardly found in continental Europe, and substantial anthropic influence in the composition, structure, and functionality of ecosystems has been continued for millennia. In parallel to population increase, though, human activities have cycled in Europe before than elsewhere, revealing an unexpected, parallel alternation of fragmentation and connectivity within European landscapes. Indeed, the last decades of the 20th century have been characterized by social, structural and ecosystemic changes, that have reshaped the cultural, economic and ecological landscape of Europe. In the Alpine region, such changes have been paramount. In parallel, territories abandoned by humans were recovered by natural habitats and used as connecting bridges for re-establishing wildlife species, also aided by EU regulations and network of protected areas. Among all, populations of large carnivores have increased and expanded, offering the unexpected outlook of a 'complete' trophic chain re-establishing at the very edge of highly anthropic areas. Nowadays, this process is at a tipping point. Re-establishment of biodiversity has clashed against major threats, such as geographic and functional barriers, for example valleys with a very dense anthropic concentration or disappearance of habitat types. In this project, we focus on the distribution of the

brown bear population in the Alps, starting from the core of a reintroduction project happened in early 2000 in Trentino. We aim at a obtaining a realistic prediction of the distribution of the brown bear population in Trentino/Central Alps, and of the connectivity potential across the Alpine-Dinaric metapopulation, in presence of large stretches of under-utilized areas and, in contrast, hot-spots with intense anthropic use. These predictions will be compared with the current matrix of protected/non-protected areas, and with possible future scenarios of increased/decreased structural connectivity. The project will take advantage of the large amount of georeferenced data available in the study area and of advanced modeling and GIS techniques. The expected outputs will be the evaluation of the status quo for bear conservation and for the establishment of functional meta-population, and the assessment of ameliorating actions. The results of the project will be important for bear conservation, but also for an improved 'societal connectivity' between wilder areas and areas of intense anthropic presence and use.
The project will be developed in full harmonization with the objectives of the Biodiversa funded project 'Bearconnect' (Functional connectivity and ecological sustainability of European ecological networks: a case study with the brown bear), so that an intense scientific exchange and coordination with the Bearconnect consortium and network will be pursued. The project will also coordinate, when possible, with other existing projects (e.g. Life Dinalp Bear). The doctoral student will therefore work in a stimulating international research environment.
The expected deliverables of the projects will be: scientific publications on high ranked ecological and biological conservation journals; suitability, connectivity and predictive distribution maps; conservation guidelines.
A substantial outreach programme will be performed both locally and in the context of the aforementioned international projects.

8 *(ref. A3 – for topic of reserved scholarships - Edmund Mach Foundation scholarship)*

Formulation of Trichoderma atroviride SC1 for soil application

P.I. : Marco Ciolli (UNITN), Ilaria Pertot (Fondazione Edmund Mach/ UNITN)

Participants: Ann Vermaete (Bi-PA - Biological Products for Agriculture Technologielaan, Belgium)

Soilborne pest control through a new formulation of Trichoderma atroviride SC1.
Soilborne pest and diseases are an increasing problem worldwide. According to the scientific literature yield losses due to some of the more dangerous soilborne pests and pathogens, are increasing considerably, because of the ban of several synthetic chemicals. The chemical control of soilborne pests has been conducted successfully with methyl bromide for many years, until the molecule was banned because of its effect on the ozone layer (Montreal Protocol). Additionally, all other molecules that substituted methyl bromide – although with lower efficacy – are under regulatory pressure because of the unfavorable effects on the environment. Therefore control of several soil pests and pathogens did not find a solution yet. A suitable alternative to chemicals are microbial biocontrol agents. Namely, several strains of *Trichoderma* spp. have been reported to effectively reduce the incidence of soilborne pathogens. However to provide a sufficient effect, these strains must be applied at very high

concentration, which make the approach not economically sustainable. In addition, the introduced *Trichoderma* spp. strains in soil tend to decrease very fast because of the natural antagonism of natural soil microflora. The aim of this project is to develop a new formulation for Trichoderma atroviride SC1. The concept is based on developing a carrier, which can ease the field application, reduce the dosage per hectare and prolong the survival of the microorganism in soil. However a prolonged survival of the microorganism may be linked to an unwanted side effect on soil microbial population and functions, therefore a second aim to investigate and assess the impact of the new formulation on soil functions and ecological stability. The project is in collaboration with two industrial partners and will take advantage of the most advanced techniques in a multidisciplinary research environment. Besides the prototype formulation to be industrially scaled up, the outcomes of the project are four scientific papers on peer reviewed journals.

9 *(ref. A4 – for topic of reserved scholarships - Edmund Mach Foundation scholarship)*

Vibrational interference with the mating behaviour of the Xylella fastidiosa vector, Philaenus spumarius

P.I. : Marco Ciolli (UNITN), Gianfranco Anfora (Fondazione Edmund Mach/ UNITN), Valerio Mazzoni (Fondazione Edmund Mach)

Participants: Vincenzo Verrastro (CIHEAM-IAMB)

The recent outbreaks of the bacterium Xylella fastidiosa in Southern Italy revealed the necessity to find innovative and effective solutions to contain the outbreak of this epidemic disease. Vectors of X. fastidiosa are xylem feeders Auchenorrhyncha (Hemiptera Cicadomorpha), in particular spittlebugs such as Philaenus spumarius. As well as many other insects, this species communicates by means of substrate-borne vibrational signals to accomplish mating. The deep knowledge of the mating communication can allow the development of methods of interference with the naturally emitted sexual vibrations, to disrupt the insect mating behaviour. A multi-disciplinary partnership approach will be established in order to accomplish the research objectives.
The main aim of this PhD project is to describe the mating behaviour of P. spumarius and to assess whether technique of interference with the mating communication (e.g. mating disruption, attraction, repellence) are applicable for the species control in the field or not. In addition, a study will be conducted to evaluate differences between different Palaearctic populations in terms of both phenotype (vibrational signals) and genotype. In fact, P. spumarius is widely distributed in the North hemisphere and this gives us a good opportunity to study the geographical "language" variability of an insect. Besides the prototype device, the outcomes of the project is scientific knowledge that will be published in international journals.

10 *(ref. A5 – for topic of reserved scholarships – EUROFLOW – ETN Marie Skłodowska-Curie-ITN H2020 research fellowship)*

Linkages between fish habitat dynamics and channel morpho-dynamics at mesoscale

P.I. : Guido Zolezzi (UNITN), Walter Bertoldi (UNITN)

Studies aimed at assessing the spatial and temporal availability of river habitat for different biological species mainly assume a static configuration of the river channel. Existing habitat-based methods for environmental flow design and assessment do not explicitly incorporate morphological changes in the relation between habitat availability, sediment transport and channel (bio)morphodynamics at the relevant scales. At the flood event time scale, river morphodynamics may determine a strong spatial rearrangement of the habitat template, both in the wet channel and in the exposed morphological units at low flow. At larger time scales, trajectories of channel adjustments may force dramatic shifts in the ability of a river reach to support habitat diversity at given turnover rates.

The proposed doctoral research topic aims to address the relation between river habitat dynamics and channel morpho-dynamics at the relevant spatial and temporal scales, with a focus on both the habitats in the wet channel and in the dry morphological units at low flow conditions, to encompass habitat conditions of relevance for both fish and terrestrial species, as in the case of birds hatching on bare sediment bars.

The specific research objectives are:

(1) To quantitatively assess the variability of mesoscale habitat structure due to morphological changes in the river corridor at different time scales (i.e. flood event, decadal), with focus on both the dry channel and the wet channel.

(2) To extend the applicability of mesoscale habitat models at non-wadable, morphologically complex conditions (i.e., high discharge, large streams) through hydro-morphodynamic modelling;

(3) To develop morphodynamic-sensitive habitat metrics and to assess their use for e-flows design and monitoring over time scales encompassing multiple formative events (decadal or multi-decadal time scale)

The foreseen research outcomes are:

(1) Assessment method for temporal persistence of habitat-discharge rating curve across different channel patterns;

(2) Upgraded mesoscale habitat model applicable to a range of river conditions;

(3) Novel "morphodynamic" habitat metrics, accounting for river dynamics/sediment transport

The research will adopt the mesoscale habitat modelling approach and will integrate morphodynamic modelling, field data collection, analysis of morphological change and habitat time series and the application of suitable distribution models for target biological species. Case studies in river with different morphologies and rates of morphological changes will be preferably chosen among sites already subject to habitat modelling in th North of Italy. One secondment is foreseen at EAWAG (Switzerland), to apply the developed approach on the case study of the Spol River (CH) subject to a unique program of environmental and geomorphic flows for more than a decade. A 3-months secondment to ISPRA – the Italian National Agency for Environmental Research and Protection – will focus on the integration of the proposed approach in existing e-flow assessment frameworks for their possible improvement.

Curriculum B: Mechanics, Materials, Chemistry and Energy

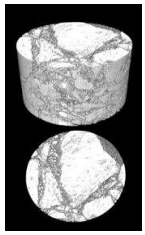
1

Nanostructured materials: production, modelling and characterization

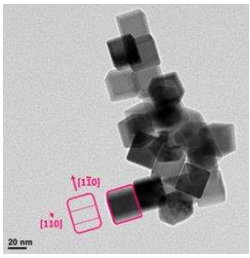
P.I.: Paolo Scardi (UNITN), Stefano Siboni (UNITN)

Nanostructured materials are of interest in different fields of basic research and technology. The project is open to one of the three following themes, according to skills and interests of proposers and candidates:

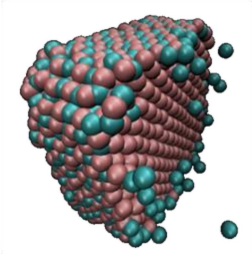
(A) **Mechanical activation of pharmaceutical compounds.**
Research involves high energy grinding of poorly soluble drugs: work is experimental and/or modelling. Grinding process in high energy mills with in-situ observations; characterization by X-ray and optical spectroscopies, electron microscopy; dissolution kinetics, bioactivity, and drug performance.



(B) **Global optimization methods to study nanostructured materials**
Focused on nanocrystalline powders (e.g., advanced metal catalysts), the project is partly experimental (synchrotron rad. facilities), but also involving algorithm development and computer programming to create new procedures of global optimization based on data from different X-ray spectroscopies and electron microscopy to shed light on real nanomaterials



(C) **Big Data in materials science**
Molecular Dynamics (MD) simulations of large systems (millions of atoms) involving large datasets (e.g., coordinates/velocities) and high frequency updates. Test case: kinetics of hydrogen uptake/release in Pd nanocrystals (storage and catalysis studies). Development of algorithms and Big Data handling /modelling procedures. Collaboration and participation in experimental work, with in-situ/ in operando measurements



Please visit: https://www.xrdlab.net/opportunita for details and updates.

2

Nanostructured thermoelectric materials for energy harvesting

P.I.: Nicola Pugno (UNITN), Paolo Scardi (UNITN)

Participants: Mirco D'Incau (UNITN)

Thermoelectric (TE) materials can convert heat into electricity and vice versa, based on two well-known effects, the Seebeck and the Peltier effect, respectively. Until recently TE devices were mostly used the latter purpose, e.g., for efficient cooling systems in instruments, and in temperature measurements. The use of TE materials for direct conversion of heat to electricity is also known since a long time, but

applications to energy production have strongly been limited by the low figure-of-merit (ZT = (S2σ/κ)T , with S as the Seebeck constant, σ electrical conductivity, κ thermal conductivity and T as the temperature) achieved so far. In fact, for most materials investigated until two decades ago, increasing the σ/κ ratio means pursuing conflicting requirements (for example, in most metals $\sigma \propto \kappa$).
Modern nanotechnology, in the past two decades, had a deep and positive impact on thermoelectrics, contributing with new, advanced materials with enhanced TE behaviour. Current research focusses increasingly more on semiconducting nanostructured materials, which exhibit high figures of merit. However, the quest for best TE materials is just started, opening a wide and promising research area on materials and processing, but also on the design of devices. The present PhD project is based on three especially convenient conditions provided by DICAM: (i) solid competences on materials for energy, and in particular, top-down approach to nanomaterials by mechanical grinding (e.g., planetary ball milling), which is considered one of the most efficient, easily scalable and low-cost technology for TE materials production; (ii) advanced skills in the design, and in particular in metamaterials, which might be the key to produce most efficient devices for energy harvesting; (iii) growing interest and already existing support in simulations and atomic-scale modelling. The project can benefit of a broad network of collaborations with laboratories and research centres all over the world, for a cutting-edge scientific research which aims at qualified scientific production with also a goal in the development of energy devices for tomorrow's technology.
Ideal candidates should have a solid background in science and technology, specific interest in developing materials (thus being active part in laboratory practices in materials production and characterization), but also be available to promote and/or participate in modelling, simulations and design of materials and devices. A degree in Engineering (industrial area) or Physics is the most appropriate pre-requisite.

Curriculum C: Modelling and Simulation

1

Modeling of hydro-chemo-mechanical behavior of clay soils for prediction of landslide displacements

P.I.: Alessandro Gajo (UNITN)

Participants: Lucia Simeoni (UNITN)

The change of chemical composition of pore water of active clays triggers water adsorption/desorption and ion exchange, both affecting the hydraulic and mechanical characteristics of soils. For instance, this process can occur in landslides with clayey soils deposited in a marine environment and currently subjected to infiltration of rain water. This process causes the reduction of shear strength and then the acceleration of the landslides. In contrast, the use of salt piles triggers an ion exchange with the effect of increasing the shear strength and reducing the rate of movement. These situations are typical of many unstable slopes of the Apennines. More generally, the chemo-mechanical coupling phenomena find application in many other engineering problems, such as soil pollution/decontamination and the improvement of mechanical properties of soils (eg. Electro-osmosis).

The research project will be based on laboratory tests, on the definition of an appropriate constitutive model, on numerical analyses with finite element codes, and finally on the interpretation of site measurements for model validation and application to real cases. The experimental and theoretical analyses will mostly concern the laboratory and site testing data obtained on the landslide of Costa della Gaveta in Basilicata (Southern Italy), where some salt piles are currently being built for stabilizing a landslide. The research will concern also the chemo-mechanical interactions affecting the viscous component of the residual shear strength. To this aim, laboratory tests will be performed for the definition of an appropriate constitutive model that will be applied to the analysis of the displacement evolution of very large, extremely slow landslides, such as those located in the Alpine glacial valleys (e.g. Valle dell'Isarco, Northern Italy).
The research is part of the project of national importance PRIN2015 "MONITORING AND INNOVATIVE STRATEGIES FOR SUSTAINABLE DESIGN LANDSLIDE RISK MITIGATION". It is therefore provided a 50% co-financing, provided within the reportable 31.01.2020.

Conference and peer-reviewed journal papers will be the major outcome of this research project.

2

New high order accurate semi-implicit finite element schemes on staggered polymorphic unstructured space-time meshes

P.I.: Michael Dumbser (UNITN)

The research topic concerns the development of new high order accurate semi-implicit discontinuous Galerkin finite element methods on general staggered unstructured meshes. The aim is to extend an existing family of schemes, which is currently available on unstructured simplex meshes (triangles and tetrahedra) and on non-conforming space-time adaptive Cartesian grids (AMR) to a much more general class of schemes that is able to run also on mixed element (polymorphic) unstructured meshes for example composed of general hexahedra, prisms, pyramids and tetrahedra, and even general polyhedra, as well as on moving non-conforming unstructured meshes. Moving non-conforming meshes will naturally lead to polymorphic space-time control volumes.
To test and validate the algorithms, the methods will be implemented on massively parallel distributed memory supercomputers for the discretization of some of the following PDE systems, with focus on computational fluid dynamics (CFD) in complex domains: compressible and the incompressible Navier-Stokes equations as well as the shallow water equations. More specifically, the methods should be applied to hydrostatic and non-hydrostatic (dispersive) free surface flows, meteorological flows and viscous compressible and incompressible flows in moving domains.
We expect several publications in leading international journals of the fields of scientific computing, applied mathematics and computational physics.

3

Mechanical modelling for the nonlinear behaviour of materials and structures

P.I.: Davide Bigoni (UNITN), Francesco Dal Corso (UNITN), Luca Deseri (UNITN)

Participants: Kaushik Dayal (Carnegie Mellon University), Massimiliano Fraldi (Federico II, Napoli)

Nonlinear modelling of materials and structures undergoing either large strains or large displacements is a fundamental step towards the design of innovative devices for advanced applications. This occurs in micro- and nano-mechanics, such as in stretchable electronics, cable deployment, nanotube serpentines, flexible actuators and sensors, vibration absorbers, self-oscillating systems, nanostructured materials under dynamic loading for impact and blast protection, composite functional materials for high-temperature sensors and actuators for hypersonic aircrafts. This also arises in biological systems such as biomembranes and cells, as well as during drug transport across biological membranes, electron transport in deformed biomolecules under stress, etc. Possible non-local behavior will be analyzed through suitable novel peridynamics models (see Dayal, 2017).

Following nonlinear coupled electromechanical effects analyzed in (Finkenauer et al., 2014) and (Cugno et al., 2017), and recent discoveries of intriguing phenomena like the action of configurational forces on elastic structures (Bigoni et al., 2015), the elastica catapult (Armanini et al., 2017), the asymptotic self-restabilization of structures (Bosi et al., 2016), the analysis of nonlinear structural systems will be developed in order to design a new generation of innovative devices with tailored force-displacement behavior, such as special high-dissipation seatbelts or "buckling actuators".

New types of coiling and uncoiling processes for elastic strips will be modeled and the related snap conditions parametrically investigated in order to optimize the energy storage/release and the launch conditions of possible attached mass. The same problem may be analyzed in the presence of electromechanical coupling. Within a nonlinear framework, where non-unique equilibrium configurations can be detected, the cases of largely overloaded strips and of long strips will be considered.

The novel behavior of a stable trivial equilibrium path after buckling (namely, a pitchfork instability) will be investigated for soft systems. This feature, so far obtained only in an asymptotic sense (Bosi et al., 2015), could be attained by introducing compliant movable constraints or the confinement of transversal displacement in deformed configurations. Analog studies may be performed in the presence of electromechanical coupling and also for active systems, like lipid bilayers and monolayers (see e.g. Deseri et a., 2016), and other kinds of microstructures.

The research activity will be theoretical, computational and experimental. The equilibrium configurations will be analytically identified through variational approach and by solving the nonlinear equation of the elastica. Specific behaviour will be experimentally proven on prototypes of material and structural systems.

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4

Computational homogenization of composite materials and heterogeneous structures accounting for higher order effects

P.I.: Andrea Piccolroaz (UNITN)

Participants: Davide Bigoni (UNITN)

Local constitutive models are unsuitable for the description of composite materials when the size of the sample is comparable with the characteristic length of the microstructure or when large strain are present. Therefore, non-local constitutive models, also known as generalised continua, are necessary, in order to capture size-effects and thus to correctly describe stress and strain fields in the vicinity of cracks, inclusions and other material defects [1,2]. However, the constitutive properties of the homogenised effective material have to be found either from experimental testing or from analytical solutions. On one hand, experimental tests revealing higher-order effects are very difficult to realise [3]. This is due to the fact that experiments have to be conducted on extremely small samples, having dimensions of the same order of the characteristic length of the microstructure. On the other hand, analytic solutions for the high order homogenization of heterogeneous materials are very few and mostly for diluted composites [4]. An alternative approach is the so-called computational homogenization [5]. This approach is based on the use of numerical techniques, usually the finite element method, in order to solve the boundary value problem at the microscale and thus obtain the effective properties by the averaging procedure applied on the representative volume element. This approach proved to be very effective for the first-order homogenization but it is not quite developed for higher-order homogenization. This project aims at the development of computational homogenization methods for composite materials accounting for higher order effects. Two distinct approaches will be explored. The first one is the static (or quasi-static) approach, where a quasi-static loading is applied to the RVE and the corresponding boundary value problem is solved numerically. The effective properties are then found by an averaging procedure. The second approach is the dynamic approach, where an elastic wave is excited in the material and the dispersion equation is found

by numerically solving the corresponding boundary value problem with quasi-periodic boundary conditions. The effective properties can be found by matching the first and second order asymptotic terms of the dispersion curve of the heterogeneous structure with those of the effective generalised continuum. For both the static and the dynamic approaches, the finite element implementation of the effective generalized medium is a necessary task that will be accomplished within the project. The techniques developed in this project will be used for the implementation of a computational multiscale approach, also known as the FE2 method. The FE2 method [6] is a nested finite element method framework that simultaneously analyses microstructure and macrostructure. The FE2 implementation will provide a tool for the prediction of the global response of microstructured heterogeneous materials by employing micromechanical models and transferring the microscale information to the macroscale analysis.

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5 *(ref. C1- for topic of reserved scholarships)*

Design, simulation and testing of smart metamaterials/metastructures for vibration mitigation of civil/mechanical systems

P.I.: Oreste S. Bursi (UNITN)

The candidate will deal with novel concepts of periodic metamaterials/metastructures for the vibration mitigation of large structures like nuclear power plants or broad tanks of petrochemical plants subjected to both seismic shear and/or Rayleigh waves. More precisely, novel smart foundations will be designed based on metastructure concepts for vibration mitigation of seismic waves including their vertical components. In addition, and with regard to vibrations due to the impulsive components of the contained fluid, new tanks will be conceived with novel periodic smart foundations endowed with resonators. Moreover, tanks can also be treated as resonating systems by themselves. These novel design concepts will also be explored for other examples of important symmetric structures, like the tanks used in regasification stations.

Emphasis will also be given to laboratory testing of prototypes through dynamic actuators and/or shaking tables.

The outcome of the research activity will consist in journal papers and prototype isolation devices.

6 *(ref. C2 - for topic of reserved scholarships)*

Modelling and simulation of novel opto-acoustic sensors for monitoring crack growth in pressure vessel steels

P.I.: Oreste S. Bursi (UNITN), Daniele Zonta (UNITN), Maurizio Ferrari (CNR-IFN, Istituto di Fotonica e Nanotecnologie - Trento)

Progress in nanofabrication recently enabled to design micro- and nanomechanical sensors whose geometry can be coupled to electromagnetic fields. Given the enormous optical control that has been achieved for atomic systems, this led to signicant interests in using light to manipulate and control macroscopic mechanical objects. This stimulated the field of optomechanics that by now has evolved into a fast developing area of research at the intersection between nanophysics and quantum optics. In particular, the presence of thermal fields and the limited dimensions of sensors renders their modelling and the relevant identification of coupled deformable materials and photonic crystals quite challenging. Therefore, it is planned to join the theoretical/experimental expertise of physicists with the Finite Element modelling and identification capabilities of mechanical engineers.
Within the aforementioned framework, the candidate should carry out numerical work in order to both model and simulate the dynamic behaviour of opto-acoustic sensors made of deformable materials coupled to photonic crystals. A testing phase of the sensors is also planned by monitoring crack growths in pressure vessel steels.
The outcome of the research activity will consist in journal papers and prototype sensors.

7

Mechanics of Biofunctionalised Electroconducting Microfibres for the Treatment of Spinal Cord Injury

P.I.: Nicola M. Pugno (UNITN)

Participants: Maria Fiorella Pantano (UNITN)

Bio-electronic microsystems hold promise for repairing the damaged central nervous system (CNS). However, this potential has not been developed because their implantation inflicts additional neural injury, and ensuing inflammation and fibrosis compromise device functionality. In Neurofibres we want to achieve a breakthrough in "Neuroregenerative Bio-electronics", developing dual-function devices that will serve as electroactive scaffolds for CNS regeneration and neural circuit activation. We engineered electroconducting microfibres (MFs) that add negligible tissue insult while promoting guided cell migration and axonal regeneration in rodents with spinal cord injury (SCI). The MFs also meet the challenge of probe miniaturisation and biofunctionalisation for ultrasensitive recording and stimulation of neural activity. An interdisciplinary consortium composed of neuroscientists, medical specialists, researchers in biomaterials, protein engineering, physics, and electrical and mechanical engineering, together with a company specialised in fabrication of

microcables and microconnectors, will join efforts to design, develop, and test the MFs and complementary technology (microfibre functionalisation, assembling, and electronic interconnection), in order to produce a biologically safe and effective bio-electronic system for the treatment of SCI. This goal will be achieved through five specific objectives: 1) To improve the electrical conductivity, strength, and chemical stability of the microfibres. 2) To develop electro-responsive engineered affibodies for microfibre functionalisation. 3) To develop the technology for MF interconnection and assembling into implantable systems. 4) To perform comprehensive investigation of the immunological, glial, neuronal, and connective tissue responses to the implanted MFs and applied electrostimulation in rodent and swine SCI models. 5) To investigate the motor and sensory effects of microfibre implantation and electrostimulation.
The aim of this phd will be the focus on point 1 of this Neurofibres project (financed by EU), mainly on all the issues related to mechanics, such as the strength of scaffold and MF, their composite coating and anchorages and the modelling such as the cellular growth and scaffold degradation, etc.

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8

Non-linear analysis of multi-material complex structural systems in presence of local and global damage phenomena

P.I.: Riccardo Zandonini (UNITN), Nadia Baldassino (UNITN)

The recent developments in the field of material and structural engineering are associated with constant innovations both in the hybrid use of materials and in the construction forms. This trend progresses in the framework of an increased perception of the environmental effects arising from construction activities. A new concept of efficiency (i.e. structural efficiency, constructional efficiency, energy efficiency, management efficiency…) can be supported by a design process combining new potential of numerical and experimental analysis. Among interesting forms of constructions, which are taking advantage of such a trend, an increasing role is played by light residential buildings in cold formed steel (CFS). The traditional design of these buildings is able to tackle a limited number of structural solutions on the basis of available experimental data. The use of experimental data is required (and allowed by the codes) due to the importance of phenomena such as buckling (local and overall) and the response of joints in cold formed members. Some recent developments do have the ambitious goals of using a holistic concept of the building response where the sheathing as well as the floor decks are optimised in order to get the best performance (even in seismic regions). The challenge is to develop numerical tools capable of accounting for all the behavioural effects.
In order to get a better picture of the complexity of the novel form of light gauge buildings a short description of the main components and related issues is here provided.
Shear walls and flooring systems are the main components. The shear walls, which

transfer to the foundations the vertical loads of the flooring systems and the horizontal forces due to wind and earthquake, are built-up with steel studs located at regular intervals and bottom and top chords. The task to transfer the horizontal forces is entrusted to bracing systems and to the sheathing which can be realized with different materials (OSB, fiber board, gypsum, steel sheathing,….). Connections with self-drilling screws and rivets are typically used with all the problems related to the bearing response. The flooring systems are built-up as a series of steel beam completed by a 'wet' or 'dry' diaphragm. The use of different materials, generally in hybrid solutions, is making the problem particularly complex.
Such a complexity has being clearly pointed out by some recent researches in North America and Europe.
The outcomes stress as well the need of accurate numerical tools adequate to search for optimal solutions in terms of the 3D steel framing and of the materials for sheathings and diaphragms.
The research would focus on the numerical analysis of CFS structural systems and it will take advantage from some experimental tests aimed at making all different issues surfacing from the local to the global scale. These tests will enable validation, also at different scale, of the numerical models proposed. The results of the study will be published in International ISI journals.

9 *(ref. C3 - for topic of reserved scholarships – PIRELLI TYRE S.p.A scholarship)*

Friction forces between patterned surfaces

P.I.: Nicola M. Pugno (UNITN),

Participants: Ugo Tartaglino (PIRELLI TYRE S.p.A)

We want to study the effects of patterned surfaces on the sliding and rolling friction properties of elastic materials. Friction is governed by simple physical laws, already well known in classical mechanics, however the resulting force on a macroscopic scale is the sum of multiple interactions that take place at different length scales: from the interatomic potentials to the adhesion effects at molecular level, up to surface roughness and elastic or plastic deformation effects of contact points. The modeling of these multiscale interactions for specific materials, e.g. rubber, is still an open problem in the tribology community.
The issue is further complicated when surface patterning is present, which introduces further degrees of freedom. Thus, we aim to study the effect on global friction forces of a structured surface with hierarchical architecture, similar to those observed in Nature. Such topic is interesting form a scientific point of view, but is also promising, since it might support the design and manufacturing of patterned surfaces tailored for industrial applications.
However, it is not simple to model these systems numerically starting from the microscopic scale, both for the theoretical complexity and the computational costs of simulations. For this reason it is often more useful to employ simplified models that reproduce the behavior of the material at each scale, in order to understand the influence of the different parameters in play on the system's overall system properties.
The research activity aims to develop appropriate numerical codes to simulate sliding and rolling friction of deformable rubber-like or composite materials with

hierarchical surface patterning. The codes will be 1-D and 2D to capture realistic the effect of 2D patterns. Additionally, the influence of wear and thermal effects will be investigated. In particular, we aim to define optimal patterning solutions to achieve tailor made frictional properties, e.g. minimal rolling friction and simultaneously maximum sliding friction.

Depending on the results obtained, we may consider some experimental measurements of friction forces between rubber and patterned, rough substrates.

10 (ref. C4 - *for topic of reserved scholarships – Adige-SYS Spa scholarship*)

Laser-Beam Cutting Modeling and Testing for Improved Quality and High-Demanding Structural Applications

P.I.: Oreste S. Bursi (UNITN), Paolo Scardi (UNITN)

Laser cutting represents a modern and effective technology able to complement and/or replace well-established mechanical and thermal processes. Hence, the cutting of metallic materials as an intermediate stage of processing is of vital importance in the industrial production process. As a result, time, cost and quality of these phases greatly impact on further processing and, thus, the overall labor cost. While exhibiting undoubted technical/practical benefits, this technique has not yet been fully explored. Hence, the tuning of process parameters that define the cutting quality, both from a geometrical and a metallurgical viewpoint, are still the subject of depth study and of strong interest, especially in the field of structural steels subjected to high-cycle fatigue. There, mechanical property requirements, especially versus fatigue problems and high strength steels, as highlighted by Eurocode 3 Part 1-9 and Part 1-12, demand a thorough study on the modifications induced by laser process on structural steels widely used in construction.
On this basis, in order to optimize typical process parameters, the candidate has to carry out a series of standard and advanced tests on both materials and structural joints as well as finite element (FE) analyses mainly at the material level. Both the thorough study of the effects of laser cutting process of structural steels and the improvement of the elated problems, in particular the main issues related to fatigue will allow the use of these structural materials and relevant laser cutting techniques on a larger scale.
The outcome of the research activity will consist in technical reports and journal papers.

Curriculum D: Architecture and Planning, Landscape

1 (ref. D1 - *for topic of reserved scholarships)*

A new model for a comprehensive comfort assessment methodology in buildings based on pre and post design procedure

P.I.: Rossano Albatici (UNITN)

The research project concerns the definition of a new integrated system for the

evaluation and classification of indoor human comfort. Starting from the indexes commonly used and included in current standards (PMV and PPD for thermal comfort, daylight factor for visual comfort and so on) new weights will be given in order to better take into consideration some parameters such as, for example, destination of use, type of users, relationship with external environment. Moreover, the characteristics of the building elements and components that have a direct influence on human comfort will be defined and studied (considering in detail some practical examples), in order to propose a new model for comfort evaluation a-priori based on materials, component and solution provided during the first stage of the design process.
The research will be also practically developed with an evaluation process in situ on three real scale buildings with same shape, exposure and use but with different structural material (concrete, brick block masonry and timber X-Lam walls) and envelope elements (green roof vs traditional roof, ventilated façade vs superinsulated façade and so on).
An integrated monitoring system will be developed, based on questionnaires (longitudinal and transversal), spot measurement of comfort parameters and long term continuous monitoring by means of a building automation system. A post occupancy evaluation will also be performed.
Main outcomes:
1. Definition and realization of a new integrated system for the evaluation and classification of indoor human comfort
2. Definition and realization of a new comprehensive procedure for the monitoring of human comfort conditions in buildings
3. Design guidelines for a proper choice and installation of building materials and elements taking into account not only their energy performance but also their impact on users comfort on a wide and integrated scale, properly evaluated apriori by means of a new methodology
4. Papers on international journal and participation to conferences

2

Towards a circular architecture: smart modular building system in a district perspective

P.I.: Rossano Albatici (UNITN)

Participants: Michela Dalprà (UNITN)

The energy issue is central in human history and can be taken as an important guideline to understand the development of civilizations and relevant social changes. The post-industrial society is nowadays facing a condition in which the limitation of traditional energy sources and the contemporary development of sustainable ones is fostering the awareness that novel development strategies and paradigms are necessary. This picture requires a new typology of buildings which is based on a new way to imagine and think the buildings themselves: an architecture that changes and adapts itself to all the powerful necessities of the human being.
In this respect, the present Project aims at setting an approach to the design of housing building structures integrated with productive activities. In view of sustainability criteria, the scaling up of the approach to district (integration of a set of housing-production structures), environment, infrastructures and infrastructural

functions (transportation, good exchange), relevant socio-economical aspects will be considered.
The main output of the Project will be the design of a versatile building module, conceived like "box" which could be composed and decomposed according to the needs of each individual and of the communities. These boxes are the shell of contents based on customized needs, mainly living modules, offices and productive activities. The prefabricated modules will be easy to be built, added, removed or customized. They are both fast to build, comfortable and highly energy efficient (based mainly on electrical energy from renewables).
The modules must have zero-impact on the environment. Starting from the contemporary economics theme of the "cradle to cradle", each module will be studied throughout its vital cycle, from born to death, and after death, making it completely invisible to the environment in each step.

Main outcomes:
1. Definition of a novel approach for the design of modular adaptive buildings
2. Scaling up of the approach to district, environment, infrastructures and infrastructural functions
3. Sankey diagram of the overall system building-district-environment in a perspective of cycle design
4. Papers on international journal and participation to conferences

3

MILITARY LANDSCAPES. FUTURE FOR MILITARY HERITAGE

P.I.: Battaino Claudia (UNITN), Quendolo Alessandra (UNITN)

Research status quo.
For many years, the War has become a subject of great interest for an ever-greater number of persons and bodies. This interest goes hand-in-hand with a cultural climate characterised by numerous initiatives that have slowly contributed towards the understanding that the "vestiges" of the Great War but also of others conflicts represent cultural artefacts to be safeguarded and treasured. Various questions have emerged in this period as regards the destiny of a cultural heritage and of works that are both so vast as to make a full and considered evaluation necessary. Moreover, this evaluation has gradually begun to involve many different disciplines, thereby bringing to the fore the need for a dialogue between various "approaches" to architecture, territory, and landscape so that we may understand how the value of such works lies in the testimony they can and must represent for our own present.
Reference to a system of relations seems to emerge from the pulsing heart of this word; a system whose coordinates and meanings are to be sought on various material and immaterial scales or dimensions: the dimension of the single structure (the fort, barrack, etc.) abandoned or totally derelict among rubble and ruined by the degradation wrought in its turn by man's and nature's violence; the territorial dimension, where the various types of vestiges form a defensive system that had a profound impact upon the identification of the territory itself and the dimension of the possibility of a memory with respect to the concrete presence of objects from the past.
The prospect of a new wave of decommissioning brings the challenges of converting

this particularly vulnerable category of architecture and sites to the forefront of the debate. With this in mind, our interdisciplinary event will share case studies; investigate significant experiences of analysis of military landscapes; establish protocols for the conservation, surveillance and maintenance of heritage sites, and propose strategies for restoration and reconversion for civil uses (e.g. residential, social, cultural, productive, touristic), focusing particularly on examples inspired by aims of social integration, reconciliation and public use.

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Key words: Military landscapes, Memoryscapes, Heritage values

1. Topic: Knowledge, analysis and representation

The forts only represent a part of the complex system connoted by vestiges of the Great War. When understood as a defensive system, such vestiges become a coordinated and reciprocally functional set of artificial elements constructed in response to the morphological characteristics of the territory and connected to various communication routes: in other words, a general, militarised pan-territorial system modifying the territory to build permanent fortifications, excavating and digging trenches, shelters in caves, galleries and tunnels, and also designing transport and military service works and infrastructures such as railways, military roads and mule tracks.

2. Topic: Networks of military sites

The reference to the territorial system denotes the knowledge that such vestiges must be understood as a "mosaic", a metaphor for a system comprising fragments characterised by a relationship of reciprocal coherence. Consequently, safeguarding and cultural deployment should not only address single, isolated artefacts but the whole context within which the traces of the memory are deposited; because respect for the context also implies paying due attention to the landscape as also to the tutelage and respect for the environment in the widest sense.

3.Topic: Strategies for protection and cultural enhancement

The themes of memory and the transmission of testimony acquire ever-greater complexity in relation to the "sense" of this particular heritage. Critical, too, is the level of economic compatibility between the protection and enhancement of military landscapes. This aspect is particularly urgent in the context of the current international economic crisis.

Research Outputs

Defining case studies and theoretical developments on the topic of reconversion and civil use, both public and private, in relation to the existing methods for protection at various scales. In detail, the research investigates architectural and spatial values and the way they may establish new connections with the related landscape, between memories and new identities.

The expected research outcomes are papers and books, International Conference.

4

THE SUSTAINABLE REGENERATION OF MINOR HISTORIC CENTRES

P.I.: Maria Paola Gatti (UNITN)

Participants: Giorgio Cacciaguerra (UNITN)

The consumption of land for the construction of new buildings, with the utilisation of materials and energy is ongoing. The abandonment of old structures that accelerates the physical and social degradation of historic urban and peripheral areas is ongoing as also the critical condition of real estate assets built before 1971 with respect to such functional parameters as comfort, technology, energy and structural safety.
The historic centres of medium to small townships continue to remain abandoned. Regeneration has been attempted through a superficial knowledge of the places and their extant assets, and to a complex and heterogeneous body of law and significant financing.
Commencing from these premises, a thematic proposal is advanced here for the institution of a Ph.D. scholarship for the purpose of defining an integrated action programme in order to systematically set out and make plans for potential uses, for local resources and for the initiatives of entrepreneurial subjects supported by public resources made available pursuant to sector laws addressing urban restoration, the rehabilitation of historic places, the renewal of areas with commercial potential, culture, transport systems, healthcare and overall modernisation.
The Ph.D. project proposes an accurate analysis of the current body of laws that lay down protective constraints, and of laws proposing innovative measures, in order to define new regulations or solutions to deal with the innumerable and often complex problems of "historic centres" by making use of pre-existent or recently introduced regulations and juridical institutions, and also by drawing on such mainstream concepts as "rehabilitation", "restoration", "revitalisation" or "regeneration" of the extent heritage. The social, functional, technological and economic-financial ascertainment constitutes one of the innovative elements of this proposal for defining and organising public policies for establishing fundamental objectives for the restoration of historic townships.
In order to achieve the sustainable regeneration of "minor" historical centres, it is necessary to define the measures for rehabilitating real estate assets in relation to protective constraints, according to an integrated compositional and technical-performative approach, that also includes economic-financial feasibility, together with proposals for improving administrative procedures, all of which grounded in the knowledge of single buildings, the entire township and the territory.
The conservation and regeneration of the extant built heritage constitute the main scenario in Italy for architectural design in the coming decades. This will be determined by exigencies of environmental and economic sustainability, and especially the present limits reached by the consumption of land and the nature and incidence of seismic and hydro-geological risk.
The awareness of such a scenario requires that the project brings together several disciplinary skills in order to rationalise the solution for current emergencies, with special reference to historic centres, above all the minor and isolated centres throughout the national territory. From this point of view, the measures on the extant built heritage are in line with the international strategic objectives of the smart regeneration (SS3, Horizon2020).
Cultural heritage appears to be a cross-the- board theme involving studies in a

number of different areas: "Materials-based solutions for the protection or preservation of European cultural heritage" and "Energy strategies and solutions for deep renovation of historic buildings".
The request for policies to give leverage to and conserve the extant heritage characterises the programmes of various international and national bodies. Taking advantage of European indications, project-based research is a possible answer for advancing proposals for conservation and modernisation sustained by knowledge so as to determine appropriate techniques and methodologies of intervention.
It should also be noted that the drawing up of a national plan of action to be implemented for prevention measures throughout the territory (soil stabilisation, upgrading infrastructures, etc.) and on buildings (guidelines for seismic prevention, etc.) would be a path rife with difficulties.
Moreover, it is more than ever appropriate to analyse planned and scheduled actions that were not implemented, notwithstanding the availability of considerable financial resources (which, moreover, could be used to promote other actions).
Such executive difficulties are very often linked to an intricate system of constraints, to cumbersome procedures, and to the limited participation of private initiatives in partnership schemes and, consequently, disjointed or superficial planning. Therefore, the need emerges to develop an operating methodology that effectively leads to "systematic" and overall planning for redevelopment and conservation measures on the extant heritage on both a territorial and a single-building scale.
It should also be noted that decree 15/10/2015 "Measures for the social and cultural redevelopment of degraded urban areas", made provision for the approval of a call for tender defining the arrangements and procedure for municipalities to submit redevelopment projects comprising a coordinated set of measures oriented to a reduction in phenomena of marginalisation and social degradation as well as an improvement in the quality of urban décor and of the social and environmental fabric. This measure envisages financing for just under 200 million but it will be hard to implement on account of the lack of projects to remedy degraded contexts.
The operational difficulty is compounded by the failure to approve legislative measures; for many years, the legislative proposal "Measures for redeveloping and leveraging historic centres and towns" has vainly sought parliamentary approval.
Notwithstanding the ample experimentation hitherto put in place, the numerous national research projects do not always address the question from an interdisciplinary viewpoint, that would be quite feasible for the territory and which would also include economic redevelopment, improvements in administrative procedures, contextual studies, etc.
Moreover, it should be noted that many research projects still posit cataloguing as the basis for giving leverage to historic centres and this has led us to draw up a large variety of disparate proposals that can only be implemented with great difficulty, thus hindering the proposal of overall redevelopment actions: social, economic, town-planning, architectural, functional, etc.