Transition to Parametric Modelling in Heritage Documentation

Andrea di Filippo

Abstract

Even today, the BIM methodology and the tools that go along with it are still intended, particularly in Italy, as an exception to the established practice, a novelty with clearly something unfinished. This pattern has only recently turned around thanks to tax breaks.
If the information on the operational steps and the reliability of the collected data is not implemented in the virtualisation itself, despite the rigour in the development of a BIM, it loses its value. The possibility of reusing the model is dependent on quality assessment, which is one of the functional aspects of the methodology.
Content validation is essential in any BIM process that is applied to existing buildings; in order to satisfy customer-specific requirements, the geometric and semantic data must be sufficiently documented and reliable. Valid solutions emerge from the literature but struggle to establish themselves because they are not well integrated into the tools outlined in the technical standards.
This paper suggests a possible strategy to update some instruments in the national normative framework and make them compatible with current BIM regulations in order to use them for quantifying information content reliability.

Keywords
Existing BIM, Content reliability, Information traceability

Framework for assessing the reliability of information content. Graphic elaboration by the author.

doi.org/10.3280/oa-1016-c430

The transition to parametric modelling

Over the past ten years, digitisation has altered representation methods and tools, resulting in a significant increase in the quantity, quality, and variety of data and products. Standard methodologies and procedures have been identified and consolidated as a consequence of the Building Information Modelling (BIM) utilisation in new construction [Jernigan 2007; Kagermann 2015; Sacks et al. 2018].
However, whether BIM is useful in the field of built heritage is still up for debate. The latter is one-of-a-kind and it is hard to imagine how a methodology for standardising representation processes could be used in a situation where saving money and time is a precondition [Akbarnezhad et al. 2014]. As a result, BIM usefulness is questioned and criticised. Since the description of an existing asset may have relevant restrictions, an in-depth examination of the purposes and modelling techniques is required [Becerik-Gerber et al. 2012; Gu et al. 2010; Singh et al. 2011; Watson 2011].
Another limitation of this approach is the inability to exchange information within a system that is naturally fragmented. Despite constant technological advancement, the process of computerisation in architectural heritage management is still poorly integrated in the control-bearing public authorities. Files in market-standard formats are used for the majority of data exchange despite their unique characteristics, ignoring the possibility of qualitative information loss.
The international state-of-the-art demonstrates a renewed interest in the unification of technical regulations on BIM and the innovation of the asset management, paving the way for the definition of IT procedures related to restoration or renovation [Shin et al. 2022].
The application of a methodology that can respond to the requirement for continuous updating of content is in line with the development of electronic protocols, which are becoming a regulatory tool as a result of the spread of international standards [Daniotti et al. 2020]. The reliability of data is the primary focus of our research. Despite the fact that this aspect is a determinant of reusing a model, there is a dearth of a unified framework for solving the crucial problem. Valid solutions emerge from the literature [Bianchini et al. 2018; Brumana et al. 2019; Brumana et al. 2022], but they struggle to establish themselves due to their poor integration with the technical standards-defined tools.
As a result, our proposal for evaluating reliability does not introduce any new features; rather, it aims to find solutions that are actually used in parametric modelling or related sectors, reform them if necessary, and reduce the theoretical burden placed on technicians.

The interchange flow according to Italian technical regulations

It is required to have a thorough understanding of the technical guidelines for managing interchange flows in the construction industry before defining any possible method for documenting the building fabric. According to UNI 11337-1:2017 standards, the three cognitive elements that must be utilised in order to transfer knowledge and negotiate between involved parties are data, information, and information content.
Data should be structured, related, worked with electronically, stored on media, and written in an open format. It can be expressed graphically (signs), alphanumerically (symbols), or in multimedia (images and sounds). This helps us organise and link the knowledge we have through appropriate vehicles (models and outputs). However, it does not specify which attributes to use when virtualising or representing physical entities and processes.
Before determining a strategy that is more efficient, it is necessary to implement a knowledge structure. The development stage (CAPEX) and the operation stage (OPEX) are identified in the UK standards PAS 1192-2:2013 and PAS 1192-3:2014, reiterating their close ties to one another. The Project Information Model, or PIM, operates as a regulatory tool for production, and the Asset Information Model, or AIM, serves as an identification tool for the actual situation and the time flow around existing structures.
This duality has been fully addressed by UNI 11337-1:2017, with an emphasis on the be-

ginning-to-end relationship among the two stages, which can be broken down into multiple phases. It is essential to note that, at least in the Italian public works system, there is no direct correlation between these aspects and design steps. Instead, they are connected to the process goals, which then descend to the virtualisation targets and objects (Level of Development, or LOD).
Determining an interchange flow is necessary for knowledge systematisation. In a broader perspective of BIM, we might see two complementary streams: one of information, which comes from the model and allows its functionalities and one of definition, which makes it clear and keeps it updated. The components that constitute the latter are covered in UNI 11337-5:2017. To handle data requirements within Italian standards, the following documents are created in accordance with British standards and UNI EN ISO 19650: Information Specification (CI), Information management bid (oGI) and Information management plan (pGI).
Prior to the awarding process, the client-defined CI indicates all requirements. The parties who are interested in the contract have to prepare an oGI, which outlines their offer to satisfy the needs of the customer. The selected supplier will create a pGI profiling the initial proposal.
In virtualisation management, operators have always been concerned with automating the association of models (Model Checking). The standards specify three distinct steps of coordination. In the case of LC1, the individual in charge of the particular product has to cover these activities; for the other two levels, the manager will be identified in the CI. According to UNI 11337-1:2017, verification moments exist for each phase and stage of the process. In addition, progress and approval statuses for models and outputs are included in the standards to make it easier for actors to consciously use data and information (UNI 11337-4:2017).

The need to update technical standards

There are still a few issues that are not properly addressed. The characterization of existing assets has become a significant topic since the introduction of BIM in the architecture, engineering, and construction (AEC) industries (fig. 1). In Italy, more than 60% of all structures were built in the 1970s, and the majority of them lack digital documentation. Consequently, costly reverse engineering procedures are almost always used to obtain the required data [Valero et al. 2011; De Luca et al. 2011; Pauwels et al. 2008].
When it comes to the advanced phases of a building lifecycle, the creation of a BIM model is a process that calls for a significant financial and time investment. This raises whether it

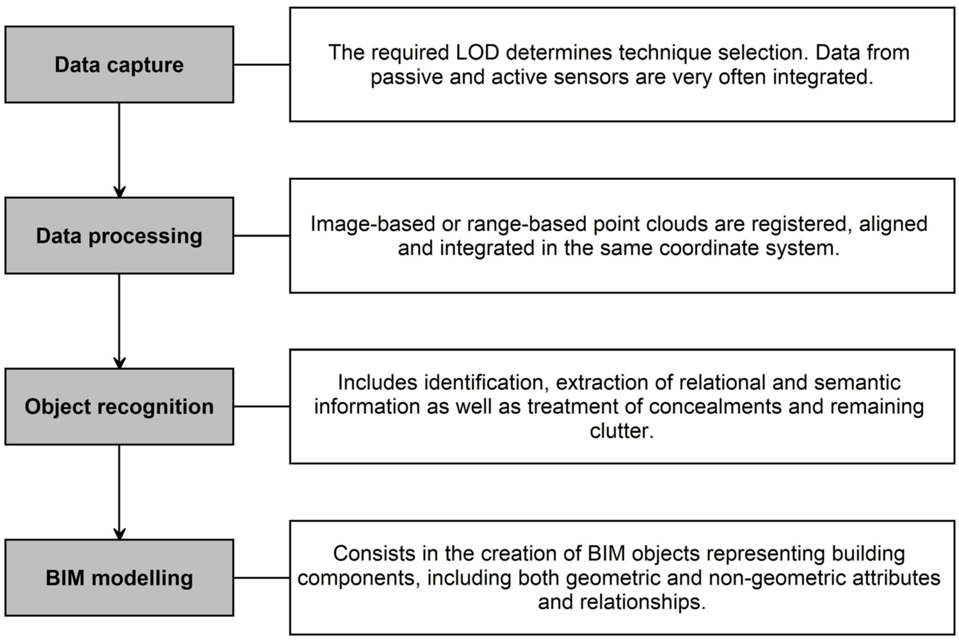

Fig. 1. Technical aspects of as-built BIM. Graphic elaboration by the author.

is worthwhile, and the first topic to be explored is why we require it. We might be able to justify the additional costs, which depend on digital survey and 3D model production (fig. 2), for projects that involve major improvements and renovations [Parrinello et al. 2021; Sanseverino et al. 2022]. However, given that most buildings will not undergo such extensive upgrades, you need to consider whether developing a BIM is worthwhile [Arayici et al. 2017; Volk et al. 2014]. The *D.Lgs. 50/2016* and *D.M. 560/2017* mandate the use of digital tools only for public works performed in Italy, while a significant portion of the existing structures is owned by private individuals.
Many of these buildings lack CAD drawings or possibly even paper documents [Stefani et al. 2010]. One would then start from a condition of almost total absence of information and the quality and features of a BIM model should be calibrated for specific purposes before it can be produced. Although the information process coordination is not necessarily solved by BIM, it can be a useful tool, particularly during the operation stage of existing structures. To guarantee the desired outcomes, its implementation comes at a cost and necessitates training for all parties involved. Therefore, it is necessary to inquire whether the benefits are sufficient to justify the investment, particularly in the private sector.

The Level of Development for existing buildings

The definition of the Levels of Development is a central issue in heritage documentation. In accordance with Italian UNI 11337-4:2017, the client must specify it for each object and phase of the implementation process. This is where the directive table, which suggests distinct ranks based on discipline, comes in handy. The issue arises at this point. A forward engineering approach is used to conceptualise the standard levels, with the contents increasing as one progresses from the idea to the actual element.
Moving from these observations, referring to an existing building surveyed and then modelled one might be led to attribute the product to a LOD G, where the digital objects express the updated virtualisation of the state of an entity at a defined time, containing the trace of management, maintenance, repairs and replacements carried out throughout the lifecycle of the work [Acampa et al. 2020].
Given the preceding considerations, it is impossible to acquire a complete knowledge of all geometric and informational aspects of an existing structure without making significant investments in resources. The same architectural survey using photogrammetric and laser scanning techniques only provides comprehensive documentation of the building 'skin'. As a result, it is evident that the LOD system needs to be rethought in light of the structure type because it is extremely challenging and, most importantly, costly for a private individual to implement the methods and technologies required to collect the missing data [Barba et al. 2021]. Models and outputs derived from the survey can be integrated with a variety of documents (projects, deeds, etc.) in order to provide an economically viable solution. Therefore, it is possible to achieve a LOD G for all virtualised architectural elements, despite the fact that validation

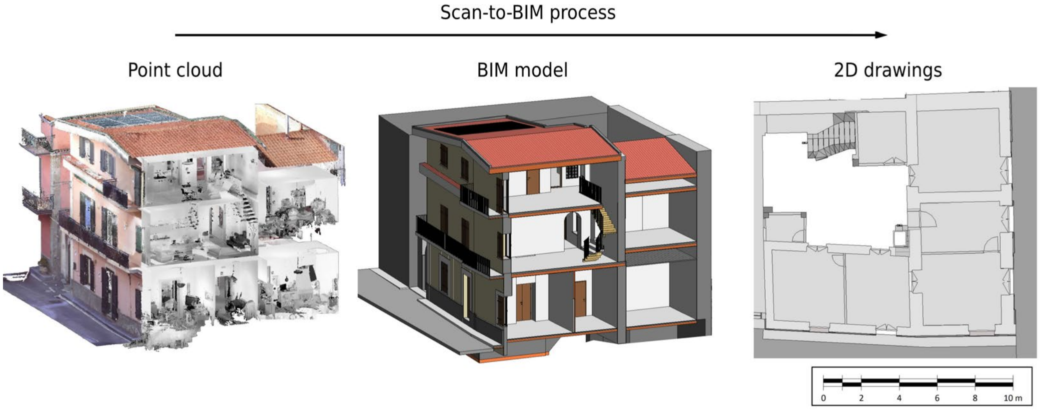

Fig. 2. Conventional workflow for Existing BIM. Graphic elaboration by the author.

of all attributes in the field is not feasible. This is a significant issue, but it cannot be easily solved. Fortunately, the introduction of the Level of Information Need (LOIN) in UNI EN ISO 19650 and UNI EN 17412 enables us to move beyond the static approach of LODs and calibrate the content in accordance with a conscious and mature demand, providing mixed LODs for virtualised elements. In spite of the increased adaptability, there is still no clear reference to the existing structure, necessitating the definition of not only the desired information depth but also the solutions by which it can be attained.

An approach to assessing the reliability of content

The issue of the information traceability and reliability in a BIM model is barely addressed by technical regulations. In the literature, there are some attempts to define a reference framework. These are often devoid of national and international guidelines for the effective management of interchange flows and the creation of models.
The UNI 11337 standards in parts 4 and 5 cover the coordination, progress, verification, and approval of information content in accordance with the Common Data Environment. The most valuable aspect for an in-depth examination of reliability includes the verification levels, which outline the interchange flow alongside the other three points mentioned earlier.
We are interested in the formal internal corroboration at the first level (LV1) that comes after the elaboration and the substantial validation at the second step (LV2) that follows the sharing and deals with the connection to other models. By modifying the LV1, which aims to ensure information readability, traceability, and consistency and is not only formal but also significant for individual virtualization, we intend to incorporate our proposal into this framework.
We can figure out how to verify the object reliability. We employ a tool that is already outlined in Italian regulations: the levels of knowledge about a facility in relation to financial resources, available time, and structural analysis methods. They are described in the Technical Standards for Construction (NTC 2018) and the relevant circular, but state legislation has always included them. Our proposal introduces three main innovations compared to the regulation (fig. 3): the availability of a single classification system devoid of edification methods (I), the existence of a level 0 that indicates there is no information (II), and the division of the investigated properties and characteristics into distinct parameters (III). Additionally, we substitute 'reliability' for 'knowledge' to avoid confusion with Italian acronym that represent interchange coordination levels in the BIM domain, coinciding with that of the NTC 2018 levels of knowledge. This suggests that the AEC national regulations are still inconsistent. The informational contents discussed are material, structural and geometric. The latter necessitate a comprehensive investigation because it is not enough to indicate how the building is surveyed; the measurement uncertainties must be taken into account.

Conclusions

Digitisation has emerged as a crucial solution for the systematic documentation of historical resources. Despite the decreasing instrumental and operational costs of producing reality-based virtualization, there is a growing demand for models that can be used not only to describe the building geometries but also to manage it throughout its lifecycle.
A response to this need is the BIM philosophy, which provides a useful tool for decision-making and a significant alternative to conventional representation methods based on CAD drawings that only concentrate on geometric attributes.
Although the growing interest in advanced lifecycle phases in heritage documentation and the widespread acceptance of BIM in the design and construction of new buildings, the creation of as-built/as-is models requires a significant outflow of resources. Typically, this is done by fitting parametric objects to the survey-derived point cloud in a highly interactive manner. This task becomes especially challenging if the building is full of unique elements.

Level of reliability (LR)	Geometry (G)	Structural details (S)	Material properties (M)
LR0 Absent	Unknown geometry, derived from assumptions by analogy or historical images and documents.	Unknown construction techniques, derived by analogy with other elements or from images and documents.	Unknown materials, deducible from historical images or documents.
LR1 Limited	Geometry assessed from the original plans or from quick surveys using traditional techniques.	Simulated design according to the standards of the time and limited on-site investigations.	Values usual for construction practice at the time and limited on-site testing.
LR2 Extended	The geometry is known thanks to surveys with digital technology, but not certified.	Incomplete design drawings with limited on-site investigations; alternatively extensive on-site investigations.	From original design specifications or original test certificates, with limited on-site testing; alternatively, from extensive on-site testing.
LR3 Exhaustive	The geometry is known thanks to digitally controlled surveys that are certified for accuracy.	Comprehensive design drawings with limited on-site investigations; alternatively comprehensive on-site investigations.	From the original test certificates or original design specifications, with extensive on-site testing; alternatively, from extensive on-site testing.

Fig. 3. Scheme for identifying levels of reliability related to information content. Graphic elaboration by the author.

Even though the literature focuses a lot on the development of modelling strategies, we can see that there aren't many ways to evaluate the traceability and reliability of information sources, which are crucial for their repeatability.
Content validation is essential in any BIM process that is applied to existing buildings; in order to satisfy customer-specific requirements, the geometric and semantic data must be sufficiently documented and robust. Effective solutions emerge from the literature, but they struggle to establish themselves because they are not well integrated into the technical standards. As a result, our proposal for reliability assessment does not add any new features; rather, it looks for solutions that are already used in parametric modelling or related sectors, reformulating them as needed to reduce the notional burden on engineers who could use normative instruments they know and are experts in.
In the field of heritage documentation, it is hoped that a stimulus for the complete and correct implementation of BIM methodology will be the comprehension and mastery of information tools.

References

Acampa G., Forte F., De Paola P. (2020). B.I.M. Models and Evaluations. In G. Mondini, A. Oppio, S. Stanghellini, M. Bottero, F. Abastante (Eds.). *Values and Functions for Future Cities*, pp. 351-363. Cham: Springer.

Akbarnezhad A., Ong K. C. G., Chandra L. R. (2014). Economic and environmental assessment of deconstruction strategies using building information modeling. In *Automation in Construction,* Vol. 37, pp. 131-144.

Arayici Y., Counsell J., Mahdjoubi L., Nagy G., Ḥawwās S. Z., Dweidar K. (2017). *Heritage building information modelling*. Routledge Abingdon.

Barba S., di Filippo A., Cotella V. A., Ferreyra C. (2021). BIM Reverse Modelling Process for the Documentation of Villa Rufolo in Ravello. In *DISEGNARECON*, Vol. 14(26), pp. 1-1-1.11.

Becerik-Gerber B., Jazizadeh F., Li N., Calis G. (2012). Application Areas and Data Requirements for BIM-Enabled Facilities Management. In *Journal of Construction Engineering and Management,* Vol. 138(3), pp. 431-442.

Bianchini C., Nicastro S. (2018). From BIM to H-BIM. In *2018 3rd Digital Heritage International Congress (DigitalHERITAGE), 2018 24th International Conference on Virtual Systems & Multimedia (VSMM 2018)*. San Francisco, 26-30 October 2018, pp. 1-4. IEEE.

Brumana R., Banfi F., Cantini L., Previtali M., Della Torre S. (2019). HBIM level of detail-geometry-accuracy and survey analysis for architectural preservation. In *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-2/W11, pp. 293-299.

Brumana R., Stanga C., Banfi F. (2022). Models and scales for quality control: toward the definition of specifications (GOA-LOG) for the generation and re-use of HBIM object libraries in a Common Data Environment. In *Applied Geomatics,* Vol. 14(1), pp. 151-179.

Daniotti B., Pavan A., Lupica Spagnolo S., Caffi V., Pasini D., Mirarchi C. (2020). Evolution of the Building Sector Due to Digitalization. In B. Daniotti, A. Pavan, S. Lupica Spagnolo, V. Caffi, D. Pasini, C. Mirarchi (Eds.). *BIM-Based Collaborative Building Process Management*, pp. 1-16. Cham: Springer.

De Luca L., Busayarat C., Stefani C., Véron P., Florenzano M. (2011). A semantic-based platform for the digital analysis of architectural heritage. In *Computers & Graphics*, Vol. 35(2), pp. 227-241.

Gu N., London K. (2010). Understanding and facilitating BIM adoption in the AEC industry. In *Automation in Construction,* Vol. 19(8), pp. 988-999.

Jernigan F. E. (2007). *Big BIM, Little Bim: The Practical Approach to Building Information Modeling: Integrated Practice Done the Right Way!* 4Site Press.

Kagermann H. (2015). Change Through Digitization-Value Creation in the Age of Industry 4.0. In H. Albach, H. Meffert, A. Pinkwart, R. Reichwald (Eds.). *Management of Permanent Change,* pp. 23-45. Wiesbaden: Springer Fachmedien Wiesbaden.

Parrinello S., Dell'Amico A. (2021). From Survey to Parametric Models: HBIM Systems for Enrichment of Cultural Heritage Management. In C. Bolognesi, D. Villa. (Eds.). *From Building Information Modelling to Mixed Reality*, pp. 89-107. Cham: Springer.

Pauwels P., Verstraeten R., De Meyer R., Van Campenhout J. (2008). Architectural information modelling for virtual heritage application. *Digital Heritage – Proceedings of the 14th International Conference on Virtual Systems and Multimedia*. Limassol, Cyprus, 20-25 October 2008, pp. 18-23. Marinos Ioannides.

Sacks R., Eastman C., Lee G., Teicholz P. (2018). *BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers*. John Wiley & Sons.

Sanseverino A., Messina B., Limongiello M., Guida C. G. (2022). An HBIM Methodology for the Accurate and Georeferenced Reconstruction of Urban Contexts Surveyed by UAV: The Case of the Castle of Charles V. In *Remote Sensing,* Vol. 14(15), pp. 1-23.

Shin S., Moon H., Shin J. (2022). BIM-Based Maintenance Data Processing Mechanism through COBie Standard Development for Port Facility. In *Applied Sciences,* Vol. 12(3), pp. 1-20.

Singh V., Gu N., Wang, X. (2011). A theoretical framework of a BIM-based multi-disciplinary collaboration platform. In *Automation in Construction,* Vol. 20(2), pp. 134-144.

Stefani C., De Luca L., Véron P., Florenzano M. (2010). Time indeterminacy and spatio-temporal building transformations: an approach for architectural heritage understanding. In *International Journal on Interactive Design and Manufacturing (IJIDeM),* Vol. 4(1), pp. 61-74.

Valero E., Adan A., Huber D., Cerrada C. (2011). Detection, Modeling and Classification of Moldings for Automated Reverse Engineering of Buildings from 3D Data. In *28th International Symposium on Automation and Robotics in Construction (ISARC 2011)*. Seoul, Korea, 29 June-2 July 2011, pp. 546-551.

Volk R., Stengel J., Schultmann F. (2014). Building Information Modeling (BIM) for existing buildings - Literature review and future needs. In *Automation in Construction,* Vol. 38, pp. 109-127.

Watson A. (2011). Digital buildings - Challenges and opportunities. In *Advanced Engineering Informatics,* Vol. 25(4), pp. 573-581.

Author
Andrea di Filippo, Università degli Studi di Salerno, anddifilippo1@unisa.it

To cite this chapter: Di Filippo Andrea (2023). Transition to Parametric Modelling in Heritage Documentation. In Cannella M., Garozzo A., Morena S. (Eds.). *Transizioni. Atti del 44° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione/Transitions. Proceedings of the 44th International Conference of Representation Disciplines Teachers*. Milano: FrancoAngeli, pp. 2685-2691.

 Isbn 9788835155119