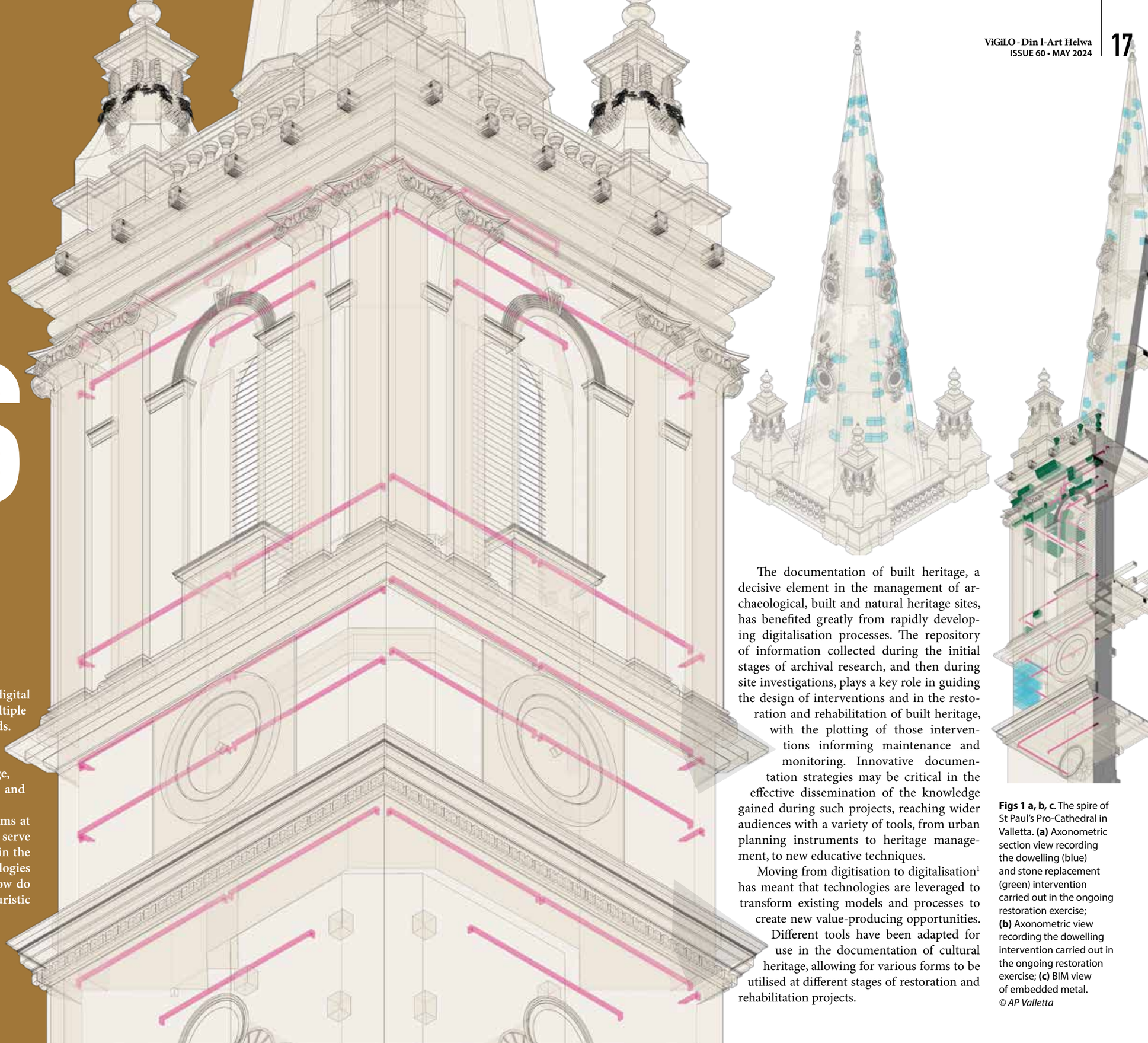
GIANT LEAPS

STRETCHING CULTURAL HERITAGE PARADIGMS

BY CHARLENE JO DARMANIN AND GUILLAUME DREYFUSS

Recent years have seen giant leaps in the use of digital technologies, with widespread utilisation across multiple levels in an interdisciplinary entanglement of diverse fields. The striving for sustainable development and digitalisation processes has been a catalyst in recent years for such technologies to rapidly develop in the field of cultural heritage, with the implementation of ground-breaking methodologies and new realms of innovation in multidisciplinary teams.

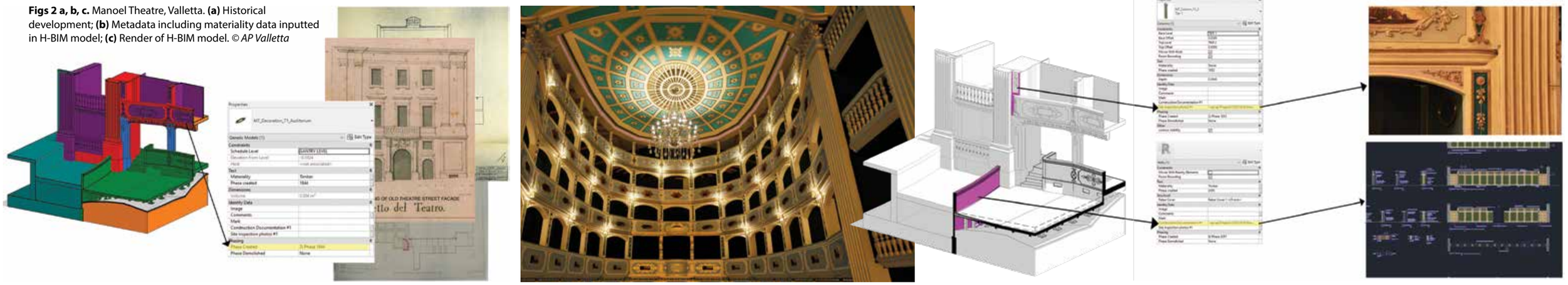
This article highlights some of the tools (and in no way aims at an exhaustive review) being developed, and their potential to serve as a catalyst for developing new mindsets and methodologies in the conservation of cultural heritage. Rapidly advancing technologies have brought a far-sighted future to the here and now. But how do we bring our heritage from a distant past to align with a futuristic present, without losing it in the tech-wilderness?



The documentation of built heritage, a decisive element in the management of archaeological, built and natural heritage sites, has benefited greatly from rapidly developing digitalisation processes. The repository of information collected during the initial stages of archival research, and then during site investigations, plays a key role in guiding the design of interventions and in the restoration and rehabilitation of built heritage, with the plotting of those interventions informing maintenance and monitoring. Innovative documentation strategies may be critical in the effective dissemination of the knowledge gained during such projects, reaching wider audiences with a variety of tools, from urban planning instruments to heritage management, to new educative techniques.

Moving from digitisation to digitalisation[1] has meant that technologies are leveraged to transform existing models and processes to create new value-producing opportunities. Different tools have been adapted for use in the documentation of cultural heritage, allowing for various forms to be utilised at different stages of restoration and rehabilitation projects.

Figs 1 a, b, c. The spire of St Paul's Pro-Cathedral in Valletta. **(a)** Axonometric section view recording the dowelling (blue) and stone replacement (green) intervention carried out in the ongoing restoration exercise; **(b)** Axonometric view recording the dowelling intervention carried out in the ongoing restoration exercise; **(c)** BIM view of embedded metal. *© AP Valletta*



Figs 2 a, b, c. Manoel Theatre, Valletta. **(a)** Historical development; **(b)** Metadata including materiality data inputted in H-BIM model; **(c)** Render of H-BIM model. © *AP Valletta*

As early as 1968, the Comité International de la Photogrammetrie Architecturale (CIPA) was set up as a cross-disciplinary organisation that applied technology from measurement, visualisation and computer science to the promotion and support of documentation and recording of cultural heritage. As one of the oldest International Scientific Committees of ICOMOS, CIPA Heritage Documentation (as it is now known) and its partners have played a leading role in defining the proper, innovative and research-focused uses of digital media in cultural heritage conservation, providing all stakeholders in the heritage field with the opportunity to explore new approaches, to develop innovative practices and to share research results through their platform.[2]

Citizen science and crowdsourcing

Din l-Art Ħelwa, Heritage Malta and international organisations have worked tirelessly in raising public awareness on the significance of cultural heritage as part of their contribution to safeguarding and promoting heritage. Cultural heritage has now become popular for leisure activities and for enthusiasts, with the potential opportunity for experts in the field as well as non-experts to participate in scientific research.[3]

Digital technologies have made citizen science and crowdsourcing more easily accessible for projects such as Monument Monitor[4] and CARE[5], where members of the general public contribute to a cross platform mobile device application to assist with managing and observing change in remote heritage sites.[6,7] Citizens act as 'sensors' to monitor a range of conditions, from the deterioration of archaeological and built heritage sites to reporting the condition of Neolithic and Early Bronze Age rock art carvings, increasing the participation of the public in the preservation of their cultural heritage.

Digital twins and virtual reconstructions

The concept of the 'digital twin' is increasingly gaining traction, with the celebrated case of the Notre-Dame Cathedral in Paris, where ongoing restoration and reconstruction after the tragic fire of 2019 was partially aided by the gaming industry. Digital scans carried out for the development of the game *Assassin's Creed* by Ubisoft helped in its faithful reconstruction, due to the data already available.

The creation of digital twins continues to promote the development of Virtual and Augmented Reality models, translating the data repository tool into one used for educational purposes. Lacunae in archaeological sites, built heritage, decorative surfaces[8] (mural paintings in St Augustine's church in La Laguna and the caves at Lascaux and Cosquer) and other structures[9] (harbour structures in Ireland) are virtually reconstructed, communicating the original structural forms for educative and investigative purposes and providing visitors with immersive experiences.

Satellite data

The innovative use of satellite data has unleashed new possibilities, such as the University of Malta study researching thermal behaviour in traditional *deffun* evaporative roofs.[10] The study promotes a sustainable solution to the implementation of traditional roof build-ups in historic buildings, through analysis utilising a combination of remote data (from Unmanned Aerial Vehicle (UAV) and satellite imagery) and in-situ measurements. This example in Malta also highlights the relevance of international collaborative research networks to enable better and further uses of existing tools and data.

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Artificial intelligence

Shared interests in the research paths of cultural heritage and artificial intelligence are leading to some integration of both disciplines, with methods and models from machine learning promising significant potential for faster, more accurate and less intrusive digitisation processes.[11,12] Automated curation in libraries, archives and museums (such as through text recognition from historical printed documents and handwriting, deciphering ancient languages and decoding epigraphic marks), and computational analysis of cultural heritage data (such as in the digital humanities), have been greatly refined through AI allowing for easier extraction of search results and contextualization of digitized content.[13]

AI learning models have also been adapted to urban development, with a particularly innovative case used in the mapping of London Borough aimed at 'small site' development to reach the required housing targets in an attempt to promote sustainable development.[14] Although is it evident that some challenges and ethical risks remain (particularly due to the lack of a formal framework for the adherence of algorithms to ethical standards set by the European Union for the use of AI in the protection of cultural heritage[15]), AI offers great potential for its application in cultural heritage.[16,17]

Heritage management and decision-making processes

Innovative tools have also been adapted and developed for documenting, managing and visiting cultural heritage, with benefits to cultural heritage management.[18] A-BIME, a private firm focused on the implementation of digital technologies in recording and assessing heritage assets, is currently using H-BIM Technology, a technique in constant development across the international conservation field,[19] to support project management requirements in the conservation and restoration of Notre-Dame Nouvelle de Chemille, Saint-Pierre de Chanzeaux, and Saint-Pierre de Chemille in France. The methodology also assisted in the preliminary documentary research and three-dimensional surveys of the capitals of the de La Madeleine church, reconstructing each stone block of sixteen capitals of the double colonnade for a better understanding of the monument undergoing intervention. Similarly, the methodology was adopted for the restoration of Le Corbusier's apartment-studio in Paris, with BIM serving for structural and hydrothermal simulations to forecast changes to the designed restoration interventions.[20]

Historic repair and maintenance (R&M) industries are also striving to streamline processes through the development of a digital process-wheel to provide a structured and standardised approach for data capture and

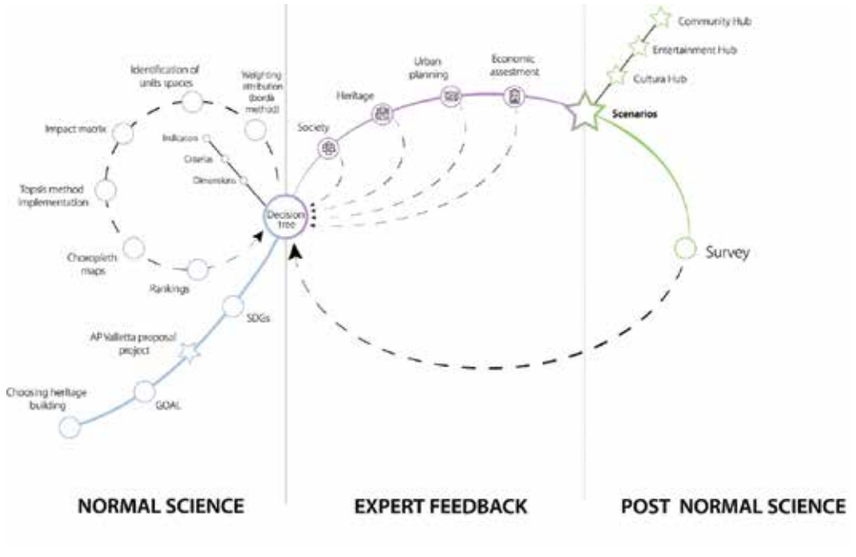

Fig. 3. HBIM regenerative decision-making processes workflow. *Department of Architecture (DiARC), Universita Federico II (Naples)*

sharing, for a more efficient approach to the project management of historic buildings,[21] a process which still needs to be developed here in Malta and implemented using shared platforms across all stakeholders (public, private, NGOs). The established process focuses on the performance and productivity of the project, while ensuring that valuable information collected throughout the project is retained.[22] The established framework facilitates collaboration between stakeholders aiding in successful project delivery, with the ultimate goal being the protection of heritage assets.[23]

The restoration of Elizabeth Tower (Big Ben) in London has also seen the implementation of a BIM strategy in an award-winning project. The use of the technology allowed the team to develop and test their innovative design solutions before construction, managing construction logistics in a limited space with restricted site access, while minimising disruptions on the adjacent Parliament building.[24] The objective of the BIM strategy was twofold; to create a reliable digital asset register for both the new and existing building fabric elements and to create an asset information model for facility management purposes on completion.[25]

AP Valletta has been developing initiatives to document and record interventions through self-funded research to ensure that projects are carried out in full knowledge of their historical, technical, social, and cultural environment, based on an approach that focuses on both a sustainable built environment and heritage as core principles of the practice operation.[26] The authenticity of an object-based approach against that of a process-based approach to architectural conservation is challenged to include the transformative and adaptive nature of resilient architecture, and tested against the idea of restoration, reconstruction, recording and thorough documentation, arguing for a continuous creative process in the care and long-term maintenance of architectural heritage.[27]

This has been tested and pioneered locally in two architectural projects, the Manoel Theatre and the Anglican St Paul's Pro-Cathedral, both in Valletta, with the development and results published in *Treasures of Malta* in 2022. The documentation and database repository are compiled through the implementation of H-BIM. By modelling the sites at different junctions in their conservation regimes, the exercise allows for a thorough and dynamic recording of the findings and interventions, permitting a critical comparison and analysis of the iterative and creative processes over time to inform the approach required for the strategies implemented.[28] The resultant product is a building document that serves as guidance for future interventions in these historic buildings.

The research of AP Valletta has delved further into the use of H-BIM for regenerative decision-making processes for fragile heritage environments, using the Old Power Station in Marsa as a case study. This is being carried out in collaboration with the Department of Architecture (DiARC) at the Universita

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Federico II (Naples) and is part-financed by the Internationalisation Partnership Award Scheme Plus (IPAS+) 2022 of the Malta Council for Science and Technology. The cutting-edge BIM technology here serves as a tool and repository of layers of information at the micro scale and macro scale, through a focus on the historic property and fabric, and through a study of the urban context, respectively. The workflow developed aims to manage and run simulations to forecast the anticipated effects of a redevelopment scenario on its surrounding area—from traffic, environmental, social, economic, architectural and policy perspectives.

Conclusion

There is no doubt that digital technologies are here to stay, with their development taking place at such a rapid speed that new technologies are quickly becoming outdated. Web and cloud-based solutions also mean that Open-Source platforms now allow an easier dissemination of imperative information on current and previous interventions on cultural heritage (such as ARK-BIM[29] for archaeology), with sharing of data and access to such platforms being crucial for their effective use, and still warranting significant improvements. This means that the application of these technologies requires an adaptive mindset, for their successful implementation in the cultural heritage field. With the opportunity to develop new methodologies and strategies for the conservation of built heritage, we are called to stretch our paradigms to a broader understanding of the meaning of cultural heritage, reflecting both constant and changing values.

Our conservation strategies need to be redirected to fit the needs of a rapidly changing world, with a heritage discourse that needs to acclimatise to new realities. Policies and frameworks are still lacking, both internationally and locally, with their development imperative to the decision-making process in the restoration and preservation of cultural heritage. The tools, easily accessible and available, allow for a collaborative approach and with trans-disciplinarity being required by default. The dissemination of information gathered, documented, and discovered through analysis and intervention, has the potential for multi-faceted approaches to reach across different audiences and viewpoints. Digital technologies are not only a tool, but an opportunity to reach out to professionals, stakeholders, citizens and society at large, to maintain and further their engagement with cultural heritage in a structure of porosity and communication.

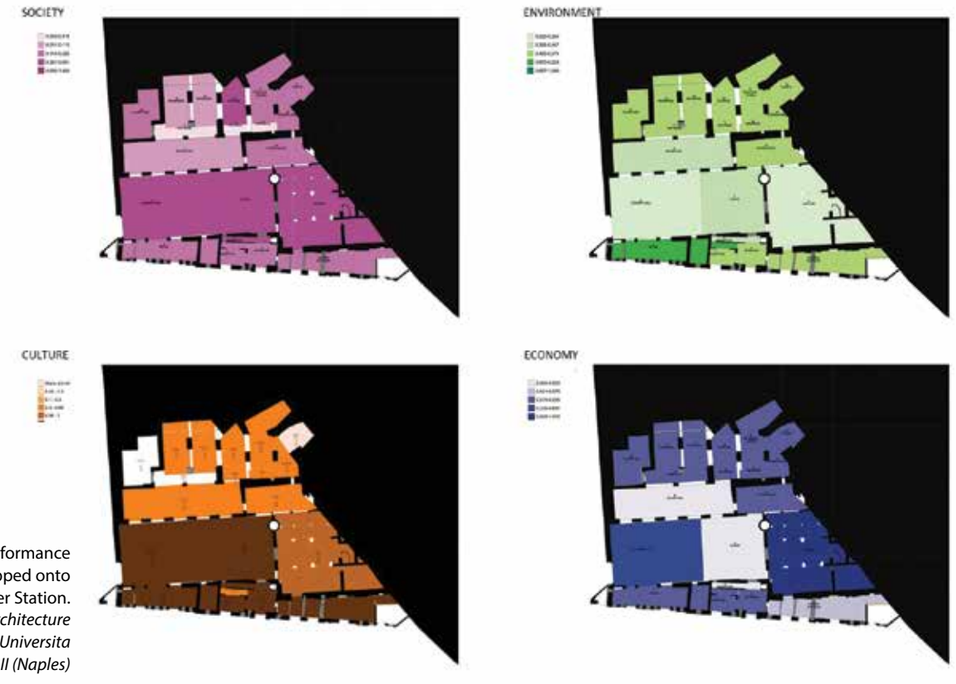

Fig. 4. Performance indicators mapped onto the Old Power Station. *Department of Architecture (DiARC), Universita Federico II (Naples)*

NOTES: ***(1)*** *Digitisation involves conversion of data into a digital format, while digitalization makes use of this digital data, processing it through cutting-edge technologies resulting in transformation through the development of processes and workflows, improving decision-making;* ***(2)*** *Smith, L. & Santana Quintero, M. (2018). Digital workflows for the conservation and sustainability of historic places. Journal of Cultural Heritage Management and Sustainable Development, Vol. 8(4);* ***(3)*** *Brigham, R. & Grau-Bove, J. (2022). Citizen science in sustainable heritage conservation. In Fouseki, K., Cassar M., Dreyfuss G. and Ang Kah Eng, K (Eds.), Routledge Handbook of Sustainable Heritage (126–137). Routledge;* ***(4)*** *Ibid;* ***(5)*** *Turner, M., Dowsland, S. Mazel, A., Giesen, M. (2018). Rock art CARE: A cross-platform mobile application for crowdsourcing heritage conservation data for the safeguarding of open-air rock art. Journal of Cultural Heritage Management and Sustainable Development, Vol. 8(4);* ***(6)*** *See Note 3;* ***(7)*** *Ibid;* ***(8)*** *Soto-Martin, O., Fuentes-Prto, A., Martin-Gutierrez, J. (2020). A digital reconstruction of a historical building and virtual reintegration of mural paintings to create an interactive and immersive experience in virtual reality. Virtual Reality and its Application in Cultural Heritage, 10(2), 597;* ***(9)*** *Shotton, E. (2018). Living in the clouds: conceptual reconstructions of harbour structures. Journal of Cultural Heritage Management and Sustainable Development, Vol. 8(4);* ***(10)*** *Cassar, J., Galdies C. & Muscat Azzopardi, E. (2023). Sustainability of traditional, historical roofs in the Mediterranean: A rediscovered opportunity for a carbon neutral future. Sustainability, 15(17);* ***(11)*** *Bordoni, L., Mele, F. & Sorgente, A. (2016). Artificial Intelligence for Cultural Heritage. Cambridge Scholars Publishing;* ***(12)*** *Neudecker, C. (2022). Cultural Heritage as Data: Digital Curation and Artificial Intelligence in Libraries. Qurator 2022: 3rd Conference on Digital Curation Technologies, September 19–23, 2022, Berlin, Germany;* ***(13)*** *Ibid;* ***(14)*** *https://www.architectsjournal.co.uk/news/opinion/housing-development-in-london-has-a-new-weapon-ai;* ***(15)*** *Pansoni, S. Tiribelli, S., Paolanti, M., Di Stefano, F., Frontoni, E., Malinverni, E.S., Giovanola, B. (2023). Artificial intelligence and cultural heritage: Design and assessment of an ethical framework. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XLVIII-M-2-2023, 29th CIPA Symposium 'Documentating, Understanding, Preserving Cultural Heritage: Humanities and Digital Technologies for Shaping the Future', 25–30 June 2023, Florence, Italy;* ***(16)*** *See Note 12;* ***(17)*** *See Note 14;* ***(18)*** *See Note 11;* ***(19)*** *Nik Umar Solihin Nik Kamaruzaman (2019), Historic building information modelling (HBIM): A review, The European Proceedings of Multidisciplinary Sciences, 4th International Conference on Rebuilding Place;* ***(20)*** *Bruez, M., Gandini, B., Groux D. (2019). Le Corbusier's apartment-studio: 3D model data of preliminary research for the restoration. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W11, 2019 GEORES 2019–2nd International conference of Geomatics and REstoration, 8–10 May 2019, Milan, Italy;* ***(21)*** *Mcgibbon, S., Abdel-Wahab, M., Ming, S. (2018). Towards a digitised process-wheel for historic building repair and maintenance projects in Scotland. Journal of Cultural Heritage Management and Sustainable Development, Volume 8(4);* ***(22)*** *Ibid;* ***(23)*** *Ibid;* ***(24)*** *https://www.purcelluk.com/discover/purcell-implements-bim-for-world-famous-elizabeth-tower/;* ***(25)*** *https://www.bimplus.co.uk/digital-construction-awards-2023-mcalpine-elizabeth-tower-project;* ***(26)*** *Dreyfuss, G. & Darmanin, C. (2022). Augmented Memories - embodying history and processes from layers to elements. Treasures of Malta, 85, 67–74;* ***(27)*** *Ibid;* ***(28)*** *Ibid;* ***(29)*** *Diara, F. & Rinaudo, F. (2021). ARK-BIM: Open-source cloud-based HBIM platform for archaeology. 3D Virtual Reconstruction for Archaeological Sites, 11(18).*

Charlene Jo Darmanin is a design director at AP Valletta, a conservation architect by profession with research interests in managing change in built heritage.

Guillaume Dreyfuss is director of research at AP Valletta, a trained art historian working within the architectural practice for 20 years to initiate, develop and nurture a sustainable approach to the built environment.