

The 'health record' of the church of Santa Maria Assunta in Pontecurone: contamination between historical knowledge and non-destructive testing results

*Original*

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# Proceedings of AIPnD art'23

*14<sup>th</sup> International Conference on non-destructive investigations and microanalysis  
for the diagnostics and conservation of cultural and environmental heritage*

*Brescia (Italy) - 2023, November 28<sup>th</sup>/30<sup>th</sup>*

**edited by Monica Volinia, Antonello Tamburrino**



15

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The Series Cultural Heritage collects scientific contributions concerning the protection, the restoration, the enhancement and the management of Cultural Heritage both in general and in specific aspects. This purpose is pursued through both theoretical and operational contributions about the knowledge of cultural heritage, able to propose conservation and valorization actions, to suggest management strategies, and recommend adequate dissemination channels. The series collects essays on landscape and urban structures; on historic gardens and parks; on the archaeological heritage and on that which has been reduced to a state of ruin; on historical architecture and that belonging to the so-called "modern movement"; on the widespread heritage with traditional characteristics (rural, mountainous, vernacular).

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Proceedings of AIPnD **art'23**  
*14<sup>th</sup> International Conference on non-destructive investigations and microanalysis  
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Brescia (Italy) - 2023, November 28<sup>th</sup>/30<sup>th</sup>

edited by  
**Monica Volinia, Antonello Tamburrino**



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# art'23

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**2011** Firenze (Italy)

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**2017** Torino (Italy)

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# Introduction

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Emanuele Romeo\*

Politecnico di Torino, Italy

\*Editor in chief of the series Cultural Heritage

The series Cultural Heritage collects scientific contributions concerning the protection, the restoration, the enhancement and the management of Cultural Heritage – with a focus on architectural and landscape heritage – both in general and in specific aspects. Theoretical and methodological books alternate research ones, more pertinent to the practical sphere, i.e. regarding conservation and enhancement actions. Further goal of the series is to suggest prevention and maintenance strategies, even through proper channels of dissemination.

The AIPnD ETS - Italian Society for Non-destructive Testing by deciding to publish the proceedings of *art'23 - 14th International Conference on non-destructive investigations and microanalysis for the diagnostics and conservation of cultural and environmental heritage*, enriches the series of new knowledge, providing readers, researchers, scholars with interesting insights into the value, above all material, of architectural heritage.

The publication of the proceedings represents a new specific field until now never dealt with in this series, bringing out strongly the need, if we talk about cultural heritage, to work through the cooperation of different disciplines and different actors: universities, research institutions, specialized companies, professionals, who work together to the preservation of the Heritage, by proposing innovative prevention actions aimed at a more compatible management than in past decades.

The first conference, organized by AIPnD held in 1983, was the result of the far-sighted vision of Giuseppe Nardoni, who wanted to broaden the Association's fields of interest just to include further actors than industry. Since then, the conferences have become even more international, held every 3 years and itinerant, as shown by the last edition in Argentina. This year, a lucky coincidence, art'23 will take place in Italy, and in particular in Brescia, city birthplace of AIPnD and, together with the city of Bergamo, the Italian Capital of Culture 2023.

The Conference and all the contributes in this volume attest the international nature of the event, thanks to the presence of high profiled scientific and organizing committees, of universities and research institutes, but also a connection with the guest country, Italy, due to the sponsors and to the honor committee.

The volume opens with the greetings of President Ezio Tuberosa followed by five Plenary Lectures offering an overview of research on assets with high artistic and historical value in specific territorial realities such as Brescia, Turin, Genoa and Paris, and a Technical Sponsor Lecture on the state of the art and development of radiographic techniques, aimed at the conservation of cultural heritage.

The book is composed by four different sections, and each section concerns Cultural Heritage in the broadest meaning of the expression, i.e. applications on both movable and immovable assets: Non-destructive Testing in Cultural Heritage; Microanalysis and Conservation of Cultural Heritage; Monitoring of Cultural Heritage; Environmental Control and Protection.

The authors of the contributes belong both to research institutions (University, Enea, CNR) but also to companies operating in both public and private field: this represents the significant and innovative multidisciplinary AIPnD way of researching and working. Thus, an interesting international comparison emerges as the result of a combination of academic and practical research, without neglecting specific case studies related to contingent experiences and sites. The cross-reading

of the essays highlights the spillovers that scientific and academic activities have in the operational field, where, for example, evidence that what has not yet been standardized is employed through protocols increasingly channeled within scientific boundaries, even if sometimes dissonant from market needs.

The interdisciplinary perspective is ensured by the presence of different knowledge and skills all aimed at the experimentation and application of techniques and technologies at the service of Cultural Heritage; while the international panorama of studies and research increasingly enriches the field of diagnostic investigations with new experiences, through specific protocols of understanding between research bodies and territorial realities.

And, in addition to these protocols, there are the educational spin-offs: from Bachelor's and Master's degree courses in the Faculties of Architecture and Engineering, to Level III courses and Master's degrees, without neglecting the collaboration with public and private educational and research bodies operating in the same territory.

In fact, AIPnD ETS (founded in 1979) is a nonprofit scientific, cultural and professional organization; and the promotion of scientific and technical knowledge and technological development of non-destructive testing is one of the main purposes of the Association, which is realized through dissemination activities, creation of educational materials, training courses in view of the certification examinations, required and/or necessary to operate in certain fields and, specifically, in the field of Cultural Heritage.

As an example, I would like to cite the Laboratory of non-Destructive Diagnostics (founded in 1992) of the Politecnico di Torino, one of the main actors of the art'23 Conference. The Laboratory purpose is the knowledge of the architectural and environmental heritage in its technological and technical aspects, through the use of non-destructive investigation techniques including infrared thermography, endoscopy and resistography, used for the analysis of the state of conservation and the search for defects or alterations “under the skin”, or not detectable at a direct visual analysis.

I would like to conclude by saying that the authoritativeness of the organizers and of the editors (Monica Volinia, Marco Giachino, Dario Foppoli and Antonello Tamburrino) has granted

the high profile of this book, while the specific skills of all the contributors have enriched the scientific community with new insights into the cultural and material value of architectural, historical, artistic and environmental heritage, by contributing fully and correctly to the dissemination of the research carried out and the results obtained. Mission, this, which for years has been the main objective of the Cultural Heritage series, also thanks to the attention of WriteUp Publishing House in choosing and selecting which studies and research to publish, together with the Scientific Board.



## President's Greetings

---

Ezio Tuberosa

President of AIPnD ETS - Italian Society for non-Destructive Testing



Welcome to the 14<sup>th</sup> art'23 Conference in Brescia.

Italy is the so called “Belpaese”, preserving an unparalleled cultural heritage: in spite of this, it was not easy to choose the conference venue - but in 2023 Brescia and Bergamo are the Italian Capitals of Culture, so here we are.

Art in its broadest meaning covers every human activity, carried out individually or collectively, leading to forms of creativity and expression that are based on technical devices, innate or acquired skills and behavioral norms deriving from study and experience.

Therefore, art is a language, that is, the ability to transmit emotions and messages. However, there is no single artistic language nor a single unequivocal code of interpretation, nor even a term equivalent to “art” exists in most spoken languages.

In its most sublime meaning, art is the aesthetic expression of interiority and of the human soul. It reflects the opinions, the feelings and the thoughts of the artist in the social, moral, cultural, ethical or religious context of his/her historical period.

Art can also be considered a profession of ancient tradition, carried out in observance of a few rules, even if requiring a lot of love for what is created. Today art is widely considered as way to universal communication, and therefore can be the means to transmit a message of equality and peace among peoples: nothing further, unfortunately, from what is happening now in the world.

Thanks, so, to all the “professionals”, to all the “experts”, to all the “lovers” of this wonderful and indecipherable word “ART”, and thanks to the Italian Association of non-Destructive Testing, to the whole Board, who have made it possible to create yet another this wonderful event once again.

*Benvenuti a Brescia alla 14° Conferenza di art'23.  
L'Italia, il “Belpaese” che conserva un patrimonio culturale senza eguali, non ha facilitato la scelta della sede della conferenza, ma quest'anno Brescia e Bergamo sono le Capitali Italiane della Cultura, allora eccoci qui.*

*L'arte nel suo significato più ampio copre ogni attività umana, svolta singolarmente o collettivamente, porta a forme di creatività e di espressione che poggiano su accorgimenti tecnici, abilità innate o acquisite e norme comportamentali derivanti dallo studio e dall'esperienza.*

*Pertanto, l'arte è un linguaggio, ossia la capacità di trasmettere emozioni e messaggi. Tuttavia non esiste un unico linguaggio artistico e neppure un unico codice inequivocabile di interpretazione, addirittura non esiste neppure un termine equivalente ad "arte" nella maggior parte delle lingue parlate.*

*Nel suo significato più sublime l'arte è l'espressione estetica dell'interiorità e dell'animo umano. Rispecchia le opinioni, i sentimenti e i pensieri dell'artista nell'ambito sociale, morale, culturale, etico o religioso del suo periodo storico.*

*L'arte può essere considerata anche una professione di antica tradizione svolta nell'osservanza di poche regole ma richiedente tanto Amore per quello che si crea. Ma l'arte è spesso una forma di comunicazione universale e pertanto può essere il tramite per trasmettere un messaggio di uguaglianza e di pace tra i popoli, nulla di più lontano, purtroppo, da quanto sta accadendo ora nel mondo.*

*Grazie, allora a tutti i "professionisti" a tutti gli "esperti" a tutti gli "amanti" di questa meravigliosa e indecifrabile parola "ART", grazie anche all'Associazione Italiana delle prove non Distruttive e a tutto il Board, che hanno permesso di realizzare ancora una volta questa meravigliosa manifestazione.*

# The ‘health record’ of the church of Santa Maria Assunta in Pontecurone: contamination between historical knowledge and non-destructive testing results

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## ABSTRACT

The historical architecture of the church of Santa Maria Assunta in Pontecurone (Alessandria, Italy), of late medieval origins and with significant transformations until the 20<sup>th</sup> century, is a clear palimpsest of different construction and decorative phases. Nowadays, although used as a parish church, it shows a critical framework of alterations. The need to best rearrange the data in preparation for a wished restoration program required the involvement of a team of experts from the Politecnico di Torino – as members of a protocol agreement – to verify the current state of conservation of the building.

Between 2019 and 2022, the study focused on examining rich but dispersed and fragmented historical sources, which provided important information for the knowledge of architectural components. In the meantime, an NDT diagnostic campaign to understand non-visible phenomena and structural problems was carried out. In particular, infrared thermography allowed the comprehension of the vaulted systems laying, the mapping of fissures and the reading of the stains caused by infiltration and rising dampness. Moreover, thanks to an innovative application of this technique, it was possible to evaluate the heating system's effectiveness through the survey of the distribution of hot air flows in the room context and on the surfaces. Instead, endoscopic inspections revealed the stratigraphy under the floor level, which is completely damaged, and resistograph analysis verified the quality of the antique roof trusses at some significant points.

The contribution will deal in detail with the systematization of the data in the health record, a tool already tested in other contexts (such as at Chambord Castle, to which this project refers) that can be constantly implemented and easily consulted. Furthermore, it easily communicates and records the knowledge about the building, relating historical information with results obtained from the application of non-destructive testing.

**KEYWORDS:** church of Santa Maria Assunta in Pontecurone, cultural heritage, NDT, health record, building conservation, infrared thermography.

## Methodological foreword. The 'health record' as a knowledge management tool

In the field of restoration, the conservation process of cultural heritage requires a good knowledge of the materials and the history of monuments and sites. For this reason, the approach we are going to explain in this paper, referring to the experience of the church of Santa Maria Assunta in Pontecurone<sup>1</sup> (Fig. 1), represents a method that can be suitable to systematise all the data about the building in light of a hoped restoration programme. Moreover, the development of the several steps of the study is also an example of collaboration between territorial public bodies and scientific experts that work together<sup>2</sup> to discover and highlight the pathologies and problems of the stratified palimpsest. It is urgent to underline that investing in cultural heritage as a promotional factor also means investing in knowledge and detecting complex situations that require planned monitoring and intervention to prevent the development of decay and the irreversible loss of material testimonies<sup>3</sup>. With this aim, the results of all previous studies and campaigns about the church, even if carried out with different methods, have been catalogued, translated and made available in a synoptic and implementable database, here called the 'health record', thanks to which it is possible to define the state of conservation and the priorities for safeguarding the building.

## The case study between historical information and restoration yards

The 'health record' information system arises from the assumption that any new operation on cultural heritage should be profitably based also on its previous conservation history. For this reason, between 2019 and 2022, the research focused on the dispersed and fragmented historical sources, which provided important

information for the knowledge of architectural components and previous restoration yards.

In short, the church of Santa Maria Assunta is a clear palimpsest of several construction and decorative phases: it was built around 1175<sup>4</sup> and it revealed subsequent and significant transformations<sup>5</sup> unraveled up to the 20<sup>th</sup> century, when a series of interventions were achieved with the aim of structural consolidation, conservation of the architectural organism and the preservation of interior decoration (Fig. 2). The analysis of these restoration yards constitutes the heart of the research because they offer the possibility of identifying returning problems and operational interventions that have already proved effective on the building. Chronologically, between 1925 and 1929, the church was closed to the public due to static problems, so the first structural monitoring was carried out to determine the importance of the overturning phenomena, which led to the installation of a steel beam at the extrados of the nave to which chains were anchored to stop the façade from overturning<sup>6</sup>. On the same occasion, a restoration of the roof took place, with the replacement of some wooden elements and tiles and the installation of new channels for collecting rainwater. In the 1930s, the external plinth was rebuilt entirely to protect the masonry from dampness<sup>7</sup>, the existing single-lancet windows were restored, the 18<sup>th</sup> century semicircular windows were closed and new windows were opened on the façade and the side elevations.

Subsequently, documents attest to the work on the bell tower, the insertion of chains in the naves and extraordinary maintenance works on the roof between 1974 and 1977. In 1979, the problem of dampness was again evident, so a ventilation space with vents along the perimeter walls was built in an attempt to restore the perimeter masonry from rising damp. Finally, the last structural intervention dates back to 1982: it involved the construction of reinforced concrete beams along the perimeter walls and the chaining of perimeter walls and arches of the minor naves with metal tie rods.



Fig. 1 The façade and the South-East flank of the church of Santa Maria Assunta in Pontecurone (2022).

### NDT diagnostic campaign

In addition to traditional disciplinary knowledge, competence regarding new tools for diagnostic investigation nowadays occupies a central role in the definition of the conservation program on the built heritage. The restoration project, in addition to the traditional knowledge campaign, the historical study of the sources, and the architectural and decay survey, cannot ignore tests and analyses in advance of the choices of intervention, which allow for in-depth analysis of the state of conservation, in particular where visual examination and the study of archival sources don't provide suitable results<sup>8</sup>.

In this case study, the NDT campaigns were conducted in 2020-2021 using remote visual inspection, infrared thermography, and resistograph analysis, focusing on several issues: instability of the flooring, decay in masonry, and strength of the wooden beams of the roof system.

Endoscopic inspections were performed inside the disconnections in the cement tiles floor



Fig. 2 The chains in the left nave during the restoration yard of 1974-1977 (Parish Historical Archive).

and showed no cracks, bulges, or moisture on the bedding layer of the damaged tiles.

Thermographic acquisitions, conducted with protocols different (active or passive) depending on the objectives, made it possible to identify the textures of vaulted systems, locate cracks and plaster detachments (Fig. 3),

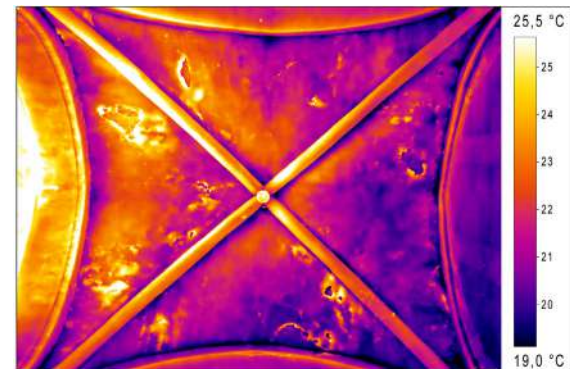


Fig. 3 Right side nave, 4<sup>th</sup> bay. Active IR scan: gaps and plaster detachments (February 24<sup>th</sup>, 2021).



and map evaporative fronts caused by infiltration from the roof and rising dampness. Since the evaporation front is subject to variations, the IR evaluation took place in different seasons and was correlated with the weather and microclimate data acquired over the whole period.

Resistographic testing was applied to a sample of three trusses out of the ten covering the nave to obtain a qualitative indication of the wood element's preservation state. Each truss was analyzed in the most structurally stressed sections. At the same time, the wood's surface moisture was measured using a penetration hygrometer. The results do not reveal any specific critical problems.

In addition to the more common aims of the NDT surveys, an experimental IRT campaign<sup>9</sup> was undertaken to verify the efficiency of the current heating system in the church<sup>10</sup>. On seven strips of cardboard that were fixed to the chains of the three naves and fixed to the floor, the superficial temperature distribution was evaluated over time following the heating (Fig. 4). This method allowed, at the same time, assessing the thermal comfort of the worshippers depending on their position (in space and standing or

sitting) and the thermal stress to which plaster and wooden furnishings are subjected, especially in the higher areas.

### The systematisation of data in the 'health record' as a critical working basis for conservation

As mentioned in the foreword, the study presented in this paper is part of a research program concerning the preliminary investigation of the church of Santa Maria Assunta conservation program. Referring to the debate on knowledge management processes and taking some case studies as examples<sup>11</sup>, the work focused on the definition of a tool that collects historical notes about construction, information about restoration yards carried out since the 19<sup>th</sup> century and the synthesis of the current state of alteration of the monument<sup>12</sup>. Often, in the operational context of restoration, it happens that data on the state of conservation, diagnostic investigations and previous interventions performed are in a fragmented

Fig. 4 Central nave: Infrared microclimate analysis. Scan at 1h45' after the start of heating (April 14<sup>th</sup>, 2021).

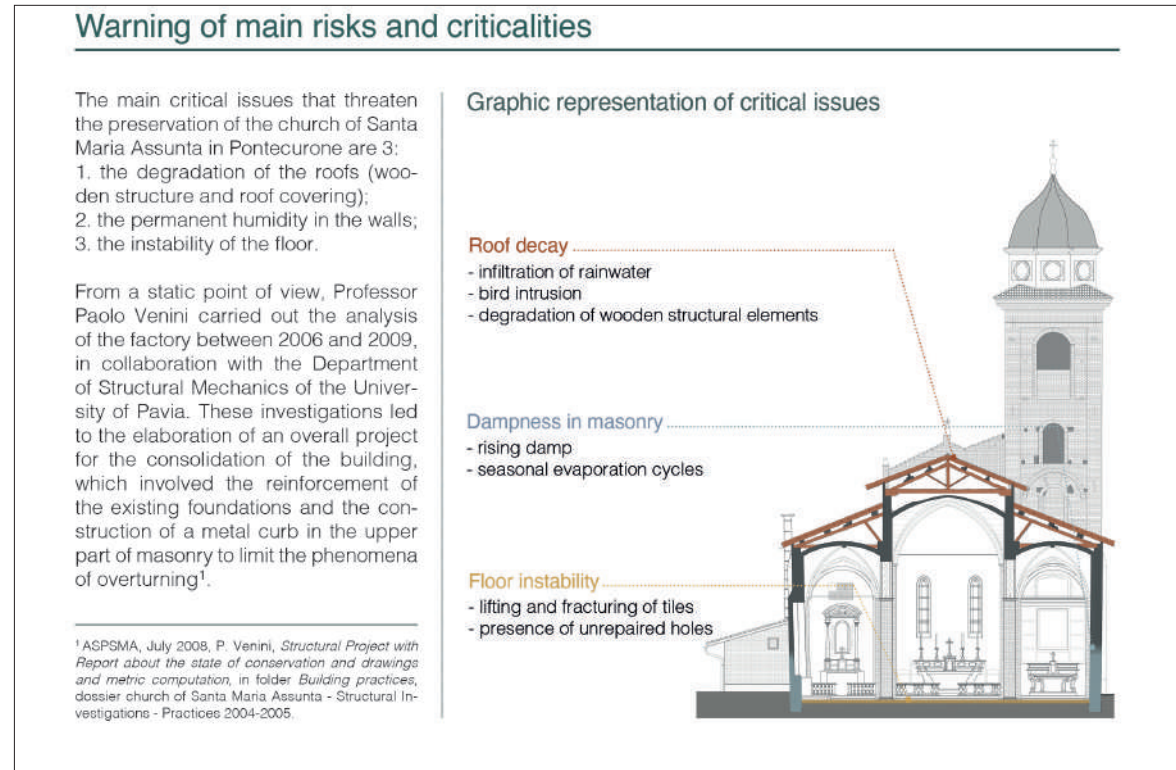


Fig. 5 The three main criticalities of the church summarised in the last section of the 'health record'.

and dispersed state as to be unusable. For this reason, the systematisation of all information is necessary to preserve experience and integrate historical research with the technical-scientific analysis from the diagnostic investigations. The whole of these fundamentals is the basis for the description of monument identity and for the development of its 'health record': a critical working basis essential for the definition of a preservation process, that becomes a precious database over time, also useful for the periodic monitoring of the health of the architecture<sup>13</sup>.

In the case of Santa Maria Assunta, the research tries to translate this theoretical reflection into a concrete tool that represents a process innovation and can be constant-

ly implemented and easily consulted, in which all the mentioned aspects, from historical analysis to the results of NDT diagnostic campaigns, are put together to offer a synoptic scientific reading of the monument and to underline its critical issues and main problems (Fig. 5).

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## Notes

This paper is the result of the joint work of the authors. In particular, however, the foreword is shared, the section on the case study is written by Giulia Beltramo, the one on the NDT diagnostic campaign by Monica Volinia and the one on systematization of data in the 'health record' by Monica Naretto.

<sup>1</sup> Pontecurone is a town in the province of Alessandria, located in south-eastern Piedmont.

<sup>2</sup> In 2020 was activated a Protocol Agreement between researchers and technicians of Politecnico di Torino, the Diocese of Tortona, the Soprintendenza Archeologia Belle Arti e Paesaggio per le Province di Alessandria Asti e Cuneo, the Centro Conservazione e Restauro "La Venaria Reale" and the owner of the building.

<sup>3</sup> Gasparoli 2023.

<sup>4</sup> Year in which the first catalogue of the Diocese of Tortona parish churches attested its existence.

<sup>5</sup> Festuccia, Franco, 2021; Vanni, 2023.

<sup>6</sup> The same problem is still evident today: direct survey operations have revealed the overturning of the masonry on the main façade (Vanni, 2023).

<sup>7</sup> As in the previous note, the problem of dampness issue represents another analogy with current decay and the criticalities because it has required restoration work also in the past.

<sup>8</sup> Fiorani, 2009.

<sup>9</sup> Camuffo, Bertolin, Fassina, 2010.

<sup>10</sup> Air heating with vents located in the upper part of the presbytery and directed to the naves.

<sup>11</sup> Calò, Cavagnini, Riva 1999; Bartolomucci 2004; Coccoli, Scala 2006; Janvier-Badosa, Beck, Brunetaud, Al-Mukhtar 2013.

<sup>12</sup> The research about the Chambord Castel (Janvier-Badosa, Beck, Brunetaud, Al-Mukhtar 2013) is a significative reference for the development of the 'health record' of the church of Santa Maria Assunta in Pontecurone.

<sup>13</sup> Treccani 2006.

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edited by Monica Volinia, Antonello Tamburrino



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Non-destructive Analysis has turned out to be crucial methods to achieve more successful and longlasting preservation of works of art and environmental heritage. With the aim to promote education and competence in this field, the "art" logo was created almost forty years ago and it still represents, in national and international sphere, one of the most successful initiatives in this area. The Proceedings of AIPnD art'23 Conference, settled in Brescia, 2023 Italian Capital of Culture together with Bergamo, collect contributions of delegates, conservation scientists and curators, art historians, analytical scientists and architectural researchers, with the aim to offer to the international audience innovative applications of NDT in many important areras related to Cultural Heritage.

Monica Volinia, Architect, Technical supervisor of the Laboratory of Non-Destructive Diagnostics (Politecnico di Torino) since 1996, is Level 3 in "Controls in the field of Conservation of Cultural Heritage with regard to Architectural Structures" for the methods Infrared Thermography, visible and wood according to UNI EN ISO 9712. Since 1994 she deals with the study and development of non-destructive diagnostic techniques for the knowledge and analysis of the historical-architectural heritage through the use of infrared thermography, remote visual inspection and wood penetrometry. She is author and co-author of numerous publications on procedures and non-destructive methods in the study and analysis of cultural heritage. She is a member of scientific committees in the field of NDT and Cultural Heritage. Since 2019 she has been a board member of AIPnD, the Italian Society for Non-Destructive Testing Monitoring Diagnostics.

Antonello Tamburrino, degree in electronic engineering from the Università di Napoli Federico II (Italy) and Ph.D. degree in electronic engineering at Politecnico di Torino, from 2014 to 2018 was a Full Professor of Electrical Engineering at the College of Engineering, Michigan State University (USA). Since 2006, he has been a Full Professor of Electrical Engineering at the Department of Electrical and Information Engineering, Università di Cassino e del Lazio Meridionale (Cassino, Italy). He has authored or coauthored more than 250 papers appeared in refereed international journals, books, and proceedings of international conferences, and he is a co-editor of three proceedings. His current research interests include inverse problems, electromagnetic imaging, nondestructive evaluation, computational electromagnetism, plasmonics, and homogenization methods. Tamburrino is currently an Editor-in-Chief of the scientific journal *International Journal on Applied Electromagnetics and Mechanics*, a Subject Editor of the scientific journal *NDT and E International*, an Associate Editor of the scientific journal *Non-destructive Testing and Evaluation*, and the Chair of the scientific committee of the Italian Association for Non-destructive Testing, Monitoring, Diagnostic.

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