Dissonant Heritage and Digital Practices. Enhancing Material Conservation and Memorial Narratives

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Abstract

This paper addresses the theme of Dissonant Heritage associated with armed and interpretative conflicts, within the framework of the Co.Co.War PRIN project. The aims to evaluate how digital technologies can support the knowledge production, interpretation, and public engagement of sensitive legacies, while mediating between preservation needs and plural narratives. An integrated digital-heritage methodology is proposed, including GIS-based technologies, advanced surveying techniques, 3D modelling and printing. The approach is tested through two complementary applications: an open-access geo-app mapping dissonant heritage across EU and non-EU contexts, and a site-specific case study focusing on the Former House of the Fascist Party in Predappio (Italy). By linking territorial analysis with digital and physical outputs, the study highlights the potential of digitalization to facilitate negotiation and re-signification processes for contested heritage, support conservation-oriented decision-making, and foster new forms of critical access and community participation.

1. Introduction

Cultural heritage is commonly associated with positive, shared values, messages, and emotions. However, there are highly sensitive legacies of the past that evoke negative, conflicting, and divisive feelings among individuals and groups involved in the processes of heritage interpretation. These legacies are linked to traumatic events such as wars or totalitarian regimes, to latent or unresolved ethnic, social, and religious tensions; they may also become contested as a result of deliberately distorted forms of communication – increasingly mediated through social media – that manipulate collective memory and turn heritage into a source of social friction. The presence of such heritage generates painful recollections within communities, which may result in the withdrawal of care and, in some cases, in hostile practices such as neglect, vandalism, or destruction. In the academic literature, this phenomenon is referred to as *Dissonant Heritage* (Tunbridge and Ashworth, 1996), a term complemented by others that have expanded its taxonomy, including *Undesirable Heritage*, *Difficult Heritage*, *Contested Heritage* (Macdonald, 2006 and 2009; Silverman, 2011; Lähdesmäki et al. 2019). Dissonance in heritage is therefore a complex social phenomenon arising from the misalignment between the historical significance of a heritage asset and the contemporary values of democratic society, and it poses substantial challenges for the management of this type of heritage (Battilani et al., 2024).

In the digital era, digitalization has become a key catalyst of social processes, and cultural heritage has benefited from the rapid development of advanced digital technologies. The digital revolution has opened new opportunities for accessing heritage and reshaped how individuals experience and interact with heritage assets and sites. Heritage digitalization, however, is not only a technological issue but also one of potential. Since the early 2000s (ICOMOS, 2000), international policy and guidance documents have highlighted these opportunities, encouraging the adoption of digital practices for heritage preservation and management, as well as for communication and promotion. These practices include metadata and digital archives, integrated digital surveying, Geographic Information Systems (GIS), Heritage Building Information Modelling (HBIM), digital twins, extended reality (XR) applications (AR, VR, MR), and the growing integration of Artificial Intelligence (AI). Digital technologies also support the diversity of cultural heritage and the continuous reinterpretation of its evolving values.

This process is particularly relevant for Dissonant Heritage, which more than any other form of historical legacy reveals how quickly and deeply perceptions of heritage can change. A heritage asset may be valued, celebrated, or even idolized, and later become denigrated, rejected, and excluded from official narratives. In such cases, digital tools provide an effective means to develop plural cultural content and historically grounded narratives, avoiding ideological taboos and polarized discourse, reconnecting communities and fostering public reconciliation with the past. In this sense, digital technologies play a fundamental, complementary role in the material preservation of cultural heritage, bridging communication and conservation. As stated in the Leeuwarden Declaration, “good storytelling, using all opportunities offered by digital technologies, is key to conveying the history of the place and enhancing its heritage value” (Architects’ Council of Europe et al., 2018).

Among existing initiatives, particular attention is given to practices aimed at developing extensive knowledge and critical awareness in the field of Dissonant Heritage. Digital mapping is especially prominent, ranging from online lists – such as the one published by the Dissonant Heritage Action Group for dissonant sites in European peripheral contexts (Potz and Scheffler, 2022) – to GIS-based maps, like the one developed by the European Cultural Route ATRIUM, which identifies 25 cities associated with totalitarian regimes and their architectural legacy (ATRIUM map, 2026), or the EuroClio project, integrated into the interactive geodatabase of Contested Histories, which includes over 600 objects, buildings, or sites across 134 countries, each accompanied by a record detailing the associated conflict (Contested Histories map, 2026). There are also geo-apps targeting specific typologies of difficult heritage, such as the military landscape of the Galla Placidia Line along Italy’s Adriatic coast, which geolocates German WWII bunkers, promotes cycling bunker tours, and supports slow, mindful tourism (Linea Galla Placidia geo-app, 2026; Ugolini et al., 2021). These mapping initiatives enable scholars and the general public understand the scope and scale of dissonant heritage and represent it spatially, while also serving as heritage catalogues and monitoring tools for institutions responsible for safeguarding these sites.

At the level of individual heritage assets, light installations and immersive soundscapes are frequently used to engage younger generations with sites that carry complex histories. A notable example is the Open Buzludzha Festival, now in its sixth edition: a cultural event organized around the Buzludzha monument – one of the most iconic post-war modernist buildings in Bulgaria and Europe, long abandoned and contested – which features 3D mapping shows and musical performances, attracting hundreds of visitors and promoting the site as a space for art, education, and tourism (Open Buzludzha, 2026). These technologies are also employed in museographic contexts to faithfully convey the history of contested sites, as at Atlantikwall Raversyde in Ostend, Belgium. They are often combined with systematic digital documentation of heritage, particularly photographs and videos, as seen in the Museum of the Second World War II in Gdańsk, Poland (Jaeger, 2020). One particularly well-developed area concerns immersive museum experiences, exemplified by the recent Deutschlandmuseum in Berlin, which presents 2,000 years of German history, including its darkest chapter under Nazism (Deutschlandmuseum, 2026).

Data acquisition also supports artistic reflections and practices. For example, the exhibition *Dead Images*, curated by the creative co-production team of the TRACES project and held at the Edinburgh College of Art in 2018, featured a 30x3m photograph of over 8,000 human skulls displayed in a corridor at the Natural History Museum of Vienna. This high-resolution panorama was designed for life-size printing, producing a highly detailed image that sought to stimulate ethical and political reflections on human remains in museums. The photograph was handled with great care, limiting the potential proliferation and commodification of images of skulls in the age of mechanical, now digital, reproduction (Harries et al., 2019). Similarly, the project *Who is ID 8470?*, curated by artist Tal Adler, explored the ethical display of a human skull from the Humboldt University collection by presenting a multimedia mosaic of conflicting voices instead of the skull itself, offering a multi-perspective engagement with the object (Macdonald and Adler, 2024).

Studies capturing public voices on social media are also noteworthy. Applied to Dissonant Heritage, such analysis could help reveal public perceptions and indicate how heritage sites may shape visitors' emotional experiences, while potentially supporting the assessment of conservation risks by estimating hostility levels or detecting hate speech in online discourse (Bareither, 2021; Gitari et al., 2015).

In the current context, increasingly shaped by culturalized conflicts, these examples highlight the strategic role of digital technologies in understanding, documenting, interpreting, and conserving contested heritage. They also support negotiation and inclusive dialogue, reinforcing the ethical dimension of digital practices as an open and challenging space for research. [CM]

2. Research Aim

The overall aim of this research is to investigate the potential of digitalization in the field of dissonant and contested heritage, demonstrating how advanced technologies can enhance both the understanding and management of complex, politically sensitive legacies. This work is part of the Co.Co.War project – *Dissonant Heritage and War. Conservation and Communication of a Difficult Legacy* – which focuses on architectural heritage whose dissonance stems from armed or interpretative conflicts. Founded in 2022 by Italian National Research Program (PRIN), the three-year project explores value-oriented strategies and innovative tools to detect and mapping dissonance, and to preserve and communicate these architectures. The research perspective is rooted in heritage conservation, coordinated by three academic units (University of Bologna – lead partner, Università Politecnica delle Marche, and Politecnico di Torino), while also aiming to deepen the underexplored nexus between conservation and communication (Co.Co.War project, 2026).

The specific aim of this paper is to address the digital challenges inherent in representing and narrating controversial heritage and to propose concrete tools to support this task.

Two complementary tools are presented, operating at different scales. The first is an open-access geo-app that organizes a significant sample of dissonant heritage cases according to geographic and semantic criteria. This tool allows research units to observe the phenomenon from a broad transnational perspective, identify patterns in the origins of dissonance, and advance understanding of this field. The most innovative aspect lies in its systematization and consolidation of strategies to pave the way for the conservation of dissonant heritage. The geo-app also fosters community awareness of conflict-related heritage, facilitating the communication of dissonance and allowing external users to submit new cases for validation and inclusion in the platform.

The second tool is a testing case involving the integrated digital surveying of a dissonant building mapped within the geo-app, accompanied by the 3D modelling and printing of a highly symbolic and divisive architectural element. The resulting 3D model not only supports heritage conservation and enhancement, but also enables the creation of accurate digital or physical replicas and the development of immersive artistic experiences, which will be presented at the opening of the project's travelling exhibition in Turin, at the Castello del Valentino, in February 2026. [CM]

3. Methodology and case studies application

The paper presents an integrated digital-heritage methodology for understanding and managing dissonant heritage. Its primary contribution lies in the strategic use of complementary technologies – GIS, Terrestrial Laser Scanning (TLS), Unmanned Aerial Vehicle (UAV), and photogrammetry – to document, analyze, and narrate dissonant heritage, both at the territorial and architectural scale.

This approach is demonstrated through case study applications linked to the two specific research aims and expected outcomes.

The first focuses on a sample of 130 contested buildings and sites across Europe and beyond, selected for their engagement in processes of re-signification, rejection, or damage.

The second examines the former House of the Fascist Party in Predappio, Italy – a site of profound symbolic significance as Mussolini's birthplace, where Fascist propaganda materialized the myth of the Dux through urban and architectural forms, and where tensions between cancel culture and polarized narratives persist (Tramonti, 2025). In the second case, both the building as a whole, an example of rationalist architecture, and a key architectural element – the bell atop the Torre Littoria, central to Fascist propaganda rituals – were studied. Long abandoned and inaccessible to the public, the building has been undergoing a re-signification process since 2011, including a conservation and reuse project developed with the Studio Valle in Rome. The analysis of the Littoria bell informs its dismantling and restoration, while also supporting broader reflection on its potential reinstallation on site or in museum display, including the creation of precise 1:1 digital and physical replicas of the entire volume or selected components.

For both case studies, the research follows a well-established pipeline consisting of the following steps:

- *Data acquisition and collection*, carried out using both historical-humanistic approaches and a range of advanced data-capturing techniques;
- *Data processing*, using software suitable for representing and narrating dissonant heritage at territorial and architectural scales;
- *Implementation*, including the deployment of the geo-app in ArcGIS and integrated digital modelling (point clouds segmentation, reality-based modelling, and add-ons) for the House of the Fascist Party;
- *Validation*, through the online release of the geo-app and verification of the digital materials produced for both physical conservation and storytelling of the House of the fascist Party and its Littoria bell.

These steps will be presented in the "Results" section in relation to the two case study applications. Usability testing, scheduled for the coming months, will allow both digital practices and tools to receive feedback from online users of the geo-app and from visitors to the project's final exhibition, who will be able to interact with the printed bell fragment as well as the building itself once the conservation project is completed. For this reason, these activities are not included within the scope of this paper. [CM]

4. Results

4.1 Mapping the dissonance: Co.Co.War geo-app

At the territorial scale, the Co.Co.War project developed a GIS-based workflow to map the geographical distribution and qualitative characteristics of dissonant heritage within the research framework. The results concern the construction of a georeferenced corpus of case studies and its integration into an online geo-app. The geo-app has been designed as a dual-purpose tool, serving both to investigate and communicate dissonance. It facilitates structured comparison across an expanding dataset, while providing direct, visually-oriented access to the cases through interactive map navigation and curated pop-up contents.

4.1.1 Data acquisition and collection: Case identification was based on the integration of heterogeneous sources, predominantly web-based. This choice was driven not only by pragmatic considerations but also by a structural condition of dissonant heritage, which is frequently characterised by uneven, fragmented, or deliberately obscured documentation due to taboo, political sensitivity, contested narratives, and, in some contexts, intentional information manipulation. Accordingly, the data acquisition phase combined systematic online reconnaissance with expert-driven inputs derived from the research group's prior fieldwork, consolidated research trajectories, and shared disciplinary expertise in the study and management of contested heritage. In this sense, data acquisition was conceived not merely as the collection of accessible information, but as a critical process attentive to gaps, silences, and distortions as constitutive elements of the phenomenon itself, and therefore as methodological constraints to be explicitly acknowledged rather than implicitly compensated.

To complement this expert-driven approach, a second acquisition channel was introduced to enable participatory data enrichment. An online *Join the mapping* submission form was implemented and disseminated through targeted events, conferences, and the project website. This mechanism was designed to support the incremental expansion of the dataset by incorporating contributions from different communities of practice (researchers, practitioners, local stakeholders, and institutions).

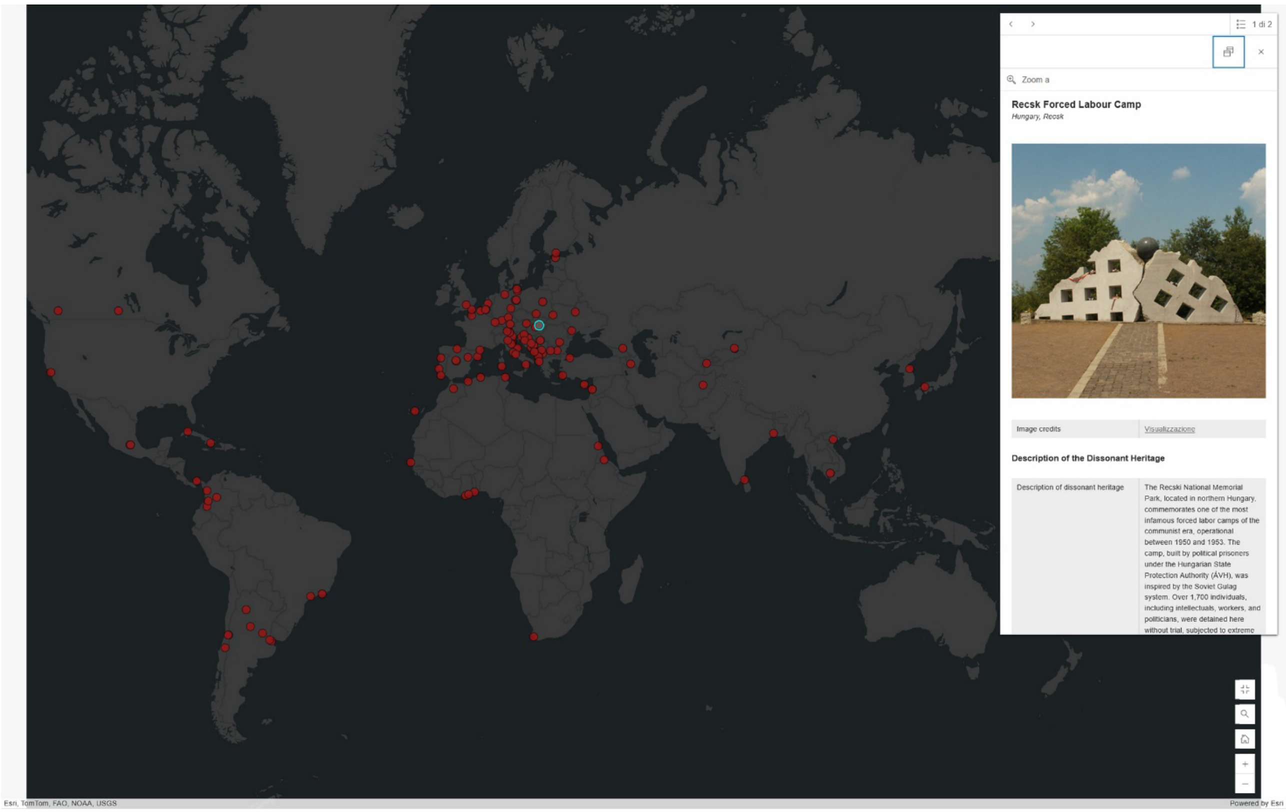

Figure 1. Co.Co.War geo-app interface showing the spatial distribution of the mapped dissonant-heritage cases and an example of curated pop-up contents for a single record within the dataset

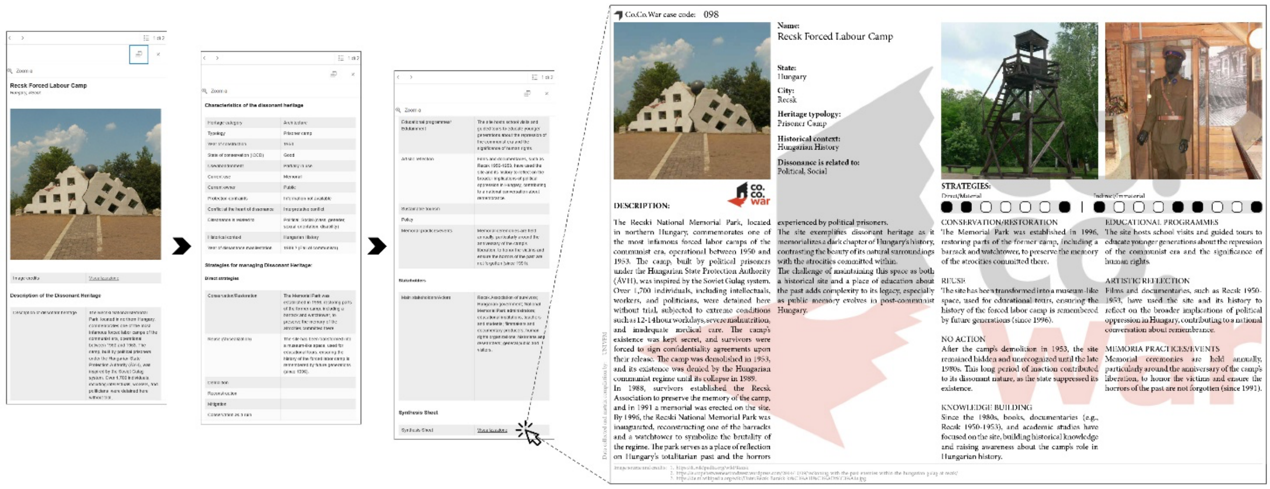

Figure 2. Geo-app information outputs: on-screen pop-up attributes displayed during map navigation (right) and example of the downloadable synthesis sheet linked from the pop-up

Submissions were not incorporated automatically; instead, each proposal underwent a structured validation process conducted by the research team to assess their consistency and alignment with the project objectives and the adequacy of the available information to meet minimum standard of documentation, description and interpretation. This participatory mechanism remains active and ongoing, with the corpus intentionally conceived as an open and extensible dataset, capable of being updated and refined over time.

4.1.2 Data processing: In preparation for GIS implementation, the research team developed a shared, structured spreadsheet database (.xls), designed to accommodate an expanding number of cases while ensuring consistency, traceability, and interoperability of data. The dataset was organised into four macro-sections. Section A, devoted to *General Information* on each heritage site, is articulated into heritage identity, geolocation, main features and legal framework. Section B focuses on *Characteristics of Dissonant Heritage*, with specific attention to the description of the dissonance and its material and immaterial consequences, tracking also the evolution of the dissonance perception over time. Part C collects *Strategies for the conservation and communication of Dissonant Heritage*, enabling a comparative analysis adopted across different contexts and stakeholders. Finally, Part D records *References and Compilation Responsibility*, ensuring transparency with respect to data sources, authorship, and the chronology of data entry and subsequent updates.
Several features of the database were specifically designed to support the management of a large dataset and to facilitate its transition into ArcGIS. First, interoperability and collaborative access were ensured through online hosting, enabling shared data entry, revision, and version control among members of the Co.Co.War research group. Second, the database combines open descriptive fields with controlled vocabularies: selected closed fields with predefined options were introduced to enable aggregation and comparative analysis, while open descriptive fields were retained where the complexity of dissonance requires interpretative notes. Third, the dataset incorporates explicit fields linking records to external digital resources, such as shared image repositories, as well as the geospatial coordinates required for GIS-based spatialisation. In this way, the spreadsheet functions not just as a data repository, a but an interface between qualitative interpretation, geospatial positioning, and subsequent dissemination within a web-based environment.

4.1.3 Implementation: The processed dataset was implemented as a web-based geo-app using Esri ArcGIS Pro and ArcGIS Online. Operationally, the shared database was exported in .csv format and imported into the GIS environment, at this stage in Esri ArcGIS Pro. Geographic coordinates (latitude and longitude) were used to generate a point feature class representing the spatial locations of each case. This dataset was then published online as a hosted feature layer to support web mapping and interactive consultation by two different target groups: expert and non-expert users. On this basis, a web map was created and prepared for online dissemination, ensuring that attribute fields derived from the database could be displayed consistently (Figure 1).
A key implementation task for both levels of user expertise concerned the design of pop-up interfaces, structured to mirror the logic of the research spreadsheet and therefore maintain coherence between the underlying data architecture and its public representation. Each pop-up interface was designed to open with the case study name and to include, as an immediate entry point, a square image preview. These images are retrieved through a URLs stored in the .csv and linked to externally hosted .jpg files provided via Postimages, adopted here as a practical image-hosting solution. Beyond their visual anchoring function, the pop-ups were configured to reflect the research structure of the database and guide interpretation, rather than merely display raw attributes. Particular attention was also devoted to visual consistency with the Co.Co.War project's communication design, adopting a graphic layout aligned with the project's palette and its broader web identity.
In addition to the on-screen access to attribute data, the geo-app provides links to downloadable synthesis sheets for each case of dissonant heritage (Figure 2). These sheets were designed using Adobe InDesign and published as .pdf files within an open-access Google Drive repository. The corresponding download link is embedded in the pop-up interface, allowing users to move from a concise, interactive overview to a stable and printable document format. Following the configuration of the web map and its associated pop-ups in Esri ArcGIS Pro, the resources were published on ArcGIS Online and a public sharing link was generated and subsequently embedded within a dedicated webpage on the Co.Co.War project website. In this way, an

institutional-grade GIS infrastructure is connected to an outward-facing web environment, with the explicit intention of supporting both research operations – cases analysis, controlled dataset enrichment – and communicative goals – browsing, discovery, and comparative reading across different contexts.
Furthermore, for expert users, integration into a GIS environment enables geospatial analyses aimed at achieving a deeper understanding of dissonance and of the strategies adopted to mitigate it. Spatio-temporal analyses can be performed by relating geographic information to temporal data, thereby producing maps that depict the evolution over time of phenomena potentially detrimental to heritage conservation.

4.1.4 Validation: At the current stage, validation is conceived as an ongoing, multi-layered process combining technical checks with an assessment of cultural readability. From a technical perspective, validation is focusing on the consistency between the initial spreadsheet fields and published attributes, the stability and accessibility of external links (images and pdfs), and the legibility of the pop-up structure across devices and access modes. From a user perspective, structured usability tests are planned in the near term to evaluate navigation clarity, information hierarchy, and the effectiveness of the pop-up design in supporting comprehension and retrieval. A further, particularly significant validation moment will occur during the final exhibition of the project, starting from February 5, 2026, at the Castello del Valentino. It is conceived as a testing phase not only for technical performance but also as an assessment for cultural and scientific response – that is, for the geo-app's selection, visualisation, and short-format narrative are received, interpreted, and potentially contested by publics and stakeholders engaging with dissonant heritage. [GD]

4.2 Dealing with dissonance: the Former House of the Fascist Party in Predappio (Italy) and its Littoria bell

Building on the structured data provided by the geo-app, digital technologies were applied to foster community engagement with site-specific dissonant heritage and to mediate interaction with their troubled past. From the geo-app's extensive dataset, the Former House of the Fascist Party in Predappio (Italy) was selected for its highly representative status in both national and international debates on dissonant heritage, standing as a paradigmatic example of Fascist ideology and a manifesto of twentieth-century Italian architecture (Figure 3).

Figure 3. The Former House of the Fascist Party in Predappio (Italy), 2025

The building, commissioned by Benito Mussolini in 1934 and designed by architect Arnaldo Fuzzi, was inaugurated in 1937, serving as an instrument of Fascist propaganda. The building's architectural scale and prominence strongly shape the urban environment of the town, which was designed *ex novo* in the 1920s as a planned town (città di Fondazione). The complex is organized into two main volumes arranged in an L-shape and connected by a central core. Deliberately oversized, it occupies a corner plot and develops along the principal urban axes, with the Torre Littoria asserting the composition through its vertical emphasis (Delizia et al., 2015; Tramonti, 2025). The exterior is clad in a polychrome system combining travertine and ceramic finishes, highlighting façade hierarchies. Several external elements originally served to reinforce its political connotation, including the fasces placed on the Torre Littoria, the flagpole (now dismantled and stored indoors), and the Littoria bell, which remains still located in its original position.

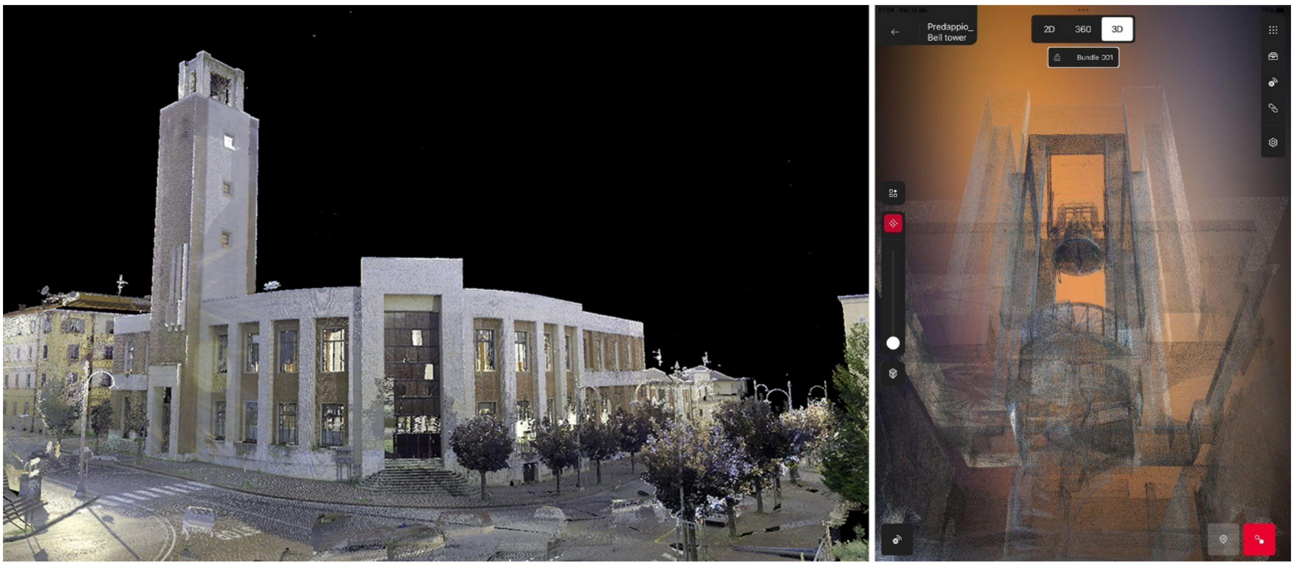

Figure 4. Architectural-scale survey outputs: integrated 3D point cloud of the building exteriors obtained by combining TLS and UAV photogrammetry (left), and on-site TLS preview of the upper Torre Littoria dataset acquired to support the documentation and localisation of the Littoria bell (right)

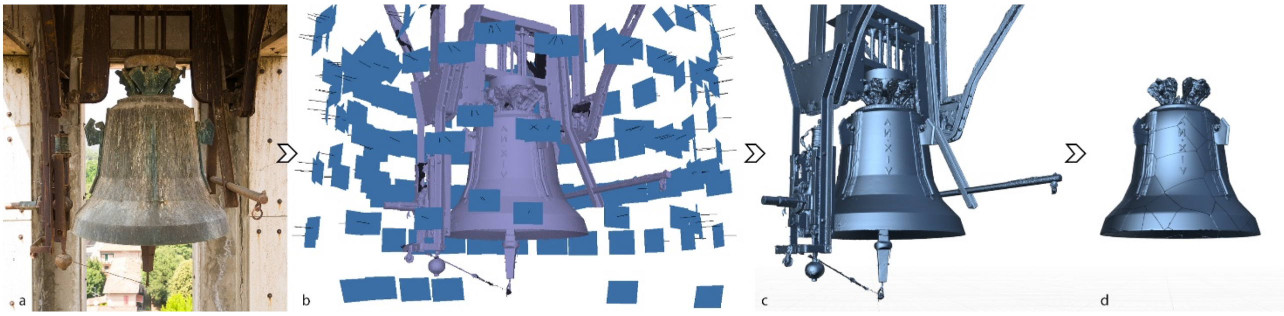

Figure 5. Workflow for the digitisation and model preparation of the Littoria bell: sample close-range images from the photogrammetric survey (a); Structure-from-Motion reconstruction (b); high-resolution 3D model of the bell including the ringing mechanism (c); mesh subdivision into modular parts to support subsequent 1:1 replication and handling (d)

Dissonance emerged after the Second World War with the fall of Fascism and the discrediting of its symbols. After its decommissioning, the building suffered decades of neglect and abandonment, which further exacerbated its fragile condition. Since 2011, a process of heritage recognition and enhancement has been shaped by negotiations over the building's difficult past and its potential reuse. Within this framework, the Co.Co.War project has contributed to the definition and implementation of value-based strategies to engage with this difficult legacy by stressing the use of digital technologies.
Thus, this second study focused on the digital documentation of the asset's most symbolically significant components. In line with the established workflow, two digital models were generated: one of the building's exteriors, supporting knowledge acquisition and conservation planning; and a high-resolution model of the bell crowing the Torre Littoria, enabling full-scale 3D-printed replicas, tactile interaction, and participatory engagement with the community. These outputs will be incorporated into the forthcoming final exhibition of the project.

4.2.1 Data acquisition and collection: A preliminary on-site inspection was carried out to define the most suitable survey strategy, also considering the prolonged abandonment of the building and the related safety and hygiene constraints, which necessitated strict precautions.
The exterior survey was performed through an integrated campaign combining TLS and UAV photogrammetry to ensure comprehensive coverage of the external architectural envelope. Data were acquired over one day by two operators. A Leica RTC360 scanner was used to capture the building exteriors and the upper portions inside of the Torre Littoria, collecting 31 scans with a scan density of 6.3 mm at 10 m. Subsequently, an UAV photogrammetric acquisition was performed using a DJI AIR 2S equipped with a 13.2 × 8.8 mm CMOS sensor (approximately 20 MP). A total of 98 photographs were collected at different heights to document façade portions inaccessible from the ground and to capture roof surfaces.
During the same day, the Littoria bell was documented through a close-range photogrammetric procedure designed to capture fine decorative details. Image acquisition was conducted using a telescopic pole and a Sony α9 digital camera equipped with a 35.6 × 23.8 mm CMOS sensor (approximately 24.2 MP). A total of 349 photographs were acquired, ensuring at least 70% overlap across image pairs. To improve colour reliability and exposure consistency, each image set included an X-Rite ColorChecker Classic, used for white balance correction and exposure adjustment.

4.2.2 Data processing and implementation: The exterior point cloud of the building was first generated by registering the TLS scans in Leica Cyclone REGISTER 360+. In parallel, UAV images were processed in Agisoft Metashape following a consolidated Structure-from-Motion (SfM) workflow. The point clouds derived from TLS and UAV acquisitions were subsequently combined in the open-source software CloudCompare, resulting in a unified 3D dataset of the building exteriors, which serves both as a digital replica and as a baseline for supporting re-signification processes, conservation activities and future artistic reflections (Figure 4).
For the bell in the upper part of the Torre Littoria, a dedicated photogrammetric pipeline was adopted. High-resolution images were pre-processed in Adobe Photoshop and then imported into Agisoft Metashape for 3D reconstruction through SfM workflow. The bell was segmented from the broader dataset and further refined through post-processing operations aimed at optimising geometry and generating high-quality textures. The resulting high-resolution model, comprising 2,315,056 faces, enables detailed analysis of bell's geometry, materials, and conservation conditions. It also supports assessments for future cleaning and restoration, as well as critical reflections on potential enhancement scenarios, including either the reinstatement of the restored bell in the tower or its exhibition elsewhere, given the identified structural issues of the tower. In this context, the digital model provides a reliable basis for producing accurate full-scale physical replicas (Figure 5).
Within the project, two full-scale replicas of selected portions of the bell were produced and integrated into an artistic performance for the final exhibition, providing physically accessible artefacts and expanding opportunities for community engagement and participatory interaction in the re-signification process of this controversial object. In line with the artistic concept, two bell fragments were isolated, refined and fabricated as transparent-resin 3D prints. To this end, transparent resin printing was performed using the innovative Formlabs Form 4L resin printer (Low Force Display, LFD™), whose maximum build volume is 353 × 196 × 350 mm. First, the model of the entire bell was optimised to reduce mesh complexity through re-topology and, where required, local manual refinement to preserve the legibility of highly plastic decorative portions. Then, it was subdivided into modular parts using the Cell Fracture add-on in Blender, employed here as a controlled splitting tool. The fragments selected for fabrication were further locally refined and prepared for printing. The final meshes of the two printed fragments comprised 171,848 and 259,559 faces, respectively, and were exported as .stl files for fabrication (Figure 6).

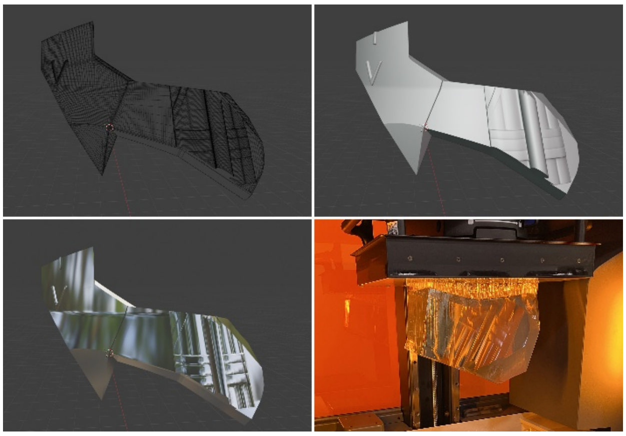

Figure 6. Selected fragments and physical output: bell portions shown as wireframe (a), solid view (b), and rendered preview for exhibition-oriented visualisation (c), together with the resin 3D-printing phase of one fragment (d)

4.2.3 Validation: Given the sensitive nature of the content, as with the geo-app, the validation phase is understood as a complex process integrating both the technical and cultural dimensions of the project.
From a technical standpoint, the building exterior and bell datasets were acquired and processed according to established workflows, resulting in digital models suitable for a wide range of applications. The fabrication stage functioned as an operational test of the models' technical reliability: 3D printing proceeded without issues; the resin replicas accurately reflected the prepared digital geometries and were suitable for safe handling and interaction by visitors. A subsequent validation phase will take place during the exhibition, assessing the durability of the resin artefacts under real-use conditions and systematically collecting visitors' perceptual responses.
Furthermore, the high-resolution model supported the reading of inscriptions located on the upper portion of the bell, which were otherwise difficult to interpret due to surface deterioration and limited visibility, supporting the assessment of the object's history, authenticity, and production process.
Despite the complexity and sensitivity of this case study, no hostile behaviour occurred during on-site operations. Developed as part of the Co.Co.War project, the acquisition activities fostered conscious debate on such a difficult legacy and strong local community engagement, providing valuable real-time feedback. [AC]

5. Conclusion and future works

The conducted experiences demonstrate how digital technologies can play a strategic role in documenting, understanding, and narrating heritage, its discrepancies and conflicts, fostering a value-oriented approach that intertwines the material dimension of the asset with the immaterial dimension of collective memory and social perceptions. In this sense, digitalization is not limited to recording data or producing models; it becomes a critical tool for knowledge, mediation, negotiation, democratic dialogue, and participation.
The results obtained – spanning from the georeferenced mapping of sample of dissonant heritage sites to direct experimentation on architectural heritage – allow us to look beyond the technical act of the digital process, highlighting its contribution to managing complex cultural dynamics of heritage, proving to be a powerful medium for the representation of history and trauma, and for heritage discourse.
The findings of the impending usability tests, which are to be conducted for both digital tools, will furnish additional feedback and enable the refinement, if deemed necessary, of the tools and processes implemented within the Co.Co.War project.
Future research will further investigate the potential of digital technologies to analyze social behaviours and public perceptions of dissonant heritage. In particular, sentiment analysis of social media content can act as a "thermometer" for gauging community responses to difficult heritage sites. By monitoring online communicative dynamics, these digital methods can detect early indicators of narrative polarization, risks of vandalism, or ideological instrumentalization, thereby informing proactive management strategies and awareness-raising initiatives. Thus, digital technologies not only facilitate knowledge building and interpretation of heritage assets but also enable continuous, quality data-driven engagement with the public, bridging the gap between conservation, communication, and social perception. [CM, GD, AC]

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References

Architects' Council of Europe, EFFORT, ERIH, Europa Nostra, FRH, 2018. *The Leeuwarden Declaration. Adaptive Re-Use of the Built Heritage: Preserving and Enhancing the Values of Our Built Heritage for Future Generations*. Adopted in Leeuwarden, The Netherland.

ATRIUM map, 2026. https://www.atriumroute.eu/heritage/sites (5 January 2026).

Bareither, C., 2021. Capture the feeling: Memory practices in between the emotional affordances of heritage sites and digital media. *Memory Studies*, 14(3), 578-591, https://doi.org/10.1177/175069802110106.

Battilani, P., Belcastro, M.G., Kowalsky, K., Nicolosi, T. (eds.), 2024. *Dissonant Heritage: Concepts, Critiques, Cases*. Una Europa Cultural Heritage Series, University of Bologna.

Co.Co.War project, 2026. https://cocowar.com/ (5 January 2026).

Contested Histories map, 2026. https://contestedhistories.org/digital-map/ (5 January 2026).

Delizia, F., Di Francesco, C., Di Resta, S., Pretelli, M., 2015. *La Casa del Fascio di Predappio nel panorama del restauro dell'architettura contemporanea. Contributi per aiutare a scegliere*. Bologna University Press.

Deutschlandmuseum, 2026. https://www.deutschlandmuseum.de/ (5 January 2026).

Gitari, N.D., Zuping, Z., Damien, H., Long, J., 2015. A lexicon-based approach for hate speech detection. *International Journal of Multimedia and Ubiquitous Engineering*, 10(4), 215-230, http://dx.doi.org/10.14257/ijmue.2015.10.4.21.

Harries, J., Adler, T., Kempinski, A., 2019. Disposing of dead images: Reflections on contentious heritage as toxic waste. In: Schneider, A. (ed.), *Art, Anthropology and Contested Heritage: Ethnographies of TRACES*. 1 edn, Bloomsbury.

ICOMOS, 2000. *Québec Declaration on the Preservation of the Spirit of Place*. Adopted at Québec, Canada.

Jaeger, S., 2020. *The second world war in the twenty-first-century museum*. De Gruyter.

Lähdesmäki, T., Passerini, L., Kaasik-Krogerus, S., van Huis, I., 2019. *Dissonant heritages and memories in contemporary Europe*. Palgrave Macmillan.

Linea Galla Placidia geo-app, 2026. https://lalineagallaplacidia.it/ (5 January 2026).

Macdonald, S., 2006. Undesirable Heritage: Fascist material culture and historical consciousness in Nuremberg, *International Journal of Heritage Studies*, 12(1), 9-28, https://doi.org/10.1080/13527250500384464.

Macdonald, S., 2009. *Difficult Heritage: Negotiating the Nazi past in Nuremberg and beyond*. Routledge.

Macdonald, S., Adler, T., 2024. Who is ID8470? Addressing and transgressing taboos with artistic provenance research. In: *Taboo in Cultural Heritage*, International Conference (1-2 February 2024), Amsterdam.

Open Buzludzha, 2026. https://buzludzha-project.com/en/festival/ (5 January 2026).

Potz, P., Scheffler, N., 2022. *Integrated Approaches to Dissonant Heritage of the 20th Century*. Federal Institute for Research on Building, Urban Affairs and Spatial Development.

Silverman, H. (ed.), 2011. *Contested Cultural Heritage. Religion, Nationalism, Erasure, and Exclusion in Global World*. Springer.

Tramonti, U., 2025. *Predappio 100. Gli anni della fondazione: 1925-1929.* Grafikamente.

Tunbridge, J.E., Ashworth, G.J., 1996. *Dissonant Heritage. The management of the past as a resource in conflict*. Wiley.

Ugolini, A., Zampini, A., Mariotti, C., 2021. Digital perspectives to bring dissonant heritage back to life. The military landscape of the Galla Placidia Line. *Scires-it*, 11(1), 63-80, https://dx.doi.org/10.2423/i22394303v11n1p63.

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