

## Research Group

### Acoustics, Vibration and multisensory Interactions - ACOUVI

**Reference year:**

2025

**Scientific Coordinator:**

MAFFEI Luigi / Full Professor/ Dipartimento di Architettura e Disegno Industriale / Università degli Studi della Campania "Luigi Vanvitelli"

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### **Description of research lines:**

#### **-MULTISENSORY ENVIRONMENTAL IMPACT ASSESSMENT (EIA-SENSE)**

The aim of this research line is the development of an innovative methodology for the environmental impact assessment of energy-saving projects, infrastructures and urban redesign/planning, the characterization and protection of the soundscape. The research includes the study and development of innovative and green acoustic materials, the development and application of vibro-acoustic techniques for environmental monitoring and noise mitigation, the acoustic modeling (indoor and outdoor), and the construction of immersive virtual reality environments. The research deals with a highly innovative methodological approach to the problems of interactions between perceived sensory stimuli (e.g. acoustic, visual, thermal, tactile, olfactory) and the subjective assessment.

#### **- PRODUCT SOUND QUALITY**

This research activity deals with the study, development and application of product quality assessment methodologies, during the production, and from the point of view of the end user. Industrial research addresses the issues of defects detection (fault diagnosis) at the end of the production lines using vibro-acoustic analysis techniques with the use of machine learning algorithms. The user-side research is instead oriented to the definition of new paradigms for the understanding, classification and design of sound quality (Sound Quality) of the final product (HVAC, Hybrid Electric Vehicles).

#### **- URBAN SOUND PLANNING**

The aim of this research line is the identification, characterization and conservation of quiet urban areas. The research, conducted through measurements and subjective / objective assessments in situ, aims to identify and characterize new spaces for the psycho-physical well-being of residents and visitors to historic city centres. The study proposes the development of new descriptive and

communication models to the population.

**- SAFETY, COMFORT AND PRODUCTIVITY**

The research line deals with the problems related to the influence of physical environmental stimuli (acoustic, visual, tactile, olfactory, thermal) on the levels of safety, comfort and work performance of individuals in the industrial and service sectors. The research line uses the multisensory simulation of scenarios in hybrid mode (Virtual and Physical Reality) and the use of protocols and indicators for qualitative / quantitative assessment of subjective performance (e.g. physical, cognitive) as the main experimental tools.

**- SUSTAINABLE ACOUSTIC METAMATERIALS**

The aim of this research line is the design and characterization of new sustainable porous materials and acoustic metamaterials, to be employed separately or together, to be used as sound-absorbing and/or sound insulating panels able to absorb/reduce sound in the frequency range 50-5000 Hz. In order to obtain these purposes in a sustainable way, i.e., with low environmental impact and low embodied energy, metamaterials are particularly promising because their acoustic properties and operation frequency band do not depend specifically on the nature of the composing material, but on the geometric shape, size and space between the inclusions.

**Relationships with other research groups of the University of Campania L. Vanvitelli during the last three years:**

ENVIRONMENT INTERACTION AND MULTISENSORY VIRTUAL REALITY

Principal Investigator IACHINI Santa

**Participation in research projects during the last three years:**

*Title of project:* Brain Virtual Interactivity Platform – BraVI

*Principal Investigator:* Luigi TROJANO

*Title of the call for projects:* PNR 2015-2020

*Description of the research project's activities:*

The innate ability of mankind to adapt to different environments and to environmental changes has become a crucial point for the advancements in Smart Design of Ambient Living which foresee a technological implementation of living environments to pursue well-being and safety of users. Recently, Neuroscience provides insights in the way we perceive the world around us and conversely, how it may affect our behavior and mood thus, Smart Architectural Design can be optimized by information derived from Neuroscience principles. The BraVI project stands at this crossroad between Smart Design of Ambient Living technology and Neuroscience. We will pursue the challenging concept of modifying living environments to match user requirements which are defined as mental, behavioral and emotional states. A multi-function integrated platform -the BraVI system- will be realized in which user states are detected and translated in changes of immersive virtual reality living environments, in a closed loop paradigm. The BraVI project targets area 12, Technology for Ambient Living of the FP (PNR 2015-2020) and will specifically address working and domestic living ambient with the release of two prototypes (BraVI-Lite 1 and 2). The choice of Factory and Home where BraVI technology will operate, is in line with the European and National research and Innovation agenda. BraVI will prioritize safety and security in Factory, inclusion and

active aging in Home scenarios. Nevertheless, the BraVI approach will lay the foundations for a

new idea of Ambient Living design where the user is awarded with a central role in the identification of solutions for the real user centered re-design of ambient living, even beyond the specific target environments.

*People:* Luigi MAFFEI (Scientific Responsible for Local Unit), Massimiliano MASULLO, Antonio ROSATO, Michelangelo SCORPIO

*Partners:* ASSING, ETT, Fondazione Santa Lucia, Istituto Italiano di Tecnologia, ECONA, Fondazione Neurone.

*State of the project:* Funded. Completed. Duration: 36 months.

*Submission/Start/End date of the project:* -- / 01/02/2021 / 31/12/2023

*Title of project:* DEsign Solutions for Industry 4 REady processes - DESIRE

*Principal Investigator:* Francesco CAPUTO

*Title of the call for projects:* PNR 2015-2020

*Description of the research project's activities:*

The project DESIRE, proposed in the area of the Smart Factory specialization area and mainly aimed at the automotive industry, has the main focus of study the operational stations of the production lines and the application to a real context if a DIGITAL WORK STATION(DWS), in compliance with the guidelines of the industry's 4.0 manufacturing paradigm and aimed at increasing the efficiency of the production phases and the quality of the product and the working environment. To achieve this objective, DWS control and management tools, characterized by elements of evident originality and innovation, will be developed; these innovative and original tools enable the development, the control and the optimization of each workstations by showing the human resources employed, the relative saturation levels, the operations performed, the tools used and the materials and/or components there worked. On the basis of the DWS, they will be implemented methodologies for the dynamic logistics simulation, for the virtual real-time validation of the station line sides, for the training of group leaders in immersive virtual environments. All these objectives will be realized in order to receive and enhance the responses from the 'digital' analysis of new processes introduced within workstations; they will be introduced in the workflows tools and methods of Additive Manufacturing, to provide special tooling tools for the workers engaged in complex operations. The DWS will then be embedded in an Smart Factory digital ecosystem to build the DIGITAL SMART TWIN (DST) of the stations, developing new 3D design methodologies for buildings, integrating design lines and plant engineering techniques, valued by development of rapid design tools based on the use of new process design archetypes integrated with knowledge-based manufacturing rules. In this ecosystem, the DWS will become, through the DST, the testing environment for the Digital Workshops of our plants, maximizing the effectiveness and usefulness of the achieved results. The DWS will then be supported by innovative simulation tools and methods focused on the resolution of quality-related issues for the product and the process and ultimately resolving the criticalities in the assembly operations management.

*People:* Luigi MAFFEI (Scientific Responsible for Local Unit), Massimiliano MASULLO, Giovanni CIAMPI, Nicola PISACANE, Pasquale ARGENZIANO, Alessandra AVELLA.

*Partners:* FCA ITALY S.p.A., FCA ITEM S.p.A., STEP SUD MARE S.r.l.

*State of the project:* Funded. closed. Duration: 30 months.

*Submission/Start/End date of the project:* -- / 30/09/2020 / 31/8/2023

*Title of project:* Ecosistema digitale per analisi integrata di dati sanitari eterogenei relativi a patologie ad alto impatto: modello innovativo di assistenza e di ricerca

*Principal Investigator:* Valeria PANEBIANCO

*Title of the call for projects:* Piano Operativo Salute (FSC 2014-2020)

*Description of the research project's activities:*

The pyramid-shaped project is based on a virtual infrastructure interoperable by the network centers for the exchange of health data subject to digital transformation between specialists; the creation of teleconsultation platforms for the dissemination of high specialization in the territory; the creation of virtual reference centers to which the patient with target pathologies can turn to receive multi- specialist assistance; the activation and promotion of the diagnosis and monitoring of the patient's home treatment, through remote sensing. The next plan includes the development of innovative methodologies for predictive medicine to support the diagnosis, monitoring and treatment of chronic pathologies, based on artificial intelligence techniques and sensors, which allow to improve and standardize the quality control of health data and to analyze the flows of data of considerable quantity for the study of patients monitored remotely. At the top of the pyramid, plans will be defined aimed at researching high-impact chronic non-communicable diseases for the identification of predictive models and personalized medicine based on the development and validation of artificial intelligence and network medicine methodologies through the use of multidimensional data collected thanks to the digital platform shared by the network, with the ultimate goal of developing surveillance of risk factors and prevention actions.

*People:* Lucia ALTUCCI (Scientific Responsible for Local Unit), Francesca SIMONELLI, Francesco TESTA, Paolo CALABRÒ, Felice GRAGNANO, Giuseppe ARGENZIANO, Gabriella BRANCACCIO, Rosaria BENEDETTI, Beniamino DI MARTINO, Rocco AVERSA, Luigi MAFFEI e Massimiliano MASULLO.

*Partners:* Sapienza Università di Roma, Università degli Studi del Molise, IRCCS CROB Centro di Riferimento Oncologico della Basilicata, Azienda Sanitaria Regionale Molise, Azienda Ospedaliero-universitaria Policlinico Umberto, Azienda Ospedaliera Brotzu.

*State of the project:* Ongoing. Duration 4 years.

*Submission/Start/End date of the project:* -- / 11 February 2024 / 10 February 2028

*Title of project:* New movable systems for smart/co-working taking advantage of life quality, sustainability and energy efficiency- RESTANZA

*Principal Investigator:* Antonio CIERVO

*Title of the call for projects:* Bando per il finanziamento di progetti di ricerca fondamentale ed applicata dedicato ai giovani Ricercatori – Università degli Studi della Campania “Luigi Vanvitelli” *Description of the research project's activities:*

The research project aims to design a Prefabricated Movable Building (PMB) for smart/co-working a renewable energy-based, self-sustaining in energy use, eco-friendly, modular, and flexible in set- up, and its performance will be analyzed while operating in a selected suitable small village of the Campania region (Italy). The PMB will be developed to optimize occupants' well-being, energy performance, and integration of the indoor environment with outdoor architectural/historical/landscape elements via innovative design methods (immersive virtual reality and dynamic simulation models). The project aims at 1) promoting the exploitation of renewable energy and energy-efficient systems via innovative design methods, 2) reducing the environmental/ecological footprint associated with both building and transport sectors, 3) suggesting an alternative lifestyle combining tradition and modernity, 4) facilitating social/economic rebirth of small villages with significant regenerative potential. The project provides relevant environmental/social/territorial/economic impacts, together with significant results for engineers, architects, manufacturers of PMBs, the scientific community, and policymakers.

*People:* Antonio CIERVO (Scientific Responsible for Local Unit), Antonio ROSATO, Francesca CASTANÒ, Massimiliano MASULLO, Maria Dolores MORELLI, Samiha BOUCHERIT and Raffaella MARZOCCHI.

*State of the project:* Funded. Completed. Duration: 8 months.

*Submission/Start/End date of the project:* -- / 01/09/2023 / 30/04/2024

*Project title:* Physically based and multi-objective approach for Cultural heritage valorisation through Virtual reality (PERCEIVE)

*Principal Investigator:* Michelangelo SCORPIO

*Title of the call for projects:* Avviso pubblico di selezione per il finanziamento di progetti di ricerca fondamentale ed applicata dedicato ai docenti e ai ricercatori non destinatari di altri finanziamenti della Università degli Studi della Campania Luigi Vanvitelli

*Description of the research project's activities:*

The PERCEIVE project aims to enhance the appreciation, accessibility, and preservation of cultural heritage through a novel approach utilizing IVR. It seeks to create detailed physically based digital twins that can be experienced in multisensory ways or used for lighting and acoustic design. This approach involves developing methodologies to accurately model complex architecture in IVR, ensuring high visual quality, realistic interaction with light and sound, and accessibility to hard-to-reach areas. The project will explore IVR applications in lighting design, preservation, drawing, and storytelling. Key objectives include reviewing existing IVR practices, establishing benchmarks for hardware and software, devising modelling techniques for complex architectures, creating digital twins of heritage buildings, and assessing user preferences.

*Involved persons:* Michelangelo SCORPIO (Scientific Responsible for Local Unit), Antonio ROSATO, Massimiliano MASULLO, Giovanni CIAMPI, Danila JACAZZI, Riccardo SERRAGLIO, Vincenzo CIRILLO, Santa IACHINI, Rosina IADEROSA, Daria CERMOLA and Giusi REA.

*Stato:* Finanziato

*Status:* Funded. Ongoing. Duration: 6 months.

*Submission/Project Start/End Dates:* 19/03/2024 / 01/09/2024 / 28/02/2025

*Title of project:* Sustainable Condition Monitoring of wind turbines using sound signals and machine learning techniques

*Principal Investigator:* Luca FREDIANELLI, (Coordinatore scientifico) c/o Consiglio Nazionale delle Ricerche

*Description of the research project's activities:*

Wind farms are located in poorly accessible areas, therefore any breakages of wind turbine components are not reported in good time. The project intends to develop a procedure for identifying wind turbine faults, carrying out on-site acoustic measurements, providing information in time for maintenance interventions.

*People:* IANNACE Gino (Resp. Local Unit).

*Partners:* Consiglio Nazionale delle Ricerche. Università degli Studi di FERRARA.

Università degli Studi della Campania "Luigi Vanvitelli". Università degli Studi di PALERMO.

*State of the project:* Funded. Ongoing. Duration: 2 years.

*Submission/Start/End date of the project:* -- /15 september 2023 / 15 september 2025

*Title of project:* Bio-Acoustic - Bio-Based solutions for improved acoustic applications (Research and Innovation Staff Exchange RISE - Call: HE-MSCA-SE-2021s)

*Principal Investigator:* Arif Akillilar- Tosunogullari Mob. San. Tic. A.S.

*Description of the research project's activities:*

Study of environmentally friendly materials and nanomaterials (PvP / gel) to be used in the applied acoustics sector.

*People:* IANNACE Gino (Resp. Unit Unicampania).

*Partners:* Tosunogullari Mob. San. Tic. A.S.; Next Technology Tecno Tessile Società nazionale di ricerca; Necmettin Erbakan Universitesi TR; Università degli Studi della Campania Luigi Vanvitelli; Kompetenzzentrum Holz GmbH; Kastamonu Entegre agac sanayi ve ticaret anonim sirketi; SCS-controlsys srl; Vlaamse instelling voor technologisch onderzoek n.v.

*State of the project:* Funded. Ongoing. Duration: 3 years.

*Submission/Start/End date of the project:* -- / 15 January 2023 / 15 January 2026.

**Scientific products during the last three years:**

*10 scientific publications in Class A journals and/or indexed in the Scopus/WoS databases:*

- [1] MASULLO, M., YAMAUCHI, K., DAN, M., CIOFFI, F., MAFFEI, L. (2024). Influence of Infotainment-System Audio Cues on the Sound Quality Perception Onboard Electric Vehicles in the Presence of Air-Conditioning Noise. *Acoustics*, 7,1.
- [2] LI, J., MASULLO, M., MAFFEI, L., PASCALE, A., CHAU, C.K., LIN, M. (2024). Improving informational-attentional masking of water sound on traffic noise by spatial variation settings: an in-situ study with brain activity measurements. *Applied Acoustics*, 218, 109904.
- [3] RUOTOLO, F., RAPUANO, M., MASULLO, M., MAFFEI, L., RUGGIERO, G., IACHINI, T. (2024). Well-being and multisensory urban parks at different ages: The role of interoception and audiovisual perception. *Journal of Environmental Psychology* 93, 102219.
- [4] ISTIANI, N.F.F., MASULLO, M., RUGGIERO, G., FRANCINI, M., MAFFEI, L. (2024). Music attributes and the perception of orange juice. *International Journal of Gastronomy and Food Science*, 36, 100953.
- [5] GARGIULO, M., CARLEO, D., CIAMPI, G., MASULLO, M., CHÌAS NAVARRO, P., MALIQARI, A., SCORPIO, M. (2024). Assessment of the historical gardens and buildings lighting interaction through virtual reality: the case of Casita de Arriba de El Escorial. *Buildings*, 14(1), 273.
- [6] IANNACE, G., AMADASI, G., BEVILACQUA, A., CAIROLI, M., TREMATERRA, A. (2024). Resonant Acoustic Metamaterials. *Applied Science*, 14, 5080.
- [7] MAFFEI, L., CIERVO, A., MARZOCCHI, A., MASULLO, M. (2023). Exploring the restorative benefits of work in smart working structures on vacations in small villages. *Frontiers of Psychology*, 14.
- [8] YANG, M., MASULLO, M. (2023). Combining Binaural Psychoacoustic Characteristics for Emotional Evaluations of Acoustic Environments. *Applied Acoustics*, 210, 109433.
- [9] ISTIANI, N.F.F., MASULLO, M., RUGGIERO, G., MAFFEI, L. (2023). The influence of multisensory indoor environment on the perception of orange juice. *Food Quality and Preference*, 112, 105026.
- [10] LI, J., MAFFEI, L., PASCALE, A., MASULLO, M. (2022). Effects of spatialized water- sound sequences for traffic noise masking on brain activities Neural Effects of the Spatialisation of Water-Sounds Sequences on Masking Traffic Noise: a Psychophysical Study. *J. Acoust. Soc. Am.* 152(1), 172-183.

*Additional 10 scientific products:*

- [11] CIERVO, A., MASULLO, M., BOUCHERIT, S., MAFFEI L., ROSATO A. (2024). Effects of climatic conditions on performance of innovative prefabricated movable buildings for smart/co-working in small villages of southern Italy. *International Journal of Sustainable Development and*

- Planning, 19(11), November, 2024, pp. 4127-4134.
- [12] CHUNG, W.K., LIN, M., CHAU, C.K., MASULLO, M., PASCALE, A., LEUNG, T.M., XU, M. (2022). On the study of the psychological effects of blocked views on dwellers in high dense urban environments, *Landscape and Urban Planning*, 221, 2022, 104379.
- [13] MASULLO, M., CIOFFI, F., Li, J., MAFFEI, L., CIAMPI, G., SIBILIO, S., SCORPIO, M. (2023). Urban Park lighting quality perception: an immersive virtual reality experiment. *Sustainability*, 15(3), 2069.
- [14] MASULLO, M., TOMA, R.A., MAFFEI, L. (2022). Effects of Industrial Noise on Physiological Responses. *Acoustics*, 4(3), 733-745.
- [15] RAPUANO, M., SARNO, M., RUOTOLO, F., RUGGIERO, G., MASULLO, M., MAFFEI, L., CIOFFI, F., IACHINI, T., (2023). Emotional Reactions to different indoor solutions: The Role of Age. *Buildings* 2023, 13, 1737.
- [16] FATELA, J.; MAFFEI, L., MASULLO, M. VORLANDER, M (2023). Real-world study cases for auralization validation: selection, measurements, and methods. *Forum Acusticum 2023*, Torino, Italia, 11-15 September 2023.
- [17] MAFFEI, L., MASULLO, M. (2023). Sens i-Lab: a key facility to expand the traditional approaches in experimental acoustics. *NOISECON 2023*. 15-18 May, Gran Rapids, MI, (USA).
- [18] SALAMONE, F., MASULLO, M., DANZA, L., SIBILIO, S. (2023). Effect of spatial proximity and human thermal plume on the design of a DIY human centred thermoigrometric monitoring system. *Applied Science*, 13(8), 4967.
- [19] RAPUANO, M., RUOTOLO, F., RUGGIERO, G., MASULLO, M., MAFFEI, L., GALDERISI, A., PALMIERI, A., IACHINI, T., (2022). Spaces for relaxing, spaces for recharging: How parks affect people's emotions, *Journal of Environmental Psychology*
- [20] MITREVSKA, M.J., MICKOVSKI, V., SAMARDZIOSKA, T., IANNACE, G. (2022). Experimental and Numerical Investigation of Sound Absorption Characteristics of Rebonded Polyurethane Foam, *Applied Sciences*, 12(24), 12936.

**Relationships with international and national Companies, Institutions, Research Centers, Universities during the last three years:**

The EIA-SENSE research line:

- Collaboration with Hong Kong Polytechnic University, Department of Building Services Engineering, Hong Kong (China), prof. C.K. CHAU for the development of the project “Development of noise perception models for a compact urban environment with considerations of spatial openness and greenery”.

The PRODUCT SOUND QUALITY research line:

- Collaboration with Kyushu University, Department of Communication Design Sciences, Fukuoka (Japan). prof. K. YAMAUCHI for the development of the collaborative research project “HVAC Sound Quality inside cars cabins” and “Informational Masking of HVAC noise in Electric Vehicles”.

The URBAN SOUND DESIGN research line:

- Collaboration with Anadolu University, Department of Architecture, Eskisehir (Turkey), prof. A. OZCEVIK for the development of the collaborative research project entitled “Quiet Places in Historical Centers”.

The research line SAFETY, COMFORT AND PRODUCTIVITY

- Collaboration with the Fundacion Universitaria San ANTONIO within the PON RI 2014-

2020, Action 1.1 – Innovative research doctorate with industrial characterization. Supervisor Prof. Juan- Miguel NAVARRO RUIZ, Advanced Telecommunications Research Group (GRITA).

The research line SUSTAINABLE ACOUSTIC METAMATERIALS:

- Collaboration with the University of Bologna; University of Ferrara; University of Roma Tre; National Institute of Metrological Research within the PRIN 2017. Scientific Responsible Prof. Massimo GARAI, of the research project “Theoretical modeling and experimental characterization of sustainable porous materials and acoustic metamaterials for noise control”.

**Collaborations with Consortia, Scarl or other Institutions participated by the University of Campania Luigi Vanvitelli during the last three years:**

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**ISI Web of Science Subject Categories:**

- Acoustics;
- Architecture;
- Computer Science, Interdisciplinary Applications;
- Engineering, Multidisciplinary;
- Public, Environmental & Occupational Health;
- Ergonomics
- Computer Science, Artificial Intelligence;
- Multidisciplinary Sciences;
- Transportation;
- Urban Studies.

**Scientific-Disciplinary Sectors:**

GSD: 09/IIND-07 - FISICA TECNICA E INGEGNERIA NUCLEARE

IIND-07/A Fisica tecnica industriale (già ING-IND/10 Fisica tecnica industriale)

IIND-07/B Fisica tecnica ambientale (già ING-IND/11 Fisica tecnica ambientale)

**Keywords:**

- Noise
- Acoustics
- Psychoacoustics
- Environmental Impact Assessment
- Soundscape
- Urban Sound Planning
- Quiet Areas
- Virtual Reality
- Ergonomics
- Sound Quality

**ERC Categories:**

- PE6\_12 Scientific computing, simulation and modelling tools
- PE6\_9 Human computer interaction and interface, visualization
- PE6\_11 Machine learning, statistical data processing and applications using signal processing (e.g. speech, image, video)
- PE6\_12 Scientific computing, simulation and modelling tools
- PE8\_10 Manufacturing engineering and industrial design
- PE8\_14 Automotive and rail engineering; multi-/inter-modal transport engineering
- SH4\_5 Attention, perception, action, consciousness
- SH7\_5 Sustainability sciences, environment and resources
- SH7\_8 Land use and planning
- SH7\_9 Energy, transportation and mobility