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DIGITAL BUILDING PERMITS AND DIGITAL BUILDING LOGBOOKS – CLUSTERING THE CHALLENGES AND REQUIREMENTS FOR ALIGNMENT

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Abstract

Digitalisation supporting a more sustainable, efficient, and waste-friendly built environment is key. The requirements for this go far beyond the development of digital tools. The ability to collect, track, exchange, and trace data throughout processes is decisive. Digital Building Permit (DBP) and Digital Building Logbook (DBL) share these assumptions. However, a mutual realisation is lacking, and intuitions point to attaining added value. This vision motivates the research. Action research was elected to diagnose and discuss the viability of the vision and the associated challenges. Contributions demonstrate soundness and provide relevant insights into twin paths involving both concepts.

Introduction

Before becoming real and usable, buildings and civil engineering works need to be strategically defined, technically detailed, and constructed. This sequence of events is how, iteratively, construction "ripens and materialises" the idea and the object to be built. The underlying processes involve the production of large amounts of information. Digitalisation defies the transition from paper documentation to digital documents, metadata, and models (International Standards Organization, 2018). However, the EU Industrial strategy for construction (European Commission, 2021b) and the Green Deal requirements (European Commission, 2019) entail improvements at efficiency and sustainability levels, scoping the processes themselves as well as their outcomes (Papadaki *et al.*, 2023). To attain the proposed objectives, data-driven concepts with interfaces steeped by digital sobriety assumptions (Péréa, et al., 2023) must be positioned at the centre of the concerns.

Building permitting constitutes the authority of the local administration based on applying the measures laid down by law, aiming to secure the safety, sustainability, and compliance of buildings with the regulations (Fauth *et al.*, 2024). Digital Building Permitting (DBP) includes using digital data as input and output and digital tools to support or automate checking to tackle current limitations derived from analogue documents and processes (Malsane *et al.*, 2015). Several stakeholders structure building and infrastructure cadastral data for different purposes (Buchholz and Lützkendorf, 2023). Some data derives from national or local regulations and are kept by public authorities or private agents, from promoters to owners and users. Several gaps and inefficiencies are observed due to the wide range of processes and the often practised siloed and analogue approaches (Gómez-Gil, *et al.*, 2022). DBLs aim to collect, store, and link buildings' relevant data, fostering data transparency and increasing data availability on buildings-related properties to a broad range of market players (Dourlens S., et al., 2021). Several studies and projects are being developed to define and structure reference architectures and features to deploy DBPs and DBLs. However, little research exists seeking overlaps, potential relationships, challenges and added value from mutual developments and implementation.

This study builds upon previous research on DBP (such as Noardo *et al.*, 2022) and DBL (such as Mêda *et al.*, 2022) to focus on the abovementioned aspects. Stanford Center for Integrated Facility Engineering (CIFE) horseshoe and Action Research constitute the framework, anchored in a focus group. The focus group gathered experts on DBP and DBL to assess the relationship further and discuss the common elements. The first outcome is the answer to the research question: To what extent should DBP and DBL be considered related concepts? A second outcome involves identifying mutual challenges and processes with outlined associated requirements.

The article is organised as follows: The present Introduction section portrays the topic, the motivations for the work, the scientific approach, and the organisation. Second, the Research Design and Methods are presented, detailing the characteristics of the focus group from which most results stem. Follows the Diagnosis, where a brief overview of DBP and DBL is performed supported by scientific research and grey literature. This part includes a summary of the concerns, setting the bridge to the Action section, where the focus group contents are presented, namely, quantitative results from surveys and qualitative thoughts shared. Then, the Analysis and Discussion section proposes a framework with links, assessing and clustering the practical challenges and requirements of a common approach. Examples of processes and impacts on stakeholders' practices are debated. Finally, the Conclusions present the main remarks, elaborating on limitations and future directions.

Research Design and Methods

This research aims to demonstrate if DBP and DBL are related concepts. As part of the process, commonalities and requirements are evidenced, as well as clustering challenges at the implementation level. Given its potential to structure a transdisciplinary research process, the CIFE

Horseshoe Framework (see Figure 1) was selected as the guiding framework (Kunz and Fischer, 2007).~

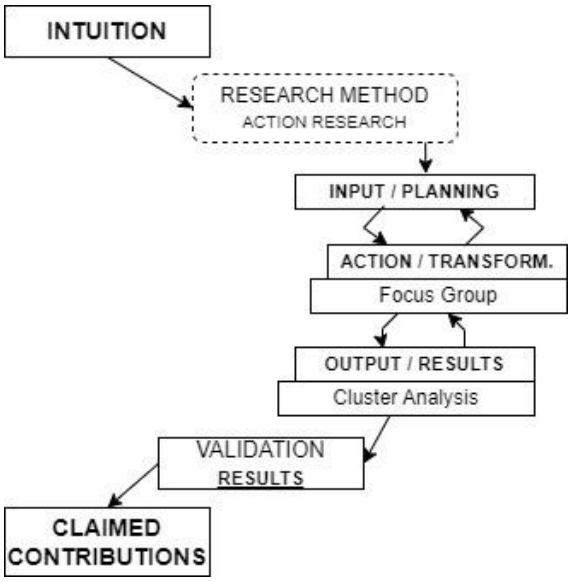

Figure 1: Research design using action research as the main method and The Stanford CIFE Horseshoe framework

The author's intuition establishes that DBP and DBL are related concepts. This relationship, which might seem obvious, does not have expression in the literature, nor is it a consensus among experts and industry stakeholders working on the associated topics and processes. Action research adopting a critical and pragmatic paradigm to investigate the intuition and propose improvements is used (Fellows and Liu, 2022).

The planning stage comprises DBP and DBL diagnosis anchored by relevant scientific and grey literature. The action stage involves a focus group in the form of an online workshop to discuss the alignment of the concepts and collect and explore qualitative and quantitative data on the requirements and challenges. The option for a focus group with selected experts was because it is the most suitable method to encounter the topic as this state. Following (Eeuwijk and Angehrn, 2017), it helps to identify and clarify shared knowledge among groups and communities, which would otherwise be difficult to obtain with a series of individual interviews.

Eighteen professionals were engaged, and the participation criteria were based on the sound knowledge/expertise on at least one of the concepts under discussion. In terms of background, the group had different origins from engineering (22,2%) and architecture (27,7%) practice to academia (27,7%) and geospatial sciences (11,1%). Regarding professional experience, 22,2% work between 15 and 20 years and 77,8% for over 20 years. The structure follows the characteristics addressed by (Jain, 2023), pursuing several iterative steps.

The outputs and research contributions comprise the discussion of all impressions and the analysis of the two surveys (see Figure 2) performed during the workshop. Cluster analysis (Romesburg, 1984) of all elements leads to the primary challenges and requirements and a proposal for a framework linking DBP and DBL.

Diagnosis

Digital Building Permit (DBP)

The process of issuing a permit for a building, independently of the phase, is a crucial milestone for any construction process. Despite being a small part of the mentioned life cycle, all relevant laws and regulations that ensure construction quality, user safety, environmental safety, etc., are enforced (Bloch and Fauth, 2023). The dependency of the legal framework and governmental processes makes the building permit process overly complex, prone to errors, non-transparent, and unpredictably lengthy (Ataide, *et al.*, 2023). Due to these characteristics, building permit issuance can be somewhat different in terms of process, information, and moment(s) during the construction process life cycle, among others. Some researchers have devoted their efforts to the topic of automated code compliance checking, for example (Bloch, *et al.*, 2023; Fischer *et al.*, 2023), which is one of the essential steps within a permit, mainly exploring the potential of using the BIM methodology (Amor and Dimyadi, 2021). Complementary to and following the international push for digitalisation, others have been looking to the building permitting process to identify ways to become more efficient and transparent through the use of digital tools (Bloch and Fauth, 2023; Fauth and Seiß, 2023; Krischmann, *et al.*, 2015).

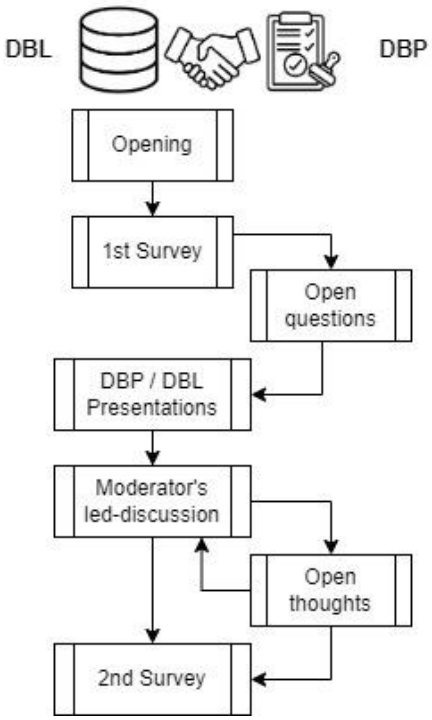

Figure 2: "DBL meets DBP" workshop – action structure

To support a digital transformation in the building permit domain, a basis of knowledge was needed, including not only the technological aspects of supporting industry in the development of the systems infrastructure but also the involved procedures, legislation on different levels and the involvement of various organisations (Fauth *et al.*, 2024). The DBP gained a specific space and attention under the EUnet4DBP initiative (Noardo *et al.*, 2020). Requirements and reviews were developed to clarify, provide awareness, identify common data and processes, and forecast common frameworks for DBPs (Noardo *et al.*, 2022; Fauth *et al.*, 2024).

Presently, there is the notion that DBP can represent a wide variety of building permitting processes running from early design phases to the handover and the commissioning of the building or infrastructure. Notwithstanding, almost all actions are driven by regulatory obligations and led by public authorities or designated bodies, meaning that similarities exist in how the process should run despite the differences in information requirements and compliance checks. The processes tend to be narrow regarding time frame, and DBP efficiency and accomplishment are linked to this objective. Finally, the issuance of a permit relies on information that is collected and structured for this specific purpose. Despite the issuance of the building permit, the storage of the information used for the process and the building permit report itself should be stored and kept during the life cycle of the construction. For example, a building usually changes during its life and most likely needs other building permits. It would be highly beneficial to have the necessary information directly by hand.

Digital Building Logbook (DBL)

An enormous amount of information is generated and used during a construction life cycle (Espinoza-Zambrano, *et al.*, 2023). However, this information is often collected in isolation, meaning that it is searched and managed to serve the purpose of a defined stakeholder in a given temporal moment of that life cycle. Other stakeholders must do the same for their specific objectives, searching for and managing the same or different information. According to (Miller *et al.*, 2014), this way of doing things leads to several gaps. Additionally, the process is highly error-prone and inefficient, diluting most of the benefits of information use. The proposal for the new Energy Performance of Buildings Directive (EPBD) (European Commission, 2021a) calls attention to the importance of effectively collecting and managing this data. The DBL concept was introduced as the common repository for all building relevant data, setting links to relevant existing databases, documentation, records and processes (Dourlens S. *et al.*, 2021).

Several recent studies have contributed to improving and clarifying the understanding regarding the DBL concept (Mêda *et al.*, 2021; Gómez-Gil, Espinosa-Fernández and López-Mesa, 2022; Alonso *et al.*, 2023). Most research works individually focus on specific aspects of the DBL, from the processes level to the data sources and functionalities, digital technologies or event contributions to progress indicators associated with the environment. Despite the wide range of discussed aspects, the DBL is broader and, as a result, also its challenges and added value. This wide range of aspects makes it very difficult for many stakeholders to understand the benefits when they are out of their scope of action or boundaries. Developing a business process modelling notation (BPMN) associated with the DBL life cycle was vital as a kick-off to detail the associated main processes (Mêda *et al.*, 2022). The objective was to set a background that enabled further granularity at process, data, and relationship levels.

The vision of the processes and their evolution throughout the construction process life cycle feeds the intuition of the potential relationships with DBP. Complementary, the outcomes from the most recent study on DBL technical guidelines (Grow, 2023) presented a proposal for DBL components where data from regulatory steps is to be collected and managed.

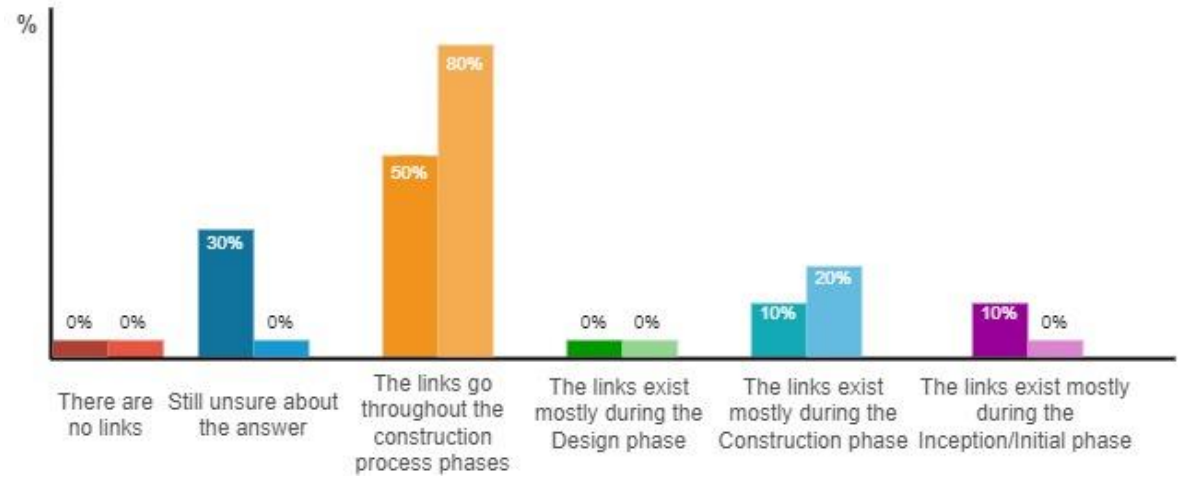

Figure 3: Focus group perception on the existing links between DBP and DBL

Action – Focus Group Workshop

A ninety-minute session was structured to accommodate several activities: two surveys, open questions, presentations, and moderators-led discussions and thoughts on challenges and priorities for future actions, all contributing to the research objectives. The two surveys were placed at the beginning and end of the session to collect quantitative data on the perception of concepts, their relationship, and how the visions evolved (see Figure 2). Figure 3 provides an overview of the respondents' visions and how they shifted during the session regarding the relationships between DBP and DBL. Darker colours (the left ones) represent the results from the first survey, and the lighter ones are the results from the second.

Interestingly, the answers point to evident links between the two concepts despite the fuzziness of the first survey on how they materialise during construction. In the second survey, most identify links throughout the construction process phases. It is one of the aspects worth further discussion.

The presentations mainly used contents already detailed in the diagnosis section. The objective was to harmonise the knowledge level regarding DBP and DBL. Several topics were raised during the discussion. Notwithstanding and for the purpose of the research, it is relevant to stress the shared thoughts associated with "Information Requirements", "Common Processes", and "Stakeholders".

When asked to share thoughts regarding the information requirements of DBP and DBL, many stated that DBP will have most of the requirements defined by regulations. At the same time, DBL seems to be more open regarding requirements. Depending on the evolutions and business models, a more risk-driven approach might be applicable. Given the wide range of situations these concepts can cover, defining a minimum set of information requirements was mentioned as needed, followed by mechanisms to assess the reliability of the information presented. The discussion also approached the existing knowledge and standards developed for Building Information Modelling (BIM). In this respect, it was found relevant to try "not to reinvent the wheel" and, in opposition, make all efforts to use the existing standards related to information requirements as they are or with updates.

A general consensus was observed regarding the existing links with Geographic Information Systems (GIS) when debating the common processes. A large majority of the participants shared that despite the wide range of processes surrounding permits, "DBP itself can be an integrated part of the DBL process". This declaration was a surprising insight, considering the objectives. To conclude, it is worth highlighting that it is assumed that DBP and DBL hold and deal with General Data Protection Regulation (GDPR)-sensitive data. Due to that, both concepts need to consider the processes to ensure GDPR compliance as part of their reference architectures.

To finalise, some thoughts were shared on the stakeholders' engagement: the awareness needs, the training, and the competencies to understand, proficiently apply and operate the technologies and processes surrounding DBP and DBL. Similarly, the previous knowledge and experiences with BIM implementation

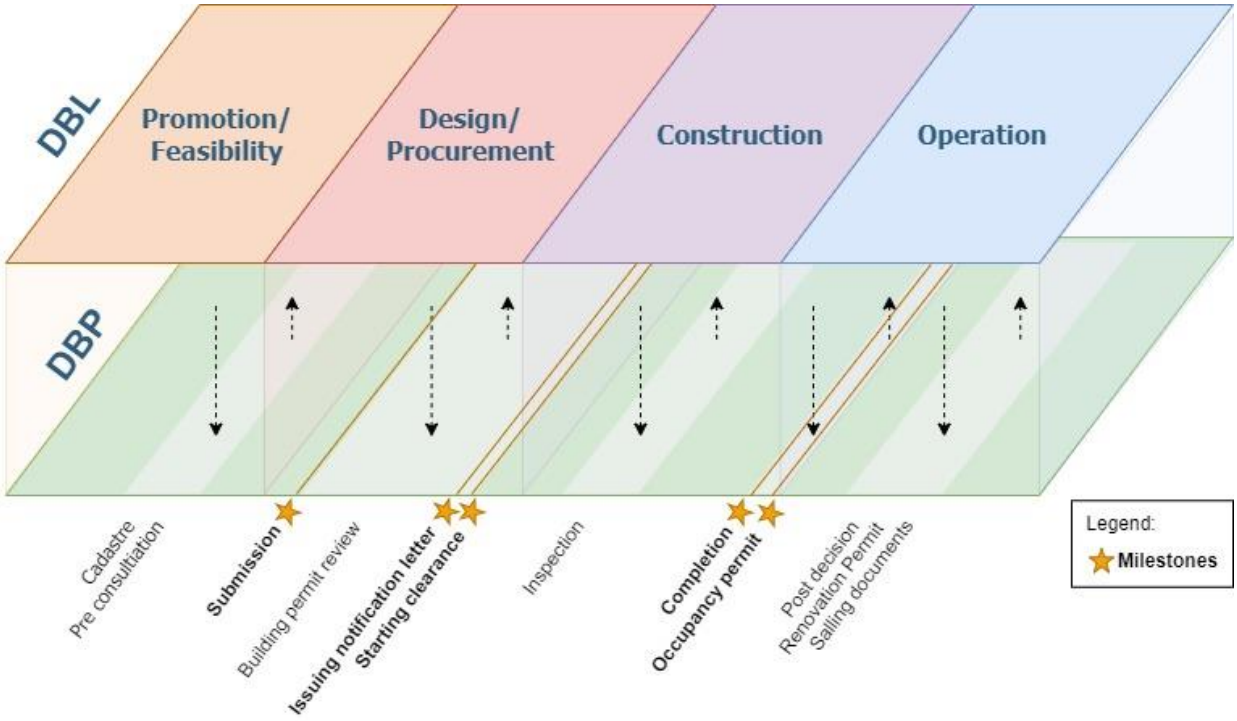

Figure 4: Process-related links between DBP and DBL

were highlighted as relevant to allow shortcuts and anticipate barriers.

Analysis and Discussion

Processes and Phases

It is possible to state that building permit processes are highly country- or even municipality-dependent. Despite this fact, there is the notion that building permitting is associated with verification, meaning that it occurs at a specific moment and often as a milestone belonging to the construction life cycle. In contrast, the processes involving the materialisation of the building logbook are more continuous. Assuming that DBL can work as a Digital Twin enabler, the concept will surpass the construction process life cycle itself, serving the purposes of the construction life cycle. Considering all the visions and statements, it is clear that DBP and DBL are related concepts, and several links throughout the construction life cycle may exist depending on the range of the building permitting processes.

Figure 4 envisages the links between DBP and DBL, using background knowledge from targeted research performed by (Fauth *et al.*, 2023) and (Mêda *et al.*, 2022) and the concerns expressed during the focus group.

Figure 4 presents a high-level framework proposal on how to merge DBL and DBP processes, establishing the data flows between both. Considering previous research, a broad vision of this permit process was considered from the building permit side, where these are required at several moments throughout the life cycle. In this respect, it is worth highlighting the cadastre evaluation and pre-consultations with the authorities to prepare a building application in the early phases and before design. The application adjustments during the review, including compliance checking and authorisation for construction, occupancy permit, and permit prior to a renovation intervention (similar to cadastre pre-consultation when there is a pre-existence and when the permit process starts again).

Looking in detail at one of the possible examples and seeking increased granularity, it is possible to pinpoint a situation during the design phase where the information requirements for the building permit (for example, building permit review performed by the Municipality) will need to be considered for the design development. All elements should be developed or deployed as part of the DBL. Depending on the type of automation, the elements can be sent via DBL or the communication can be enabled with the DBP system, which is managed by the authority. After the analysis, the building permit or the correction notice is sent using the established communication mechanism (as previously and in the opposite direction). The records are kept, and all relevant stakeholders are informed of the results (depending on the individual authorisation). The elements must be centralised or stored in a distributed ledger, depending on the system's architecture.

Requirements and Challenges

As described, the thoughts shared during the focus group were prosperous. They allowed the identification and clustering of common requirements and challenges. Eleven aspects were considered the most relevant to prioritise in terms of what concerns the challenges. Relations to BIM, awareness, training and knowledge, and related services, meaning additional services linked with DBL, and services that must be organised to feed DBP and/or DBL, were identified as the aspects where requirements exist at process, stakeholder and data levels. A second group of challenges was identified, comprising process and stakeholder requirements. These involve governance (existing standards, regulations, use of open standards and BIM, challenges in terms of revising and setting new legal diplomas), the identification and establishment of mechanisms linking existing databases, implementation costs, and all the environment associated with data security and accessibility. One challenge was identified with data and stakeholder requirements related to establishing common terminology for DBP and DBL. Data framework and Information reliability challenges were identified in association with the data level. Finally, the challenge associated with the maintenance of data and curation of the systems throughout the building life cycle was identified as bearing requirements at the process level. Figure 5 overviews the challenges and associated requirements clustered from the focus group inputs.

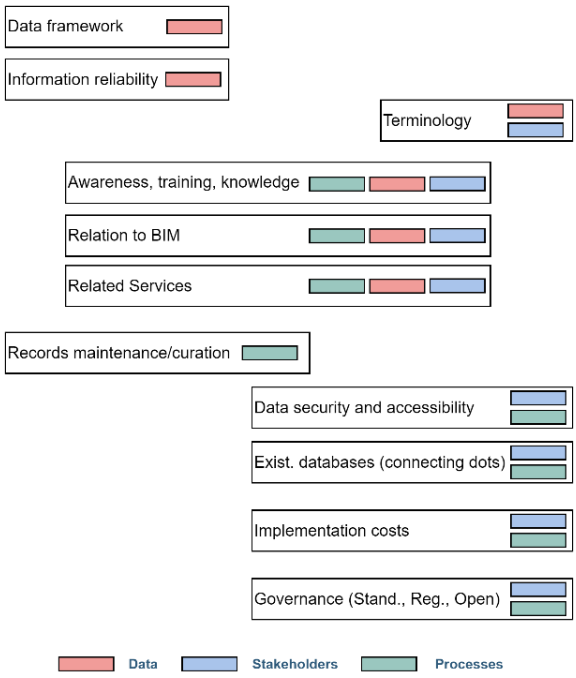

Figure 5: Requirements and Challenges deriving from the cluster analysis of the focus group inputs

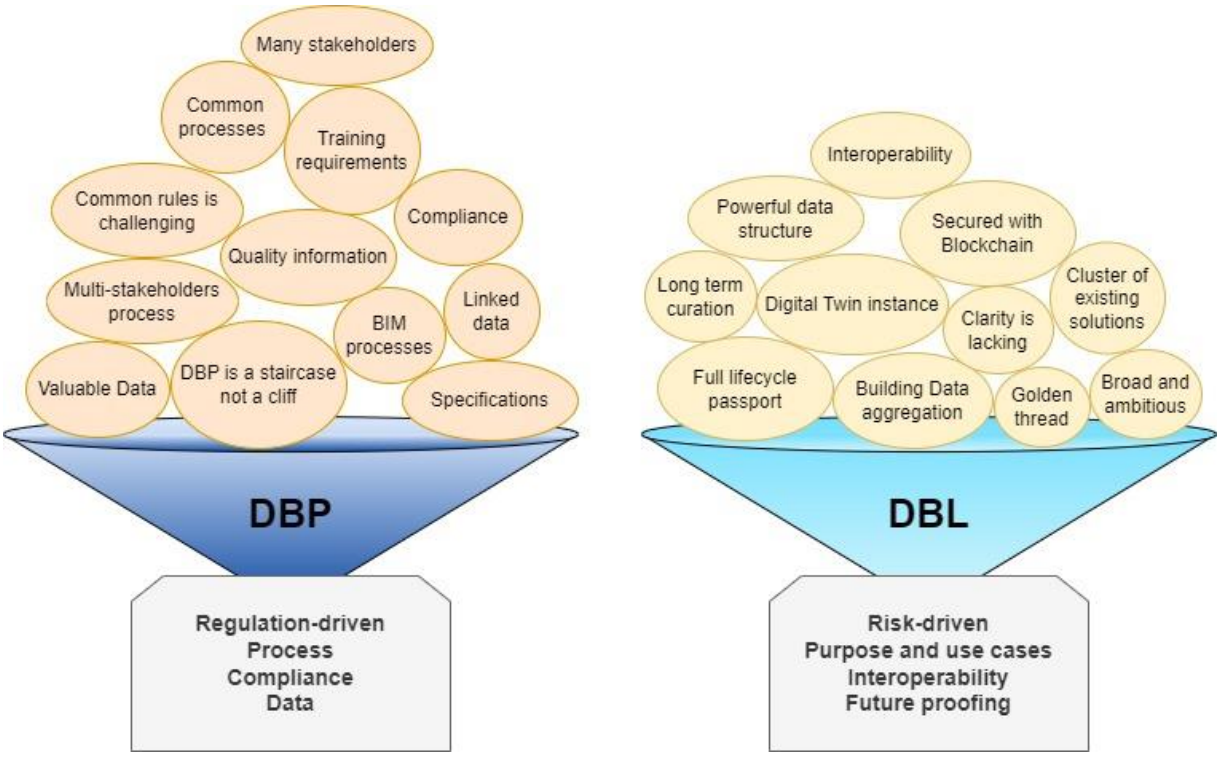

Figure 6: DBP and DBL associated concepts and main clustered characteristics

Conclusions

This research proves that DBP and DBL are related concepts and have several potential interconnections throughout the construction life cycle. Nevertheless, it is paramount to stress that DBP is more time-framed (specific processes). In contrast, DBL is more continuous through the construction life cycle. Combining the findings with previous outcomes, it is worth mentioning that there are no time lags between DBP and DBL as this is deployed together with the idea, and DBP will interact, depending on the range of processes, through the life cycle. This vision is supported by the evidence that the concepts partially share information requirements, relationships with databases, data security and reliability concerns, governance, and curation care (Figure 6).

DBP and DBL can be set as independent systems. However, given the overlaps in their scope and for the sake of digital sobriety, it is relevant to consider a shared landscape for terminology and datasets. This aspect should encompass other systems and concepts. Additionally, it is worth highlighting that the efficiency and complete accomplishment of the objectives of both concepts might be disturbed if there is the need to feed each one manually with data from the other.

From a strategic viewpoint, there can be several benefits from the synergies and proper links and data sharing between DBP and DBL. The implementation challenges will be higher due to the coordination needs from a systems architecture perspective. However, several savings can be achieved in awareness, training, and getting the confidence of stakeholders for use. As discussed, several stakeholders' activities might overlap, meaning adoption can become more straightforward by working correctly with the synergies.

This study's limitations are related to the defined scope and level of granularity. Nevertheless, this was set intentionally to set the background for future and more in-depth research activities. This research focused on specific dimensions, such as processes, data, technologies, solutions, and stakeholders' needs, setting assumptions to work further on the articulation between DBP processes and DBL.

As studies point to the integration between BIM and GIS, DBP and DBL, which are still in their infancy, should benefit from a joint endeavour, contributing to the accomplishment of digital twin transition goals for the built environment and effectively raising most relevant stakeholders into the Construction 4.0 dimension. If building permitting is a critical process in the construction life cycle, using and producing building-related data. Logbooks aim to be golden thread enablers, and complete data traceability implies embedding the digital processes for building permitting as part of the digital logbooks' framework.

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