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Evaluation of design managers' views of decision-making: propositions for situational awareness in building design

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Building design management (BDM) is a complex, iterative, and highly collaborative process, which poses several challenges for design managers (DMRs). One challenge relates to the diversity of the information required for decision-making and the resulting limited situational awareness (SA). The construction industry has shown interest in the SA concept, although its applications have so far remained confined to construction management and production, rather than design or its management. This geographically limited study, which explores decision-making in building design management from the DMR perspective, specifically explores how situational awareness manifests in DMRs' decision-making processes. The research data were collected through a literature review, an expert workshop, and expert interviews. The most interesting findings regarding the applicability of the situational awareness concept in BDM relate to the changing roles of the DMR, the changing balance of decision-making power, and the proposal-based decision-making practices in BDM. In this paper, we propose a novel conceptual framework for situational awareness in BDM, thereby contributing to BDM research and encouraging practitioners toward more holistic development of SA systems, including design. The framework can serve as a catalyst for future construction projects where SA systems are intended to be adopted at the design phase.

KEYWORDS

building, construction, design management, decision-making, situational awareness

1 Introduction

Why should the construction industry be interested in situational awareness (SA) in building design management (BDM)? BDM is a complex, dynamic, and collaborative process (Pikas et al., 2022). A lack of SA of what is happening around the design manager (DMR) or design team, and a lack of understanding of the impact of events and the potential consequences, tend to worsen project performance, collaboration, and customer satisfaction (Adamu et al., 2015; Martinez et al., 2023). SA is a data-driven decision-support concept that enables individuals and groups to understand what is happening and to anticipate future events based on collected data and understanding (Endsley, 2015). BDM as a function requires decisions, so exploring a decision-support concept such as situational awareness in the context of BDM is a relevant line of study. Many researchers and practitioners have shared the necessity of improving the transparency of the building design (BD) process, and SA offers one possible approach that has been tested in numerous fields (Ofte and Katsikas, 2022). To date, however, situational awareness has not been applied to BDM work. To enable further development of situational awareness in BDM, this paper first explores the issues behind the decision-making of design managers (DMRs).

Building design is unique creative work that is tailored to a client's needs (Lawson, 2006). Due to BD's iterative nature, it often conflicts with production (Nwajei, 2021). BD is a progressive and iterative process carried out by interdisciplinary teams (Steele et al., 2000), and a specific problem's design solution is rarely discovered on the first attempt (Lawson, 2006). Most of the time, a solution is sought by trying many different options and interacting with several parties, meaning that BD is difficult to observe and monitor (Viles et al., 2020). The complexity of BD is related to both the design problem and the multiple parties involved in the design (Boyd and Bentley, 2012).

The role of building design management is to lead this unique, complex, collaborative, interdisciplinary, and iterative creative human process (Gray and Hughes, 2001; Lawson, 2006; Lopez et al., 2010). BDM is a prerequisite for successful construction projects. Modern BDM involves interaction and collaboration between individual experts using digital systems, such as building information models (BIMs). Despite the use of digital aids, BDM still relies on traditional methods, such as design reviews, verbal enquiries, commenting, and progress reporting (Winch et al., 1998; Gerbov et al., 2018; Pikas et al., 2020). The DMR's key responsibilities are building a design team (or group in bigger projects), ensuring team spirit, organizing the designers' work and conditions, supporting the designers' work, and making decisions about design issues (Bertelsen, 2004). The DMR's work comprises many different areas, mixing both modern technology and traditional management.

The situational awareness concept has recently been proposed as a possible solution to shift this manual tradition of BDM toward a more holistic use of real-time digital design information (Sacks et al., 2020; Martinez et al., 2023). SA is rooted in decision-making in complex and collaborative dynamic systems. The concept refers to a person's or group's perception of a situation, constrained by human working memory and perceptual limitations (Endsley, 1995). Researchers have proposed several views of SA; the most common type includes three levels: 1) perception of the current situation, 2) understanding of the current situation, and 3) prediction (Salmon et al., 2017). SA has the advantage of reducing uncertainty and ambiguity in dynamic and complex systems through a systematic concept. The SA concept is gaining interest, and several sub-solutions and complete SA systems have been developed and used in different projects to support project management (PM), although SA has not been applied to design managers' work or decision-making in building design management (Lappalainen et al., 2021). The objective of this study is thus to examine DMRs' decision-making processes to comprehend how situational awareness is demonstrated in the decision-making process of BDM. The research question we are investigating is as follows: *How does SA manifest in DMRs' decision-making processes?*

This study's research approach and argument are reversed: in order to study situational awareness in BDM, we first must assess what decisions DMRs make and, while studying this information, to develop a concept (and possibly later a system) for building design that applies situational awareness. This paper first provides a brief overview of BDM and situational awareness. After describing the methods, we present the findings of the thematic analysis and conceptualize a proposal for situational awareness in BDM. After providing a discussion and examining the relevant literature, we present our findings before concluding the paper.

2 Literature review

2.1 Core concepts of situational awareness

Situational awareness models have been developed to manage complex dynamic processes and are typically used in decision-making (Akinci, 2015). SA systems may be described as automated repositories of this complex and dynamic situational data, information, and knowledge, providing a comprehensive view of the present and future for decision-making (Sacks et al., 2020). A concept similar to SA is sensemaking, which describes how people make decisions about the things they encounter and cues they perceive (Jensen, 2007; Linderoth, 2017); sensemaking may be described as a cognitive process that occurs within someone's mind, or as a social process that is facilitated through interpersonal interactions (Fellows and Liu, 2017). Typical sensemaking questions are "What's going on here?" "What assumptions should be questioned?" or "How does this relate to what I saw earlier?" (Baran and Scott, 2010). The connection between these questions and the concept of SA is apparent (*perception* of the situation, *understanding* of the situation, and future *prediction*). Interestingly, sensemaking is often associated with the concept of design thinking (Johansson-Sköldberg et al., 2013). We thus may reasonably assume that the use of situational awareness in BDM should not involve any fundamental impediments. Other typical concepts that individuals or groups can use to induce situational awareness include pattern matching, story building, mental simulation, and various meta-cognitive processes; within the SA concept, the mechanics of these mental processes are considered as part of the formation of SA (Endsley and Garland, 2000).

Within the SA concept, decisions are made with the assistance of the SA idea, both as individuals and as a team. The premise of SA consists of data, information about the situation (and comprehension formed on the basis of that information), and the evaluation of future events. SA is influenced by different factors for individuals and teams. Table 1 summarizes the views and factors found in the literature.

Situational awareness may be analyzed from the viewpoint of an individual or a team. SA can also be shared (by the individuals/team) or distributed (to the individuals/team). This order also corresponds to the evolution of SA research, which started with individual SA and has progressed from the team view and the shared view of SA to the research of distributed SA (Salmon et al., 2017). In terms of SA-based decision-making, the differences between these views also affect decisions. For example, people's SA can be influenced by education and training and by giving people clear goals and roles (Salas et al., 2006). In dynamic environments, however, people rarely make SA-based decisions alone, instead usually involving other people, a team, or a larger group (Shu and Furuta, 2005).

TABLE 1 Views and contributing factors of SA.

View of SA	References	Factors contributing to SA
Individual	Sarter and Woods (1991), Endsley (1995), Smith and Hancock (1995), Bedny and Meister (1999)	Goals, roles, experience, training, SA requirements
Team	Nofi (2000), Perla et al. (2000), Shu and Furuta (2005), Salas et al. (2006)	Shared mental models, cohesion, attitudes, communication, collaboration, trust, team behavior
Shared	Endsley and Robertson (2000), Salmon et al. (2017)	Transactions, understanding the meaning of the information transmitted, sharing relevant data, shared SA requirements
Distributed	Artman and Garbis (1998), Stanton et al. (2006), Salmon et al. (2017)	Transactions, knowledge sharing, reporting, requests, orders, information elements

As the number of people increases, so too do the challenges of acquiring SA. The most typical challenge in team SA involves the differences in understanding between individuals, which can lead to different situational awareness for the same situation. This state of affairs is particularly challenging for decision-making and puts information sharing and communication at the center of the SA (Salmon et al., 2008). For this reason, Stanton et al. (2006) have emphasized that effective communication links between team or group members can be even more important than such links between the team members themselves. In the context of shared and distributed SA systems, in addition to communication, some of the relevant factors that affect SA include transactions, data sharing, and various information-related elements. These linkages are also essential in the context of situational awareness and building design (Sacks et al., 2020).

2.2 Situational awareness challenges in the BDM context

Those engaged in the building design of a project often lack a definitive and cohesive understanding of the desired design. Consequently, both the design process and the design duties may persist during the pre-construction phase (Fellows and Liu, 2017). Obtaining a comprehensive situational awareness of the BD process is therefore a significant challenge for many design managers. For example, due to scheduling constraints, BD-related tasks frequently overlap, resulting in simultaneous work by many parties and the sharing of incomplete information (Tuval and Isaac, 2022). In their case study, Koskela et al. (2002) demonstrated that the BD process is a significant cause of issues in effectively managing a building site; the researchers found that the large number of design modifications often had negative consequences in construction sites, which may be attributed to the multi-tasking paradigm and the overlapping of design work periods with each other and with site operations. The current situation can be quite disordered, and obtaining a clear understanding of the actual situation necessitates a substantial commitment of time from the DMR, as well as a careful examination of signals emanating from many sources.

Ruuska et al. (2011) analysis of the significant project failure of a power plant facility presents another case example. According to the researchers, the project suffered from significant delays; one major reason was the lack of preparedness in the building design and the supplier's underestimation of the required design work for the plant's implementation phase. Notwithstanding the evident BD problem, the work on-site continued, soon incurring significant delays and cost overruns (Locatelli et al., 2014). Ruuska et al. (2011) demonstrated the necessity of using meticulous situation-monitoring techniques for the BD process.

Two primary issues that commonly arise in case studies within the building design context are important to highlight. First, during the BD phase, the iterative nature of the design process itself often hinders the ability to obtain an accurate situational awareness of the design. Second, the common fast-track project management model creates significant overlap between the design phase and the construction phase, which can quickly lead to chaos if the BD situation is not clearly available on-site. This scenario can result in "premature delay syndrome," as elucidated by Flyvbjerg and Gardner (2023), which describes cases where projects fail to overcome the delays experienced during the early design phase, which then persist throughout the entire project.

2.3 Traditional decision-making in BDM

Design managers, like other project managers, make decisions when managing their building design projects. DMRs' decisions are naturally limited to their area of responsibility (i.e., building design), which is often defined as a sub-project of the project itself. According to Marques et al. (2011), the quality of these decisions depends on the decision-maker's ability to assess the current situation in relation to various goals and possible development paths, considering past decisions and events. In dynamic environments such as building design, however, decisions are often not purely rational and are constrained by imperfect knowledge of the present and uncertainty about the future (Williams and Samset, 2010). Decision-making in uncertain projects emphasizes the making of choices: people often consider a good enough and satisfactory (and sometimes intuitive) decision to be sufficient (Isenberg, 1991; Schön, 2017). The time pressures and one-off nature of a project can also easily create a sense of urgency for the decision-maker, and people often perceive decisions as critical, almost irreversible (Bourgault et al., 2008).

Despite the limited studies of design managers' decision-making in the construction domain, researchers have revealed some interesting aspects. First, the DMR is usually not one person, and this role (and the power of the role) often changes during the project (Nwajei, 2021). For this reason, various traits of the different people involved in this task also vary, including their technical and social skills, levels of commitment to the project, personal agendas, egos, work ethics, power to influence decision-making, individual culture, and personal prejudices (Manavazhi, 2004). In terms of decision-making, the role of the DMR shifts from one person to another during building design projects; hand-over points inevitably occur, where information about one DMR's previous decisions must be passed on to the next DMR. Another point to note about this phenomenon is that DMRs' abilities and skills and many other individual factors vary, so managers' ability to make decisions will also tend to vary as the project progresses.

Manavazhi (2004) and Shipton et al. (2014) have argued that DMRs may lack technical competence, and their decision-making is often based primarily on the knowledge of experienced designers and other experts. According to Shipton et al. (2014), DMRs do not necessarily have sufficient authority to make decisions due to a lack of technical competence. Such situations may have influenced the relatively common practice in which decisions related to building design are "pushed" to the client. Winch et al.'s (1998) observations on the "propose and dispose" practice in BDM are relevant to this phenomenon—that is, the DMR presents, and the client rejects or accepts the proposal.

Several different people make decisions at different phases of a construction project. These decisions are typically influenced by various experts and designers. Because of their limited authority, clients often confirm these decisions. DMRs can thus be described as facilitators and knowledge mediators found at the interface between experts and clients (Cairns and Beech, 1999). These observations, combined with the phenomenon of a changing role of the DMR, indicate that decision-making in BDM is essentially a dynamic, living network.

2.4 The project management tradition: the activity-based approach to BDM

The building design process has conventionally been viewed from a project management (PM) perspective. PM is an orderly, predictable activity in which a project is divided into phases, activities, work packages, contracts, and so on, which proceed as a linear process that can be planned and executed according to this predefined plan (Bertelsen, 2004). Even though some have criticized the appropriateness of this reductionist and causal thinking for BDM (Gauthier and Ika, 2012; Pikas et al., 2022), the PM framework is, in most cases, the preconception underlying building design management (Boyd and Bentley, 2012).

In the PM view, in breaking down building design activities, allocating them to the available design resources, and tracking the completion of tasks in a straightforward way, the status of design work can be evaluated and used to support decision-making (Sequeira and Lopes, 2015; Sutrisna et al., 2018). The PM approach to building design management is to manage the time, cost, and quality of design by keeping track of how many drawings or models were delivered on time, how many hours were spent on them, and whether the building design met the quality criteria set for the design. Using a PM perspective can ensure the scope of the design team, although such usage does not guarantee optimal value for the client. The PM model is not an effective method for managing a reciprocal process with intensive interdependencies, chaos, and unpredictability (Knotten et al., 2015). Tvedt and Dyb (2019) and Uusitalo et al. (2021) have argued that "soft" factors such as trust, curiosity, and self-confidence are the basis of a successful building design process and should be evaluated at the same level as time, cost, and quality.

The PM-based model developed in production environments thus often conflicts with the complex, iterative, creative, and unique nature of building design work (Lawson, 2006; Pikas et al., 2022). This conflict may create an experience for production-oriented people (the site team, construction managers, etc.) that BDM is difficult and often fails. Researchers have recognized this problem and have tried to find an explanation for this contradiction. For example, Pikas et al. (2022) have suggested that the emphasis on causality in the theory underlying design models has created this problem, and social aspects in design (such as interpretations) should also be considered. Similarly, Çıdık and Boyd (2020) argue that reductionist thinking in design models is a key part of the problem. Despite pioneering research on identifying the social role of design (Cooper and Press, 1995), the social domain in design has been neglected, with solutions instead focusing on the technical domain (Cox et al., 1999; Boyd and Bentley, 2012). The social interaction of people is a key aspect of BDM that design managers need to recognize.

Decision-making in BDM is often complex and challenging, with varying goals, roles, relationships, and motivations driving design stakeholders (Best, 2010). The project management approach in BDM focuses on predefined tasks (and the management of interdependencies between them) and does not focus on the information needs of these decisions. More information is thus needed on the decisions and decision-making rationale of BDM.

2.5 Situational awareness: the improved decision-making approach in BD

From the world of SA used by individuals to make decisions, a shift has occurred to a world of shared and distributed SA systems, where individuals and groups must make decisions with the assistance of SA systems. In many sectors, decision-making with the assistance of SA systems is already an everyday reality (within aviation, energy production, and military operations, for example), and the construction sector has also taken the first steps toward using SA (Lappalainen et al., 2021). A budding interest in the use of situational awareness has appeared in BDM, which is typically carried out with traditional pre-defined activity-based methods in project management and within complex collaboration in networks and using various digital systems, such as building information models (Adamu et al., 2015; Sacks et al., 2020; Martinez et al., 2023). As Lappalainen et al. (2021) showed in their case study of developers of situational awareness systems in the construction sector, the first steps in SA mostly focus on technology, forgetting the essential purpose of SA in relation to decision-making. In the present study, we thus aim to investigate design managers' decision-making processes in order to understand the manifestation of situational awareness in the decision-making process of BDM. Our research question is as follows: How does SA manifest in DMRs' decision-making processes?

3 Methods

To explore decision-making in building design management from the design manager's perspective, a group of BDM experts were approached to explore their views on this topic. Interviewing experts is an effective method for data collection, especially if the experts have relevant and specific knowledge of a topic and are representative actors of a larger group (Bogner et al., 2009). People with experience in BDM were selected to participate in the study as part of a research consortium between Finnish construction industry actors and academia (a consortium described in Lavikka et al., 2020). At the time of the study, the consortium had 21 member companies, of which 36 experts participated in the workshop. The group was formed from various consortium members, who were selected by the consortium member companies for their building design process and design management expertise.

Nine interviews with DMRs and one remotely facilitated expert workshop were organized. The interviews and workshop were held remotely via video conference (due to COVID-19 restrictions) over an eight-month period. The workshop took place in November 2020, and the interviews were conducted between March 2021 and September 2021. Seven interviewees were volunteers who participated in the workshop and indicated to the researchers their willingness to be interviewed after the workshop. Two interviewees were not employees of the consortium companies and did not attend the workshop; they were from organizations that the researchers had contacts with from previous research projects. Three of the interviewees were women, and six were men. All were experienced DMRs. Table 2 shows the details of the sessions and the interviewees.

The expert group was approached directly with the research questions drafted by the main author and one co-author. The experts were divided into seven groups of six members during the workshop, in which they addressed the interview questions. The groups were randomized by using the feature of the digital video conferencing platform used in the workshop (Microsoft Teams) to randomly assign participants to groups. The expert groups presented their views as a summary through the spokespersons of each group, followed by a short discussion between the researchers and the group to ensure the interpretation of the answers. One-to-one interviews were conducted by the main author using open-ended interviews with a few "probing" questions that focused the interview on design management (Neuert et al., 2021); the aim was to pursue a broader range of individual DMRs' views and their rationales. The interviews and the expert workshop were recorded and transcribed. The quotes in this paper have been edited for clarity in English. Notes were also taken by the researchers during the sessions.

Data were post-processed using the Atlas.ti 9.0 software and the electronic whiteboard software Miro. Post-processing and data analysis were carried out using thematic analysis. This approach is suitable for searching for inductively new information based on and led by the research data in the study, in this case the interviews. Thematic analysis is a qualitative method of analysis and a form of content analysis that requires the researcher to interpret the data (Guest et al., 2012). The use of a systematic analysis method and careful coding enabled the researchers to move back and forth between the themes and the original expressions by the interviewees. The conclusions we drew from the data can thus be examined throughout the process without losing the original expressions, and the research data can be reliably stored.

The analysis phase focused on identifying themes related to building design management expressed by the BDM experts. During the first phase of the analysis, the transcribed interviews were reviewed word by word (however, the words were not counted) and sentence by sentence in detail (during the *familiarizing oneself with the data* step); at the same time, the data were coded with post-processing software. During the coding phase (*searching for themes*), codes were developed for the quotations and expressions (*defining and naming themes*), which were textual descriptions of the identified themes (Neuendorf, 2018). The open codes were sentence-long summaries of what the experts said during the interviews and the workshop about BDM and decision-making.

A total of 368 open codes were generated in the analysis. For example, the citation "But then if you have to make those decisions with incomplete information … and sometimes you have to make them to move things forward" (Code ID 2:57 by Interviewee D8) was summarized as a code: "The DMR must make decisions with incomplete information." These individual codes were then summarized by combining concepts with similar meanings into themes. Themes emerged as code groups by logical induction, linking codes by following the connections between the codes.

During the next phase, the researchers reviewed, refined, and rationalized the themes (*defining the main themes*). The main themes were identified through the connections between themes composed of codes: the number of identifiable relationships between themes guided us to the main theme and enabled it to be described. If few or no relationships existed, then the themes did not emerge as main themes. Finally, an integrative synthesis and conceptual clusters were created based on the themes induced by expert expressions of design management and the literature. The researchers collaborated in group to evaluate the interrelations and significances of the themes, subsequently employing a visual mind-mapping tool (Miro software) to illustrate the clusters and thematic links. The coherence of the created patterns was evaluated by the researchers, and the alignment of these patterns with insights derived from interviews and the literature review was examined. This repeated procedure culminated in the development of the final figures.

The principles of axial and selective coding to construct the framework were utilized (Vollstedt and Rezat, 2019). This procedure occurred prior to the final diagram in the figure, where various themes within the clusters were interconnected by lines, resulting in the formation of groups with shared characteristics. From these interrelated topics, a summary, referred to as a cluster, was constructed. A cluster essentially represents a synthesis of interconnected ideas, addressing the question of their collective significance. The definition of clusters was constrained by the necessity for the summary to be pertinent to the study problem. Given that the descriptor linked by dashes more accurately represented the research process, we opted to eliminate the dashes and present the clusters and themes without

TABLE 2 Expert interviewees.

Sessions	Code	Job title	E	DUR	Data
Workshop	EXP	Several titles (N = 36)	N/A	1:22	R/8T
Interview 1	D1	Project manager (construction company)	24	0:53	R[a]/3N
Interview 2	D2	Construction manager (construction company)	20	0:38	R[a]/3N
Interview 3	D3	Senior consultant (engineering office, industrial)	40	0:49	R/12T/3N
Interview 4	D4	Project manager (construction management company)	19	0:41	R/12T/4N
Interview 5	D5	Design director (construction management company)	26	0:40	R/11T/4N
Interview 6	D6	Project manager (construction management company)	9	0:48	R/13T/4N
Interview 7	D7	Project manager (engineering office, structural)	10	0:40	R/11T/4N
Interview 8	D8	Design manager (engineering office, HVAC)	13	0:55	R/13T/5N
Interview 9	D9	Lead designer (architectural office)	25	0:53	R/13T/4N
Mean			20.7	0:49	

[a]The recording does not include the voice of the respondent due to quality problems during video conference.
Note: E, professional experience in years; DUR, duration of the recording; R, video recording; T, pages of transcription; N, pages of notes.

them. The proposition was derived from the same graph featuring connecting arrows, but we streamlined this graph by restricting the topics to the situational awareness concept. Both descriptions stem from interconnected themes, initially perceived as clusters and subsequently as propositions aligned with the situational awareness concept. The employed technique enforces selectivity, prioritizing variables and elucidating the linkages among them (Miles et al., 2014; Ravitch and Riggan, 2016). The aim of the synthesis was to present empirical findings on DMRs' decision-making and to link the findings (through cluster view and concept view) to previous research literature for conceptualizing the proposal of situational awareness in design management.

4 Findings

Table 3 shows the code groups we identified, the number of open codes they contained, and sample quotes for each code group. The top of the table includes the code groups with the most open codes, while the code groups at the bottom have the fewest codes. Themes in bold in the table represent the code groups from which the main themes were drawn.

Table 4 presents 11 inductively formulated and refined main themes. The number of open codes linked to the main theme is shown on the right side of the table.

Clusters formed by the distinct implications between the main themes are presented in Figure 1. In the figure, the first four main themes of BDM form four clusters related to the research question: 1) findings affecting the DMRs' decision-making ability, 2) findings related to aspects of DMRs' management of building design work, 3) findings related to the role of the DMRs, and 4) findings related to the decision-making of the DMRs.

Figure 1 reflects several important findings from the interviews. First, the results of the interviews suggest that the DMRs' role changes during the project; at the same time, the balance of decision-making power changes. For example, one interviewee described how such a role "drifts": first, during the design phase, the role and decision-making power of the DMR is held by a representative of the design team (often the lead designer), but starting with the procurement phase, the role may shift to the construction consultant and, as the site starts, increasingly to the site organization. Second, this study revealed another finding related to the constraints on decision-making power among DMRs: they rarely make major decisions alone or with designers. Instead, decision proposals are typically prepared with the assistance of experts and presented to a client, who then makes the final decision. Third, we asked probing questions during the open interviews, one of which was related to the education and training the building design managers had undergone for their role (see Tables 3, 4; Figure 1). Their answers varied, although most respondents expressed that they had not received much training specifically related to BDM; they had mainly learned their skills in BDM on the job.

5 Conceptual proposition of situational awareness of BDM

Based on the interviews and literature review, the concept of the situational awareness of building design management is structured around four main clusters, including findings related to (1) DMRs' decision-making abilities, (2) aspects of DMRs' management of building design work, (3) DMRs' role, and (4) DMRs' decision-making. The proposed concept combines Endsley's (1995) tripartite

TABLE 3 Summary of code groups of DMRs' decision-making.

Theme	NOC	Sample quotes
Decision-making	129	We have specialist designers who know best how things have developed, and then they expect me to decide what to do. But based on their knowledge, I basically prioritize [that decision].—Interviewee 8
Client	44	[We engage in] decision-making together with the client.—Interviewee 3 I'll then decide what to present to the client.—Interviewee 8
Schedule	35	Decisions are traditionally based on a mutually agreed-on timetable, and then on the available design budget and hence the resources available. And based on those factors, decisions have to be made and information has to be gathered.—Interviewee 7
Cost	32	The design management must be able to meet a user's needs within the budget that's been allocated to that specific building component or system or space.—Interviewee 4
Education	29	[BDM] is knowledge acquired through practice.—Interviewee 3 [BDM] is mostly self-learning and watching senior project managers, how they operate through mentors.—Interviewee 8
Quality	28	You should know the goals that have been set for the design in order to decide whether the quality is sufficient.—Interviewee 9
Information	26	We have to do a bit of fishing for that information.—Interviewee 4 Making decisions feels awful when you do not have enough information.—Interviewee 7
Expectations	17	Efficiency is the first thought that comes to mind—the burning question of how quickly in the process to get those decisions out.—Interviewee 5 Sometimes it feels like when you ask for a decision, you expect to get it right away. But things do not usually work that way.—Interviewee 6
Problems	17	If you have to depart from the standard phasing, you'll find that it's not what you want and that it can cause challenges. You have to at least try to be very systematic and clear about reversing and moving forward.—Interviewee 6
Management	16	[BDM] is a whole lot of managing people.—Interviewee 5 [BDM] is simply the management and breakdown of those tasks.—Interviewee 7
Methods	14	The first decisions that come to mind [are related to] how you manage the team, how to meet and how to report or managing its quality assurance procedures.—Interviewee 5 I do not use methods that would steer that decision-making, at least not consciously.—Interviewee 9
Managing people	13	We imagine ourselves to be very rational. But we're playing with people's emotions quite a lot, and there's no getting away from that.—Interviewee 3 I've learned a lot of lessons from a retired former head of the department, who was more of a people manager.—Interviewee 8
Collaboration	12	[The design manager] is a joint role between the client, the user, and then the designers.—Interviewee 4 There was a lot of talk about the task of coordination, how to get all the design disciplines to work together.—Expert workshop
Alternatives	11	I've always tried to say that if the client should decide something, then you should always present some alternatives, and list the pros and cons of those options.—Interviewee 6
Specifier	11	Managing the design process involves [the design manager] leading the process and setting the guidelines for scheduling and costs and quality and the various project management procedures.—Interviewee 5
Changes	11	When the client wants something different from what's been decided, the schedule and costs are affected.—Interviewee 8
Right expertise	10	[BDM involves] prioritization, letting the right people do the right things.—Interviewee 3 In terms of design teams, decisions were made about team building, resourcing, sourcing the right skills for the job.—Expert workshop
Learning at work	9	I do not know if training has any benefit, but I would say that most of it comes through experience. Of course there are all kinds of training courses, and I've been to them and they have good stuff, but I feel that the best learning comes through experience and practice.—Interviewee 7
Decision proposal	9	I do not make the decisions. I make the proposals, and the client makes the decisions. We only make the proposals for both the user and the client.—Interviewee 4
Support for decision-making	9	At the design stage, most of the decision support comes from the designers from the site, especially in the construction phase, where that information is provided.—Interviewee 6

(Continued on the following page)

TABLE 3 (*Continued*) Summary of code groups of DMRs' decision-making.

Theme	NOC	Sample quotes
Meetings	9	It usually requires that there's time for a meeting, and then the team or the client decides on how to do it.—Interviewee 6 In a way, the meeting minutes provide the kind of information that the design manager can use.—Expert workshop
Sufficiency	8	The design manager also decides whether sufficient coordination has taken place.—Interviewee 9
Lean	8	In my opinion, the Last Planner System works well. It makes visualizing when decisions should be made easier.—Interviewee 6
Business	8	[BDM] is a business, too. Yes, money is involved.—Interviewee 3 Economic viability is among the main criteria that we monitor here to ensure that the project is also financially viable for us.—Interviewee 8
Prioritization	8	[BDM] is also prioritization in a certain way, where the design manager evaluates whether [a decision to be made] will go to our decision-making bodies.—Interviewee 5
Target value design	7	[Target value design] will make things much easier and will enable deliberate and well-informed decisions.—Interviewee 6
Comparing designs with targets	7	The targets are created at the beginning, so of course they're mirrored by the decisions that follow.—Interviewee 5
Speed	7	If you make a hasty decision, it will quickly cause costs in the design project. And then, even worse, if that decision makes it through to the construction phase, it will cause costs there as well.—Interviewee 8
Decision-making with insufficient information	7	Sometimes you have to make decisions with incomplete information to move things forward.—Interviewee 7

Note: NOC, number of open codes linked to the code group. The quotes have been edited and condensed for clarity in English.

structure with various distinct features related to DMRs' decision-making, highlighted both in the literature and in the interviews, especially the client's role in decision-making, decision-making based on uncertainty, DMRs' changing roles during projects, and information and support for decision-making produced by designers.

The research literature supports these clusters and related themes derived from the interview data. In particular, the changing nature of the role, variations in decision-making power (either due to the stage of the project or the client), the client's ultimate decision-making power, and pressure to make decisions without sufficient information have also been noted in previous research; these phenomena were incorporated into the conceptual framework. In line with previous concepts based (for example) on an information manager (Kärkkäinen et al., 2019) and partial solutions based on technological methods (Lappalainen et al., 2021), the proposed concept in the present study was created based on interviews with experienced DMRs and research literature related to decision-making in building design management.

The three stages according to Endsley's (1995) situational awareness concept—*perception*, *comprehension*, and *projection*—are illustrated in Figure 2. The design process is the first stage; *perception* relates to the information obtained from the design process, which we describe as different potential measurable indices known from previous research and practice (e.g., Tribelsky and Sacks, 2010; Uusitalo et al., 2021). The second stage of SA (*comprehension*) includes the BDM decision-making and the main themes that support those decisions. In the proposed model, the situational awareness of BDM is created from four characteristics related to BDM decision-making: 1) decision-making with insufficient information, 2) decision permanence, 3) the timeliness of decision-making, and 4) proposals subordinated to the customer's decision-making. The right side of the figure shows four potential indices, which could serve as key metrics for decision-making in building design management by expressing the status of decision-making in that field. The concept has a typical feedback loop as an essential element, which in this proposal is connected from the design manager to the designers. Nothing prevents connecting a similar feedback loop from the DMR's decision-making to the construction site or the client as well, however, as proposed by Pikas (2019). The *projection* stage, located in the lower part of the figure, is supported by decisions from DMRs and clients, as well as analytics and forecasts associated with the design work.

The indices shown in Figure 2 are based on methods presented in previous research and in practice; for example, various questionnaires have been used to measure the social domain of building design work, including collaboration, communication, trust, and team chemistry (Thomson et al., 2009; Chiocchio et al., 2011; Uusitalo et al., 2021). The analytics and use cases of the technical domain have been described by Sacks et al. (2020), Tribelsky and Sacks (2010), Petrova et al. (2019), Lappalainen et al. (2022), and Kenley and Seppänen (2009), among others. Nassar and AbouRizk (2014) have proposed an integrated model of these indices, while Guillemette et al. (2014) and Wen et al. (2018) have developed indices related to decision-making.

TABLE 4 Main themes of DMRs' decision-making.

#	Main theme	Themes included in the main theme	Cluster in Figure 2	NC
1	DMRs' decision-making ability	Expertise, Experience, Education, Mentoring, Learning at work	1	46
2	Managing designers' work	Resourcing, Right experience, Managing people, Management, Job counseling, Communication, Opinions	2	100
3	The role of the DMR	Roles, Problems, Client, User, Customer satisfaction, Collaboration	3	115
4	DMRs' decision-making	Decision-making, Decision-making process, Decision-making takes time, The decision holds, Prioritization, Decision proposal, Support for decision-making, Decision-making with insufficient information	4	143
5	Comparison of alternatives	Proposing solutions, Comparing designs with targets, Design solution, Construction solutions, Production methods, Alternatives, Comparison, Prerequisites for decision-making, Selection of the implementation method	3	32
6	A shared, informed view of unique needs and expectations	Uniqueness, Specifier, Expectations, Information, Shared vision, Expectations, Needs	3	125
7	DMRs' decision-making methods and tools	Meetings, Document, Reporting, Contracts, Methods, Tools, Last Planner, Lean, Target value design, BIM	4	57
8	Management of change	Design process, Coordination, Changes, Rework design	3	57
9	Design management under time pressure	Schedule, Progress, Prediction, Timeliness, Tight schedule, Rush, Urgency to open a construction site, Speed, Gate review, Progressing despite the difficulties	3	69
10	Design quality management	Quality, Deviations, Errors	3	35
11	Design cost management	Cost, Business, Sufficiency	3	50

Note: NC, number of codes.

6 Discussion

The role of the BDM can be described in terms of an expert-manager-user triangle, as described by Cairns and Beech (1999): the DMR role is a facilitating messenger between the client and the experts. The emphasis on communication alone in BDM can be a mistake, however, because the differences in power relations and knowledge vary among these three roles (Cairns and Beech, 1999). In this study, the informants were from one country, and their opinions were influenced by the local model of building and construction, where the construction management consultant typically has a strong role as a design lead. On the other hand, Al Nahyan et al. (2019) have observed a similar change in the balance of power that varies during a construction project and the effects on management, communication, coordination, and information sharing; this phenomenon seems not to be country- or market-specific. Changing roles and alterations in decision-making power and proposal-based decision-making processes require the adoption and acceptance of varying management styles at different phases of the project. This scenario is also noteworthy for situational awareness in BDM: changing roles and people and alterations in power structures should be considered in a different way than in static role-based environments where SA is used (e.g., aviation, energy production) and cannot be ignored when the applicability of the concept of SA is being considered for wider use in the construction industry.

A significant part of problem-solving for building design experts is using experience and knowledge in their day-to-day work; experience enables the search for knowledge about the problem at hand and allows people to generate a limited set of alternatives or hypotheses rather than spending time and energy trying to work out detailed clues. This strategy is what distinguishes novices from more experienced BD experts (Orasanu and Connolly, 1993). This interesting finding of DMRs' experience-based learning is consistent with work by Emmitt (2016), who has stated that qualification for BDM does not occur through education but rather is a skill acquired through the experience of designers. Workplace-based practical learning focuses on work-related tasks, and the experience gained from such learning is context-bound and contains situation-specific tacit information (Tynjälä, 2008). This finding is relevant in the possible deployment of the situational awareness concept in building design management; the skills of each DMR are based on experience and work context. Therefore, difficulties may be expected in developing a generic solution of situational awareness for BDM.

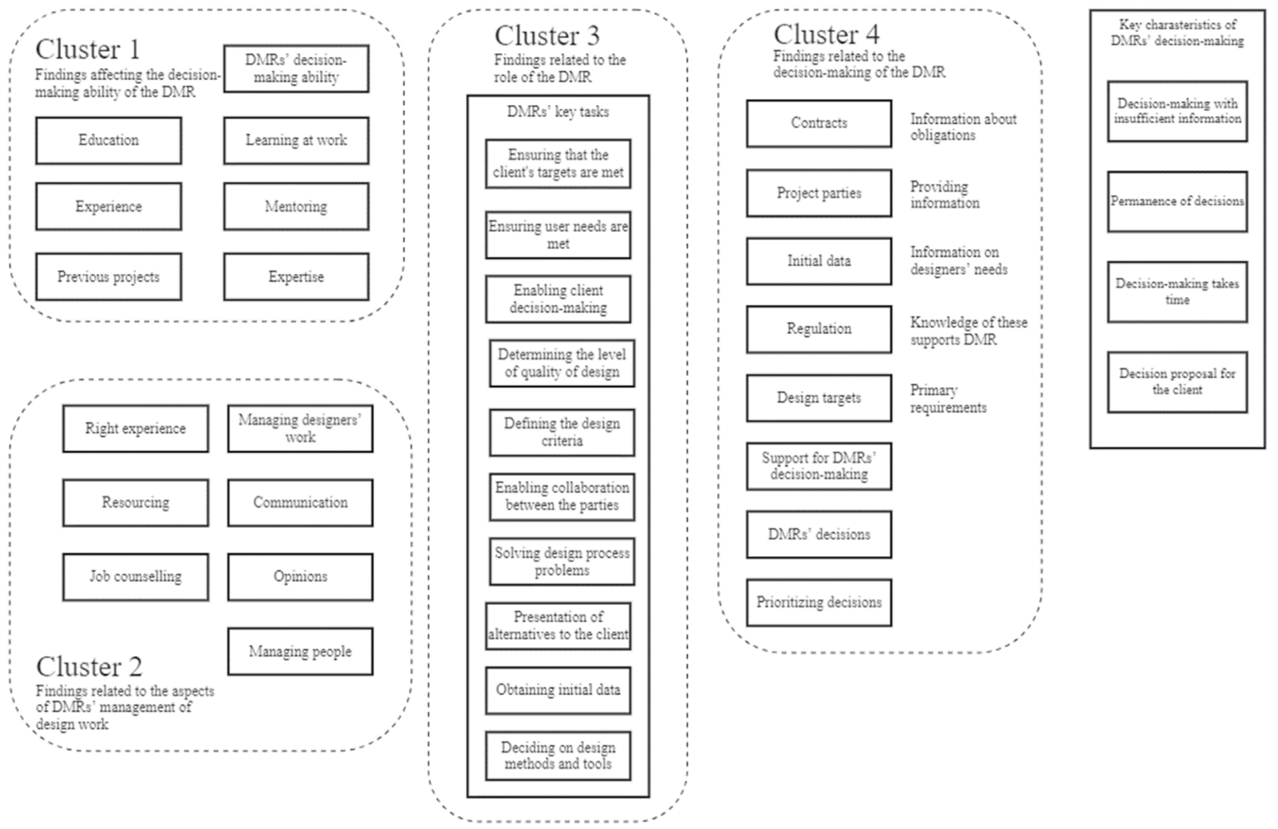

FIGURE 1
DMR's decision-making clusters and key charesteristics.

If the decision-makers and their roles change in BDM, if their decision-making authority varies, and if their experience and expertise vary, then several impediments may arise to the situational awareness concept supporting DMRs' decision-making. This paper highlights this turnover of roles and the variation of expertise, experience, and decision-making authority during the project, recognizing these factors and the information behind the concept. The situational awareness in BDM may therefore stay constant, even if the DMR changes from a designer to a representative of a construction company. The decision-making support the designers provide to the DMR, which is essential for the latter's decision-making, can be adjusted according to the person's experience and expertise. Of course, doing so requires functional social cooperation between the parties, which, in the proposed model, can be measured and monitored with the help of various social domain indices.

DMRs typically make decisions under time pressure, under the "progressing despite the difficulties" mentality. Van der Meer et al. (2020) relate this idea to the characteristic of the process-based approach of decision-making, noting the difficulty of forming a problem state that will reflect all the possible results that can follow from a given decision, the achievement of the goals, the contingencies of the decision and the result, and the probability of different results. Decision-makers therefore often choose the best decision as an alternative that they estimate will have the greatest chance of achieving their goals. Alternatively, the contradictory expressions of DMRs' time pressure and slow decision-making may also be affected by the fact that the design process varies by building type and design field; decisions that people make in the early stages of the process often lack support from sufficient evidence. The designers may later notice that the assumptions they presented at the beginning of the process do not reflect the customer's requirements and thus end up wasting time and effort during these phases (Stanitsa et al., 2022). The use of such an index of decision timeliness or decision delay could potentially reduce the time pressure faced by DMRs, which, in worst-case scenarios, could also lead to decisions that must be changed later in the project.

For decision-makers who often make decisions from practical experience based on insufficient information, SA can be biased. This "quick and dirty" or intuitive decision-making is widely used because decision models related to solving complex problems require more time and effort to be applied. The uniqueness of a project can lead to a lack of reference points for an alternative decision; during project work, making a timely decision is often more practical than spending time optimizing decisions (Wen et al., 2018). The use of such quick and efficient decision-making may also show the difference between an experienced expert and a novice (Orasanu and Connolly, 1993). But previous experiences can influence future decisions, especially when something positive has resulted from a previous decision; people tend to decide in the same way in seemingly similar situations (Juliusson et al., 2005). DMRs'

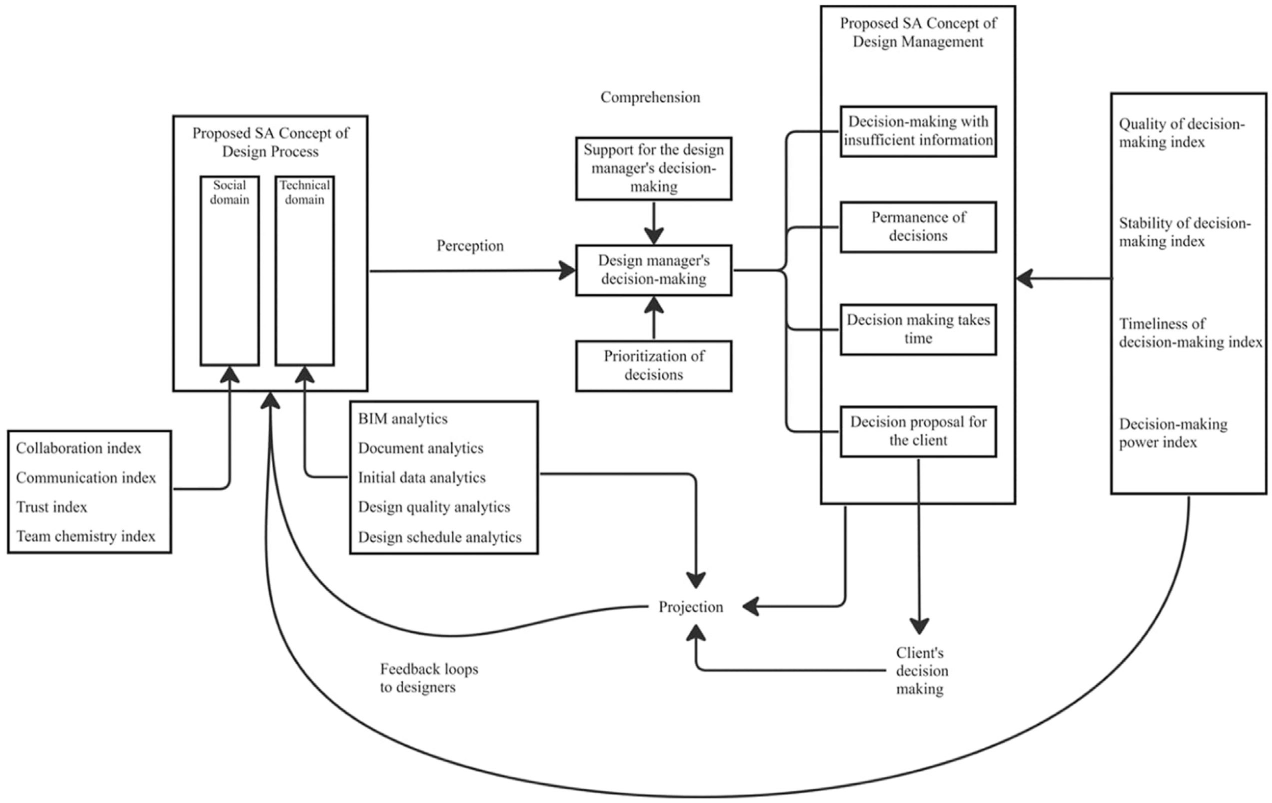

FIGURE 2
Proposal for a situational awareness concept for design management.

decision-making, which is strongly based on previous experience, is also a challenge from the point of view of the situational awareness concept because nothing prevents people from "jumping" over different levels of SA (Salmon et al., 2017). Similarly, an experienced DMR could observe the design situation and remember an earlier event and decide to proceed in this situation in accordance with previous experience; the DMR could in practice jump over the *comprehension* and *projection* steps to the *direct decision-making* step. This phenomenon should be considered when studying the possibilities of SA in design. In the proposed concept of situational awareness in BDM, intuitive decision-making involves deciding things based on uncertain information, for which we propose various indices related to the quality and stability of decision-making.

Due to the uncertain nature of the building design process, DMRs must ensure that designers understand each other. Doing so is not straightforward or standardized, as the design team is made up of personalities and individual experiences. A lack of understanding of this issue often leads to confusion and misunderstood expectations between the design team and the client; DMRs need processes to identify and manage moods and various soft factors (Tvedt and Dyb, 2019).

Due to the complexity of building design processes, in addition to the results of design activities, the focus must be on the relationships between designers. The building design process itself is the joint result of the collaboration developed by the designers during the design phase (Girard and Robin, 2006), although collaboration efforts often focus on the phase's technological side, with limited focus on the soft side (Idi and Khaidzir, 2018). On the soft side of decision-making, facts, information, experience, beliefs, intuition, and prejudice are combined in order for people to make a choice among different options (Bakht and El-Diraby, 2015). The proposed SA concept for building design management thus should include the soft and social factors of such management.

The proposed SA concept we have set out in this study is a technology-independent conceptual framework in which the indicators and data sources we have presented are mostly well known and studied in the construction sector and beyond. The framework can serve as a catalyst for future construction projects where SA systems are intended to be adopted at the design phase. Such applications will require further research, validation, and identification of potential weaknesses of the framework in the real world, which this exploratory study does not cover.

7 Conclusion

The aim of this study was to explore decision-making in building design management (BDM) from the design manager (DMR) perspective; we then aimed to use the findings for the situational awareness (SA) concept and to assess the model's potential usefulness in BDM. Specifically, we aimed to address the research question: *How does SA manifest in DMRs' decision-making processes?* We sought answers from the literature, an expert workshop, and nine open-ended interviews. We analyzed the data using the thematic analysis method, then summarized the main themes to describe the expressions related to DMRs' decision-making. Finally, we set out an inductive proposal for a concept that presents the possible use of situational awareness in BDM. The key findings of DMRs' roles and decision-making are as follows:

1. The DMR role can be played by several people in the same project.
2. The DMR role can be transferred to a different organization at various stages of the project (e.g., from the head designer to the contractor).
3. The decision-making authority of the DMR varies, with the client having the final decision-making power.
4. DMRs often learn their roles through various earlier projects.
5. DMRs make decisions under time pressure, often based on insufficient information.

Especially for developers of SA systems, these findings are essential, since the development of systems into BDM requires the definition of requirements. Based on our findings, these requirements should be requested from several different people in different organizations, and the system should also be able to react to changes in decision-making power over time. This topic is an interesting subject for further research.

The findings can also be interpreted as encouraging in terms of the use of situational awareness in BDM. DMRs often make decisions based on insufficient information. The utilization of SA concepts in other fields is based on the use and interpretation of data and data-based forecasting. We thus may assume that a situational awareness system (which could be developed by considering the special characteristics of BDM) could facilitate the work of DMRs and improve their decision-making by improving the quality of the information underlying decisions, thus also reducing previous experience-related biases related to decision-making.

This study does has several limitations, however. First, thematic content analysis has certain methodological limitations. In particular, the researchers' role as producers of understanding as an instrument limits reliability (Neuendorf, 2018). In this study, our strategy to mitigate such single-perspective bias was to involve several researchers who reviewed and criticized conclusions drawn from the research data. The authors have also attempted to present detailed evidence from the interviews and workshop within the limits allowed by the length of the paper so that readers may evaluate our conclusions, including their validity and reliability.

Another limitation is related to the number informants and their geographical location in one country, which limits their circle of experience to one country and one building culture. The authors are aware of this limitation related to the reliability and generalizability of the research, but we have striven to mitigate this bias by comparing the empirical results with those of the international research literature. In qualitative research such as this paper, a sample size of 45 respondents is very modest; yet, it aligns closely with the recommended range of 20–50 respondents established by other scholars (Marshall et al., 2013), which can be seen in a saturation of responses as the study progressed.

Because the findings also relate to commonly known themes in BDM such as concept making, collaboration, communication, trust, and team chemistry, the study's contribution is independent of geography. Nevertheless, this bias is significant, and further research will be necessary to validate the proposed concept and to ensure that our proposals are sound. A third limitation is the qualitative approach we chose for the study due to its exploratory nature. While researchers have extensively studied decision-making by using quantitative methods, our literature review did not reveal any studies that have focused on DMRs' decision-making or decision-making in BDM. Further quantitative investigations are therefore needed; this study may assist in guiding future quantitative research directions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

EL: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Software, Validation, Visualization, Writing–original draft, Writing–review and editing. OS: Resources, Supervision, Validation, Writing–review and editing. AP: Validation, Writing–review and editing. PU: Validation, Writing–review and editing. AR: Validation, Writing–review and editing.

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