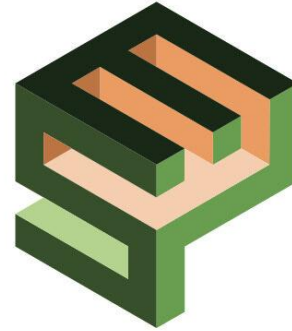




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SPM³
RESEARCH
GROUP

SPM³ Research Group: “Structural Performance Management, Modelling and Monitoring”

01/09/2025

AFFILIATION

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RESEARCH AREAS

- **Structural Health Monitoring (SHM):**
 - InSAR satellite based SHM
 - Smart sensing and edge computing
 - UAV-vision-based SHM
 - Crowdsensing and drive-by SHM
- **Digital tools for Bridge Integrity Management**
 - Digital Twinning
 - Machine Learning techniques
 - Value of Information from SHM
- **Resilience of transport infrastructure**
 - Flood monitoring and emergency management
 - Standardization

THE SPM₃ TEAM





Sustainability And
Resilience for Infrastructure
and Logistics networks



RETURN: multi-Risk sciEnce for
resilienT commUnities under a
changinG climate



George Karagiannakis
Postdoctoral Fellow



Pier Francesco Giordano
Assistant professor



Nilgün Merve Çağlar
MSCA Postdoctoral Fellow

In the project **SARIL (HORIZON-CL5-2022-D6-02-07)**, we are developing a risk-based decision support tool to manage emergency situations of the transport infrastructure in the Mantua region under a combined flood and cyber attack to the SHM system.

In the project **ERIES_SCOUR&SHAKE (HORIZON-INFRA-2021-SERV-01-07)** that we coordinate, we investigate the performance of scoured bridges under dynamic excitations. Dynamic tests will be carried out on a scaled bridge model in the healthy (pre-scour) state and in several scoured configurations, and after repair with inexpensive remedial measures. The experimental model will be entirely built at the laboratories of the University of Bristol (United Kingdom) where it will be tested.

The national project **RETURN (PNRR 2022-2024. Piano Nazionale di Ripresa e Resilienza)** involves a network of 26 national partners (universities, research institutions, local authorities, the national Department of Civil Protection, industrial companies). We are involved in several research activities. One of these is the development of an SHM-based tool to enhance resilience management of flood events.



Cost Action TU1406:

Quality specifications for roadway bridges,
standardization at a European level



CSLLPP. Assessment of the Guidelines for
risk management and monitoring of bridges



Pier Francesco Giordano
Assistant professor



Giancarlo Costa
PhD student



Saman Jamshidi
Research Fellow

COST Action TU1406: Quality specifications for roadway bridges, standardization at a European level. This project, active in the period 2015-2019, brought together for the first time both research and practicing communities to accelerate the establishment of a European harmonized guideline on the project topic. The project developed new indicators related to sustainable and economic performance of roadway bridges.

In the **national project: CSLLPP-RELUIS**, we are working on methods and tools for the acquisition of information to support bridge management systems. A large effort is being devoted to the analysis and comparison of the current guidelines and technical documents enforced in different countries with the aim of identifying differences and similarities toward the harmonization of practices. Another important topic of the project is SHM standardization to facilitate the achievement of consensus among stakeholders and build confidence and trust in this technology.



RETURN: multi-Risk sciEnce
for resilienT commUnities
undeR a changiNg climate



Monitoring and satellite data



Marie Curie Industrial Doctoral Network BRIDGITISE
"Bridge Digitalised Lifecycle Management"



Pier Francesco Giordano
Assistant professor



Othmane Lasri
PhD student

In the national project **Monitoring and satellite data (ReLUIS)**, we are developing techniques and operational protocols for the integration of InSAR with on-site monitoring information about structural conditions. Several structural types are considered: bridges, buildings, large infrastructures, and heritage structures. The protocols aim to support condition assessment and to provide information about potential criticalities due to extreme events such as landslides, floods, and earthquakes,

The project **BRIDGITISE "Bridge Digitalised Lifecycle Management"** (HORIZON-MSCA-2022-DN-01) is a Marie Curie Industrial Doctoral Network that we coordinate. BRIDGITISE is the first EU Industrial Doctorate program dedicated to the integration of digital technologies in Bridge Integrity Management. The PhD project SATELLITE uses InSAR data to detect performance anomalies through outlier detection accounting for the environmental variability.

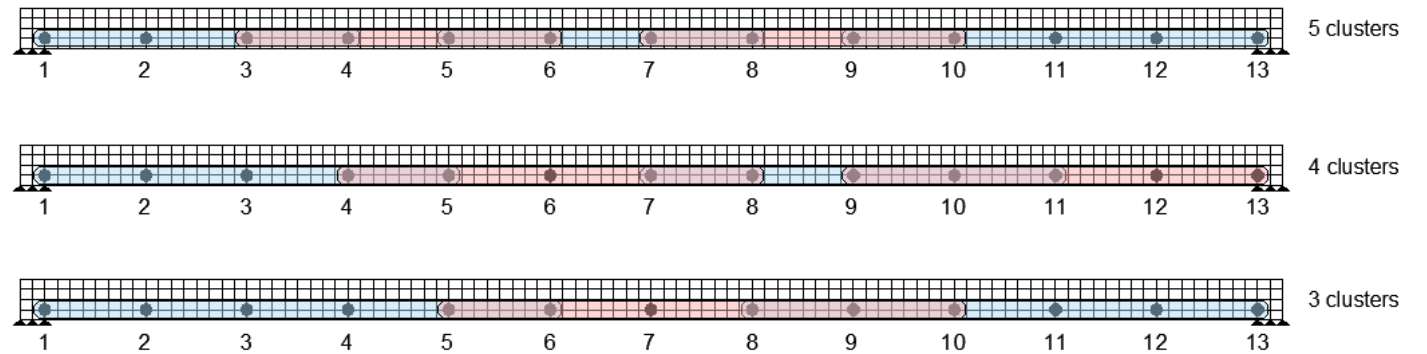
The national project **RETURN (PNRR 2022-2024. Piano Nazionale di Ripresa e Resilienza)** involves a network of 26 national partners (universities, research institutions, local authorities, the national Department of Civil Protection, industrial companies. We are involved in several research activities. One of these is the use of open-source data (European Ground Motion System) for bridge condition assessment.



CSLLPP. Assessment of the Guidelines for risk management and monitoring of bridges



Pier Francesco Giordano
Assistant professor



In the context of the national project **Assessment of the Guidelines for risk management and monitoring of bridges (ReLUIS)**, we are developing a decision support tool for the design of network architectures of edge computing sensors, optimized for damage detection in terms of reduction of volumes of transmitted data. Existing approaches for damage detection and localization will be updated and tailored to the new sensors' architectures, aiming to reduce energy consumption through the minimization of data transmission, enabled by sensors endowed with onboard computing capability.



HORUS: Holistic On-demand
Remote Unmanned Sensing



Pier Francesco Giordano
Assistant professor



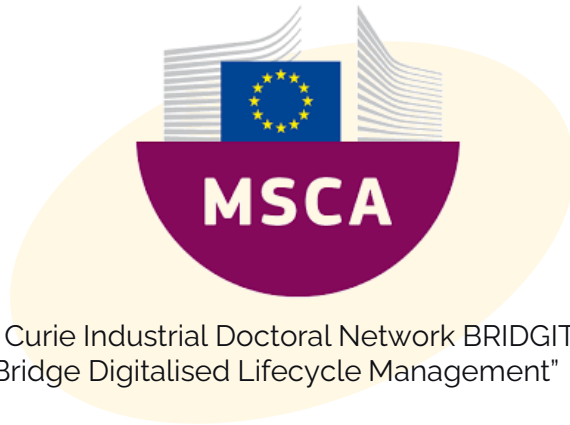
Tommaso Panigati
PhD student

The national project **HORUS (PRIN 2022 PNRR - Part of the Next Generation EU programme)** that we coordinate develops a set of modular sensing devices brought to targeted structures by swarms of drones on-demand. An evolution from fixed traditional monitoring systems, to scalable, adaptable, and connected Holistic On-demand Remote Unmanned Sensing system.

HORUS will create a human-centered cyber-physical world, where engineers will be able to perform offsite visual and tactile virtual-reality inspections of the structures using data collected by the drone swarms. Offsite and processed by AI algorithms to extract from data actionable information.

An intelligent decision support system will be developed to organize the swarms of drones, optimize data collection and optimally select the asset management strategy.

This mobile monitoring setup, integrated with high-performance data transmission capability, will empower human decision-makers to control and manage their infrastructure asset optimally, safely, and promptly.



Marie Curie Industrial Doctoral Network BRIDGITISE
"Bridge Digitalised Lifecycle Management"



Pier Francesco Giordano
Assistant professor

The project **BRIDGITISE "Bridge Digitalised Lifecycle Management"** (HORIZON-MSCA-2022-DN-01) is a Marie Curie Industrial Doctoral Network that we coordinate. BRIDGITISE is the first EU Industrial Doctorate dedicated to the integration of digital technologies in Bridge Integrity Management.

The CROWD project will exploit the large sets of monitoring information collected through crowdsensing to reduce large-scale monitoring costs and provide, more robust to operational and environmental effects. To this aim, recent advancements in wireless communication and computing technologies, that have propelled the use Internet of Things (IoT) and cloud computing, will be exploited. In collaboration with an Industrial company with expertise in Telecommunications, this PhD project will develop an IoT-supported system identification approach based on crowdsensed data to support: a) the efficient and reliable transmission of the collected data to a cloud unit for processing; b) the impact of the sensors and carriers (humans and/or vehicles) on the collected data; c) the validation of the approaches on real bridges.



Marie Curie Industrial Doctoral
Network BRIDGITISE "Bridge
Digitalised Lifecycle Management"



Eray Temur
PhD student

In the context of the project **BRIDGITISE "Bridge Digitalised Lifecycle Management"** (HORIZON-MSCA-2022-DN-01), the TWIN PhD project will deal with the development of Probabilistic Digital Twin (PDT) models. The PDT, supported by SHM data, will support integrity management through improved modeling of different and possibly interacting deterioration processes. The probabilistic approach will enable the modeling of the multiplicity of possible different and possibly interacting processes contributing to or governing deterioration processes in bridges that deterministic approaches can hardly capture.

The objective of the **industrial PhD project** carried out in collaboration with the industrial company SINA, is the development of Digital Twin models with prognostic capability to support maintenance operations. In the long term, this tool, supported by SHM data, will enable prolonging the structural service life and saving condemned structures through an improved estimation of their load-carrying capacity.

The project will exploit dynamic Bayesian networks for the interpretation of SHM data and for the prediction of deterioration, which eventually will lead to reliability measures.



Marie Curie Industrial Doctoral
Network BRIDGITISE "Bridge
Digitalised Lifecycle
Management"



Eleonora Morleo
PhD student

In the context of the project **BRIDGITISE "Bridge Digitalised Lifecycle Management"** (HORIZON-MSCA-2022-DN-01) the NEURAL PhD project will implement machine learning approaches to leverage large and complete volumes of diverse data for the development of a data-driven metamodels with prognostic capabilities. The outcome of the project will likely be assembled methods combining, e.g., neural networks, support vector machines, and decision trees for deterioration prediction.

In the context of an **industrial PhD project** carried out in collaboration with the company SINA, we will develop a method based to promptly detect anomalies in monitored bridges.

The project will combinations of machine learning algorithms for the interpretation of monitoring data and the identification of deviations from ordinary behavior.

Population-based approaches for the probabilistic characterization of the 'normal' and several diverse damaged conditions will be investigated and validated using the large set of monitored structures managed by the industrial partner.



Cost Action TU1402:
Quantifying the Value of
SHM



MSCA-PF Observation:
Optimization of Seismic SHM
Systems Based on Value of
Information Analysis



Pier Francesco Giordano
Assistant professor



Giancarlo Costa
PhD student



Nilgün Merve Çağlar
MSCA Postdoctoral Fellow

COST Action TU1402: Quantifying the value of SHM. This project was a joint effort of participants from academia and developed a framework to quantify the Value of Information provided by an SHM system, before its deployment.

The SPM3 activity focused on the quantification of the Vol from SHM to support emergency management actions such as restrictions of traffic on bridges and networks of bridges during extreme events.

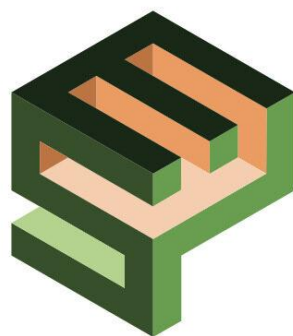
In the context of a **joint PhD project in collaboration with BAM**, we are currently investigating the Value of SHM information to foster innovation in technology development.

The goal of the project **Observation “Optimization of Seismic SHM Systems Based on Value of Information Analysis”** (HORIZON-MSCA-2022-PF-01-01) is the development of a unified decision support tool (DST) for the design of monitoring systems for integrity management of bridges and bridge networks in regions highly prone to seismic activity. The DST will be based on Vol theory and will exploit information about the capacity of the structure gained through SHM data and information about the seismic demand acquired through measurements and state-of-the-art ground motion simulations.

E01: Creation of new tools and cost-efficient security upgrades of urban infrastructures with possibilities of pooling and sharing of complex security systems, taking into account limited budgets of local authorities;

E03: Promotion of best practices, creation of EU sovereign trusted decision support tool/solution and spreading of effective tools and capabilities across entities in different EU territories despite their size and location.

Objective: development of an SHM supported DSS to manage emergencies of the transport infrastructure in the Mantua region under a combined flood and cyber-attack. The tool will be supported by monitoring data from remote sensing (satellite radar) and local sensing (water level sensors). A methodology for anomaly detection will be developed to protect the SHM data management system from cyber-attacks
(Connection to SARIL if Mantua region. Milan peri-urban is feasible. Flexible with the case study)



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