2026 European Conference on Computing in Construction
Corfu, Greece
July 12-15, 2026

NARRATIVES OF DIGITAL TWINS: HOW FRAMINGS SCRIPT GOVERNANCE

Johan Ninan and Ranjith K. Soman
Delft University of Technology, the Netherlands

Abstract

Infrastructure digital twins are transformative tools for managing complex systems. This study examines how infrastructure digital twins are narratively constructed and how these narratives shape governance. Drawing on narrative theory, we analyze 75 academic publications and their framing of digital twins to identify recurring conceptual patterns. The findings indicate that digital twins are beyond mere technical artefacts, rather are embedded in narratives that implicitly script technological function, institutional roles, and governance alignments. There is a need to treat digital twin adoption as a technical innovation and also as an institutional design challenge shaping how infrastructure decisions will be made.

Introduction

Digital twins are increasingly promoted as transformative tools for the planning, operation, and governance of infrastructure systems (Keskin et al., 2022). Across transport networks, water management, and energy systems, digital twins are expected to improve performance monitoring, predictive maintenance, and long-term asset management (Pan & Zhang, 2021). In this sense, they are often presented as key enablers of data-driven infrastructure governance. Yet research on digitalization in the construction sector has consistently shown that the success of digital technologies depends not only on technical capability but also on their integration into organizational practices, professional roles, and institutional decision processes (Miraj et al., 2025). Studies of building information modelling and related technologies demonstrate that implementation outcomes are shaped by how tools are interpreted, embedded, and governed within organizational life, rather than by their technical sophistication alone (Datta et al., 2020). This suggests that the way emerging technologies are conceptualized may influence how they are specified, procured, and ultimately used (Broo & Schooling, 2023).

The rapid expansion of digital twin research has resulted in a focus on defining what a digital twin is, identifying technical architecture, or assessing potential performance benefits (Jiang et al., 2021). Much less attention has been paid to how digital twins are conceptually framed in practice. In particular, little empirical work examines how infrastructure digital twins are described in academic discourse and what these descriptions imply about users, responsibilities, and decision processes. This is a significant gap, because the language used to characterize new technologies often shapes how problems are understood and how solutions are designed (Ninan et al., 2022). The paper therefore asks: How are infrastructure digital twins conceptually framed in academic discourse, and what institutional assumptions do these frames imply for their governance?

The aim is to contribute to an understanding of digitalization in infrastructure sectors by highlighting the role of conceptual framing in shaping technological expectations and institutional integration. In the literature review section, we review literature on digital twins in infrastructure and the role of narratives in technologies. Following this, we detail the methodological choices relating to the use of academic literature, search criteria and highlight how data was collected and analyzed. In the findings section, the dataset is summarized and in the discussion section the conceptual categories are argued. The conclusion section summarizes the findings from this research and emphasizes the theoretical and practical contributions before highlighting the limitations and scope for future research.

Literature review

Digital twins in infrastructure projects

Digital twins have rapidly emerged as a central concept in the digital transformation of infrastructure projects and support predictive maintenance, optimization, and long-term planning (Ham & Kim, 2020). They have potential to improve operational efficiency, sustainability, and system reliability by linking physical assets with continuously updated digital representations (Kaewunruen & Lian, 2019). Digital twin research in the built environment spans multiple strands, including framework development, technical integration, and case-based applications (Broo & Schooling, 2023). Much of the literature categorizes studies into technical modelling approaches, implementation architectures, or application domains such as asset management and smart cities (Keskin et al., 2022). Similarly, work focusing specifically on civil infrastructure emphasizes issues such as interoperability, data integration, and lifecycle modelling, reflecting the strong engineering orientation of the field (Jiang et al., 2021). Across these studies, digital twins are typically treated as technical systems that integrate IoT data, analytics, and simulation capabilities.

Olde Scholtenhuis & Soman (2025) challenge this techno-centric framing, showing that many construction digital twins function effectively despite operating with varying latency, fidelity, and levels of automation, suggesting that usefulness depends more on contextual decision needs than on technological sophistication. While existing focus has produced valuable advances in system architecture and modelling techniques, however, the conceptual and institutional dimensions of digital twin adoption remain comparatively under-explored.

While early digital twin research emphasized technical architectures, more recent work acknowledges that digital twins operate within complex sociotechnical environments (Miraj et al., 2025). Scholars increasingly recognize that digital twins affect organizational coordination, professional roles, and governance arrangements, rather than simply providing new computational capabilities (Agrawal et al., 2023). Research in the AEC sector has long shown that digital technologies reshape work practices and decision processes (Ernstsen et al., 2021). Studies of BIM adoption demonstrate that implementation outcomes depend on how digital tools are interpreted, negotiated, and embedded in organizational routines (Papadonikolaki et al., 2019). Similar insights are now emerging in digital twin research, where scholars highlight organizational adaptation, data governance, and institutional coordination as key barriers to implementation (Broo & Schooling, 2023). Digital twin deployment often encounters conceptual ambiguity and difficulties in creating shared understanding among stakeholders (Tripathi et al., 2024). Practitioners and other stakeholders struggle not only with technical integration but also with defining what a digital twin actually is and how it should be used within organizational processes (Kober et al., 2024). Thus, digital twins should be understood as sociotechnical systems whose performance depends on institutional integration and shared interpretive frameworks (Nochta et al., 2021).

A related strand of research focuses on the role of digital twins in supporting decision-making, policy and governance processes (Solman et al., 2022). In smart city and infrastructure contexts, digital twins are increasingly presented as tools for scenario analysis, policy evaluation, and long-term system planning (Ham & Kim, 2020). Digital twins afford multiple possibilities to support public-sector decision-making by modelling complex urban dynamics and enabling scenario-based planning (O'Dwyer et al., 2020). There is a need to understand digital twins as human-technology interfaces rather than purely analytical systems; for instance, studies of construction control rooms show how digital twins can function as collaborative decision environments that enhance coordination and judgement rather than simply automate analysis (Soman et al., 2025). Similarly, research on digital twin ontologies and standards emphasizes the need to align digital twin development with principles such as trustworthiness, public value, and governance transparency (Lavikka et al., 2018; Deng et al., 2021). Thus, digital twins must support technical performance as well as accountability and institutional legitimacy.

Despite these emerging concerns, digital twins are primarily conceptualized as information systems or modelling platforms rather than as environments for structured institutional decision-making (Korenhof et al., 2021). Researchers and practitioners use the term to refer to a wide range of systems, from data visualization dashboards to high-fidelity simulation environments (Nochta et al., 2021). To resolve this ambiguity, typologies, architectures, or maturity models are proposed (Uhlenkamp et al., 2022). Yet few studies examine how digital twins are actually described in discourse or how conceptual metaphors shape expectations about their functions.

Narratives of technology

The role of narratives and framing in shaping technological trajectories are emphasized in construction innovation, particularly on how narratives shape innovation (Ninan et al., 2022). Technologies diffuse based on technical superiority as well as how they are interpreted, justified, and legitimized through narratives that make certain futures appear plausible and desirable (Williams, 2006). Within infrastructure sectors, narratives help manage tensions between innovation and risk, often shaping how stakeholders interpret responsibility, value, and uncertainty (Sergeeva and Ninan, 2023). Conceptual framings therefore influence how technologies are discussed and how they are designed, procured, and governed (Davidson, 2002).

From this perspective, analyzing how digital twins are described can reveal the institutional assumptions embedded in their conceptualization. Language such as "platform," "service," or "dashboard" invokes particular models of interaction and responsibility that originate in software ecosystems rather than infrastructure governance. Although existing research acknowledges the sociotechnical nature of digital twins and the importance of governance considerations, little empirical work examines how digital twins are conceptually framed in academic discourse. Most studies focus on technical architectures, implementation challenges, or application benefits. Few investigate how language constructs expectations about digital twins, what kinds of actors and decisions are implied, or how responsibility and uncertainty are represented. This gap is particularly important in infrastructure contexts, where digital twins must support long-lived systems involving multiple organizations, regulatory constraints, and public accountability. Conceptual framings that emphasize software metaphors may obscure these institutional realities and shape design priorities in ways that misalign with governance needs.

Research setting and method

The present study adopts a qualitative interpretive design to examine how infrastructure digital twins are conceptually framed (Gephart, 2004). Conceptual framing is understood here as a sociotechnical process

through which technologies are described, interpreted, and rendered meaningful. Such processes are not directly observable in technical artefacts themselves but are expressed through language, metaphors, and descriptive formulations (Goatly, 2004). A qualitative approach is therefore appropriate because it allows the study of how technologies are imagined, positioned, and justified through discourse rather than through measurable performance outcomes (Dyer & Wilkins, 1991).

Academic publications are treated in this study as a discursive arena in which technological expectations and norms are constructed and reproduced. They play an important role in shaping technological trajectories because they influence funding priorities, procurement practices, standards development, and professional education. The way technologies are described in the literature therefore contributes to how they are specified and implemented in practice. The empirical material consists of peer-reviewed publications indexed in Scopus. The dataset was constructed using the search query: TITLE-ABS-KEY ("digital twin as" AND infrastructure) till 31 December 2025. This query was chosen because "digital twin as …" constructions explicitly reveal conceptual framings rather than technical functions. Such phrases tend to appear in definitional passages where authors articulate what a digital twin is understood to be. The search returned 75 publications spanning infrastructure domains including transport, energy systems, water management, and urban infrastructure. The papers represent a heterogeneous set of disciplines including engineering, information systems, urban planning, and construction management. Together, they provide a cross-disciplinary corpus capturing how digital twins are framed in infrastructure research and constitute as a naturally occurring data (Ninan, 2020). The analysis therefore focuses not on the intentions or beliefs of the authors, but rather on how digital twins are represented and what institutional assumptions those representations imply.

The study employs qualitative content analysis with iterative coding (Miles & Huberman, 1994). The analysis proceeded in three stages. Stage 1 involves the identification of framing constructions. All publications were read to identify passages where digital twins were defined, described, or metaphorically framed. Particular attention was given to sentences using the structure "digital twin as …", and these passages were extracted and compiled into a corpus of framing statements. Stage 2 involved coding of conceptual framings. Framing statements were coded inductively to identify recurring conceptual categories. Through iterative comparison, seven dominant framings emerged such as digital twin as product, digital twin as platform, digital twin as service, digital twin as dashboard/interface, digital twin as predictive or optimization system, digital twin as organizational capability, digital twin as decision environment. Each framing category was treated as an interpretive lens through which authors implicitly define the system's purpose, users, and scope. Stage 3 involved coding of institutional implications. The themes were grounded in existing literature for validation.

Findings

The analysis of 75 infrastructure digital twin publications reveals three empirical patterns such as dominance of software metaphors, marginalization of decision processes, and absence of governance-centered framings. These are described below.

Dominance of software metaphors

Across the entire period from 2017 to 2025, digital twins are overwhelmingly framed using software- and computation-oriented metaphors. Early publications establish this pattern clearly, presenting digital twins as virtual replicas, models, or services that mirror physical systems. For example, Borodulin et al. (2017) describe manufacturing processes as being "accompanied by virtual models – Digital Twins," emphasizing that these models should be implemented as "independent computational service[s]." In this framing, the digital twin is conceptualized primarily as a software artefact that represents and simulates the physical world. This metaphorical emphasis persists in subsequent years. Kudriashov and Markov (2019) frame digital twins as analytical instruments designed to analyze the behavior of complex technical systems under various operating conditions, reinforcing the idea of the digital twin as a computational lens rather than an organizational or political construct. Even as application domains expand, the core metaphor remains rooted in modelling, simulation, and software execution.

From 2020 onwards, software metaphors become increasingly elaborate and infrastructural. Zibuschka and Ruff (2020) describe digital twins as systems that aggregate data from multiple sources, implicitly positioning them as data platforms. Deutschmann et al. (2021) similarly emphasize integration, noting that digital twins must combine technical, operational, and social components within what they describe as "industrial-social mobility hubs." Despite this broader scope, the language remains grounded in systems engineering and software integration.

Subsequently, software metaphors are further reinforced through references to real-time operation, automation, and scenario generation. Michalec (2025), while critical of prevailing framings, notes that digital twins are commonly promised as systems "able to automatically operate in real-time and generate countless scenarios to advise with planning of new infrastructures." Even here, where the article explicitly interrogates governance, the dominant discourse it critiques remains firmly anchored in computational imaginaries.

Marginalization of decision processes

A second major finding concerns how decision-making is treated in the publications. While many papers state that digital twins support decisions, the decision processes themselves are rarely described, theorized, or problematized. Instead, decision-making is presented as a

downstream activity that benefits automatically from improved models and data. In early industrial literature, this marginalization is particularly pronounced. Borodulin et al. (2017) focus extensively on simulation orchestration and scalability but make no reference to who uses these simulations or how decisions are made on their basis. Similarly, Kudriashov and Markov (2019) emphasize system analysis without specifying decision contexts, actors, or institutional settings. As digital twins are increasingly linked to complex systems, decision-making begins to appear more frequently, yet still in a limited form. Deutschmann et al. (2021) acknowledge the socio-technical complexity of airports but do not elaborate on how conflicting objectives or interests are negotiated through digital twin systems. Decision-making is implied rather than examined.

By 2022 and 2023, several publications explicitly reference uncertainty and coordination, which implicitly presuppose decision-making under conditions of risk. Barat and Kulkarni (2022) frame digital twins as responses to "environmental uncertainties and hyperconnectivity," suggesting that they play a role in navigating complex choices. However, the publications do not specify decision rules, accountability structures, or the distribution of authority.

More explicit references to decision-making appear in the most recent publications, yet even here the process remains under-specified. Fett and Wilking (2025) state that digital twins offer support of decision-making processes, but do not clarify whose decisions are supported, how conflicting values are addressed, or how responsibility is allocated. Decision-making is treated as a technical function rather than a social or political practice. The marginalization of decision processes is particularly notable given the increasing scope and influence attributed to digital twins. As these systems are positioned as tools for planning infrastructure, managing energy systems, or shaping urban environments, the lack of attention to how decisions are made, contested, and legitimized becomes a significant analytical gap.

Absence of governance-centered framings

The third and most striking finding is the persistent absence of governance-centered framings across the dataset. Although many papers deal with domains that are inherently governance-intensive, such as energy systems, urban infrastructure, and sustainability, governance is rarely named explicitly and even more rarely analyzed.

In early publications between 2017–2019, governance is entirely absent. Digital twins are framed as internal tools for firms or engineers, with no reference to regulation, public accountability, or collective decision-making. This absence reflects the technical orientation of early digital twin research communities. From 2020 onwards, governance-relevant issues begin to surface indirectly. Zibuschka et al. (2020) discuss data aggregation, while Deutschmann et al. (2021) describe industrial-social mobility hubs, implicitly raising questions about coordination and oversight. However, these issues are not framed in governance terms.

The clearest engagement with governance appears in a small subset of recent publications. Michalec (2025) explicitly critiques the dominant framing of digital twins-as-models, arguing that this framing conceals the politics of data sharing. The paper highlights that debate on ethics and politics remain limited to modelling concerns such as "bias, accuracy or explainability," while broader governance questions are sidelined. Michalec (2025) argues that energy governance should instead focus on "anticipating the reconfiguration of the political and economic relationships enabled by new data sharing infrastructures." Despite this exception, governance-centered framings remain rare. Even sustainability-oriented studies, such as López-Alfaro et al. (2025), frame digital twins as tools for "reducing light pollution and promoting sustainable lighting strategies" without addressing regulatory authority, public participation, or democratic accountability. Sustainability is treated as a technical outcome rather than a governance challenge.

Overall, the findings demonstrate that digital twin discourse has expanded in scope but not in governance awareness. While digital twins are increasingly positioned as central to infrastructure planning, sustainability transitions, and public decision-making, the papers largely avoid explicit engagement with governance concepts. These findings show a consistent pattern across time. Digital twins are predominantly framed through software metaphors, decision-making is treated as a secondary and largely unexamined activity, and governance-centered perspectives are largely absent. This combination suggests that digital twin discourse remains technically sophisticated but institutionally and politically underdeveloped. The persistence of these patterns across multiple publications indicates that they are not incidental but structural features of how digital twins are currently conceptualized.

Discussion

This study sets out to examine how infrastructure digital twins are narratively framed in academic discourse and what institutional assumptions these framings imply for governance. The findings indicate that digital twins are beyond mere technical artefacts, rather are embedded in narratives that implicitly script technological function, institutional roles, and governance alignments. Drawing on narrative theory, we interpret these framings as institutional scripts that shape how technologies are expected to function within socio-technical systems.

Narratives of technological function

Across the literature, infrastructure digital twins are predominantly narrated through metaphors of platforms, monitoring systems, optimization engines, and predictive tools. These framings define the technology primarily in terms of functional capability rather than institutional purpose. Narrative theory suggests that such descriptions do more than communicate features; they establish what counts as the legitimate problem-solving role of technology within organizational life.

By emphasizing simulation, optimization, and real-time monitoring, these narratives position digital twins as instruments for enhancing technical performance. In doing so, they foreground engineering rationality while backgrounding institutional negotiation. This aligns with broader observations in science and technology studies that technical narratives often stabilize innovation trajectories by narrowing attention to calculable functions rather than contested purposes (Bowker, 2008). Within infrastructure contexts, this functional scripting matters because it frames digital twins as solutions to operational inefficiencies rather than as tools embedded in political or governance processes. As a result, literature implicitly constructs digital twins as technologies of optimization rather than technologies of institutional coordination.

Narratives of institutional roles

A second narrative pattern concerns the institutional roles implied by digital twin framings. Actors are frequently described generically as "users," "operators," or "stakeholders," while decision processes remain largely implicit. From a narrative perspective, this abstraction is consequential: it removes the need to specify authority structures, decision rights, or accountability mechanisms. Narratives that present digital twin outputs as automatically actionable insights reinforce what can be termed a technocratic authority script, in which the legitimacy of decisions derives from data visibility rather than institutional deliberation. This pattern resonates with research on socio-technical imaginaries showing how technological visions can naturalize particular governance assumptions without explicitly debating them (Jasanoff, 2015).

In the context of infrastructure systems, this narrative shift is particularly important. Infrastructure decisions typically involve trade-offs between public value, cost, environmental impact, and political priorities (Foerster et al., 2015). Yet when digital twins are framed as providing objective, real-time knowledge, the decision process itself becomes narratively compressed. Responsibility appears to follow from information access rather than institutional authority. Thus, literature implicitly constructs governance as a downstream effect of data rather than as a structured process of collective judgement.

Narratives of governance alignment

The third narrative dimension concerns how digital twins are imagined aligning with institutional arrangements. Much of the literature situates digital twins within procurement cycles, lifecycle management frameworks, or operational integration processes. Governance is therefore narrated as an implementation issue rather than as a domain of institutional design.

Narrative theory suggests that such framings matter because they define the "setting" in which technologies are expected to operate (Coeckelbergh & Reijers, 2016). By embedding digital twins within performance management and efficiency narratives, literature positions them as tools that reinforce existing institutional logics rather than as technologies that might reconfigure them. These echoes work on technological narratives showing how innovations are often framed as extensions of current systems rather than as catalysts for institutional change (Bijker & Law, 1994). The absence of governance-centered farming is therefore not merely an omission but a narrative effect. When digital twins are described primarily through operational and performance lenses, alternative imaginaries, such as digital twins as platforms for public deliberation, regulatory coordination, or cross-sector negotiation, remain outside the discursive horizon.

Taken together, these narrative patterns show that academic discourse does more than describe digital twins; it constructs institutional expectations about them. Literature tends to script digital twins as technologies for optimization rather than coordination, sources of actionable insight rather than inputs to deliberation, and tools embedded in existing institutional structures rather than catalysts for institutional redesign. This interpretation contributes to narrative theory by demonstrating how technological discourse can function as a form of institutional scripting. It also extends infrastructure governance research by showing that governance assumptions are often embedded in technical descriptions long before systems are implemented. In this sense, digital twin narratives shape not only how technologies are understood but also how their governance becomes thinkable.

Conclusion

This study examined how infrastructure digital twins are narratively framed and what institutional assumptions these framings imply for governance. The analysis shows that infrastructure digital twins are predominantly framed using software-oriented concepts such as platforms, dashboards, and services. While these framings may be useful for describing technical components, they risk obscuring the role of digital twins as socio-technical decision environments embedded in organizational processes and governance structures.

Three key insights emerge. First, digital twins are predominantly framed through narratives of technological function that emphasize optimization, monitoring, and predictive capability. These narratives foreground engineering rationality while backgrounding institutional negotiation. Second, narratives of institutional roles tend to abstract decision-makers and compress governance processes, implying that actionable knowledge flows automatically from data visibility. Third, narratives of governance alignment position digital twins within existing procurement and performance structures, thereby reinforcing current institutional logic rather than questioning them. Together, these findings suggest that digital twin discourse performs an anticipatory governance function: it defines how the technology is expected to operate within institutions before those arrangements are explicitly designed. This insight contributes to narrative theory by showing how technological descriptions act as institutional scripts that shape future governance possibilities. It also contributes to infrastructure studies by highlighting that digital

transformation is not only a technical process but also a narrative one, in which assumptions about authority, responsibility, and coordination are constructed through narratives and discourses. Practically, the study suggests that policymakers and infrastructure organizations should treat digital twin adoption not only as a technical investment but as an institutional design challenge. If digital twins are to support strategic decision-making, cross-agency coordination, and public accountability, governance arrangements must be explicitly articulated rather than assumed to follow from technical capability.

The study has several limitations. It focuses on academic discourse rather than implementation contexts, meaning that it captures how digital twins are imagined rather than how they are enacted. Future research could compare these narratives with practitioner discourse, policy frameworks, or project case studies to examine how narrative assumptions translate into institutional practice. Comparative studies across infrastructure sectors or national contexts could also reveal whether governance assumptions differ depending on regulatory environments or political traditions.

Acknowledgments

We would like to acknowledge funding from NWO, DST, and FAPESP.

References

Agrawal, A., Thiel, R., Jain, P., Singh, V., & Fischer, M. (2023). Digital Twin: Where do humans fit in?. Automation in construction, 148, 104749.

Barat, S., Kulkarni, V., Clark, T., & Barn, B. (2022, October). Digital twin as risk-free experimentation aid for techno-socio-economic systems. In Proceedings of the 25th international conference on model driven engineering languages and systems (pp. 66-75).

Borodulin, K., Radchenko, G., Shestakov, A., Sokolinsky, L., Tchernykh, A., & Prodan, R. (2017, December). Towards digital twins cloud platform: Microservices and computational workflows to rule a smart factory. In Proceedings of the 10th IEEE/ACM International Conference on Utility and Cloud Computing (pp. 209-210).

Bowker, G. C. (2008). Memory practices in the sciences. MIT Press.

Bijker, W. E., & Law, J. (Eds.). (1994). Shaping technology/building society: Studies in sociotechnical change. MIT press.

Broo, D.G., and Schooling, J. (2023). Digital twins in infrastructure: definitions, current practices, challenges and strategies. International journal of construction management, 23(7), 1254–1263.

Coeckelbergh, M., & Reijers, W. (2016). Narrative technologies: A philosophical investigation of the narrative capacities of technologies by using Ricoeur's narrative theory. Human Studies, 39(3), 325-346.

Datta, A., Ninan, J., & Sankaran, S. (2020). 4D visualization to bridge the knowing-doing gap in megaprojects: An Australian case study. Construction economics and building, 20(4), 25-41.

Davidson, E. J. (2002). Technology frames and framing: A socio-cognitive investigation of requirements determination. MIS quarterly, 329-358.

Deng, M., Menassa, C.C., and Kamat, V.R. (2021). From BIM to digital twins: a systematic review of the evolution of intelligent building representations in the AEC-FM industry. Journal of information technology in construction, 26 (5), 58–83.

Deutschmann, A., Schier-Morgenthal, S., & Kaltenhäuser, S. (2021). Digitaler Airport Zwilling–Herausforderungen bei der digitalen Transformation von Flughäfen im Kontext des Airportmanagements. Automatisierungstechnik, 69(12).

Dyer Jr, W. G., & Wilkins, A. L. (1991). Better stories, not better constructs, to generate better theory: A rejoinder to Eisenhardt. Academy of management review, 16(3), 613-619.

Ernstsen, S. N., Whyte, J., Thuesen, C., & Maier, A. (2021). How innovation champions frame the future: Three visions for digital transformation of construction. Journal of construction engineering and management, 147(1), 05020022.

Fett, M., Wilking, F., Goetz, S., Wartzack, S., & Kirchner, E. (2025). Utilization of RFLP in V-Model methodology for the interdisciplinary development of Digital Twins. Forschung im Ingenieurwesen, 89(1), 28.

Foerster, A., Macintosh, A., & McDonald, J. (2015). Trade-offs in adaptation planning: protecting public interest environmental values. Journal of Environmental Law, 27(3), 459-487.

Gephart, R. P. (2004). Qualitative research and the Academy of Management Journal. Academy of Management Journal, 47(4), 454 – 462.

Goatly, A. (1997). The language of metaphors. Routledge.

Ham, Y., and Kim, J. (2020). Participatory sensing and digital twin city: updating virtual city models for enhanced riskinformed decision-making. Journal of management in engineering, 36 (3), 04020005.

Jasanoff, S. (2015). Future imperfect: Science, technology, and the imaginations of modernity. Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power, 1-33.

Jiang, F., Ma, L., Broyd, T., & Chen, K. (2021). Digital twin and its implementations in the civil engineering sector. Automation in Construction, 130, 103838.

Kaewunruen, S., and Lian, Q. (2019). Digital twin aided sustainability-based lifecycle management for railway

turnout systems. Journal of cleaner production, 228, 1537–1551.

Keskin, B., Salman, B., and Koseoglu, O. (2022). Architecting a BIM-based digital twin platform for airport asset management: a model-based system engineering with SysML approach. Journal of construction engineering and management, 148 (5), 04022020.

Kober, C., Medina, F. G., Benfer, M., Wulfsberg, J. P., Martinez, V., & Lanza, G. (2024). Digital twin stakeholder communication: characteristics, challenges, and best practices. Computers in Industry, 161, 104135.

Korenhof, P., Blok, V., and Kloppenburg, S. (2021). Steering representations—towards a critical understanding of digital twins. Philosophy & technology, 34 (4), 1751–1773.

Kudriashov, N. S., Markov, S. A., & Potekhin, V. V. (2019). Adaptive Control System Synthesis Methods for Complex Manufacturing Objects. Annals of DAAAM & Proceedings, 30.

Lavikka, R., Kallio, J., Casey, T., & Airaksinen, M. (2018). Digital disruption of the AEC industry: Technology-oriented scenarios for possible future development paths. Construction management and economics, 36(11), 635-650.

López-Alfaro, C. V., Dincel, S., Nasar, W., Styve, A., Besenecker, U., & da Silva Torres, R. (2025). Urban Digital Twins as Tools for Sustainable Lighting Design: The Assessment of NorDark-DT. Buildings, 15(24), 4425.

Michalec, O. (2025). Models vs infrastructures? On the role of digital twins' hype in anticipating the governance of the UK energy industry. Environmental Science & Policy, 168, 104041.

Miles, M.B. & Huberman, A.M. (1994). Qualitative Data Analysis: An Expanded Sourcebook. Sage, Thousand Oaks.

Miraj, P., Wang, T., Koutamanis, A., & Chan, P. (2025). Organising digital twin in the built environment: a systematic review and research directions on the missing links of use and user perspectives of digital twin in Architecture, Engineering and Construction (AEC) sector. Construction Management and Economics, 43(6), 465-481.

Ninan, J., (2020). Online Naturalistic Inquiry in Project Management Research: Directions for Research. Project Leadership and Society. 1(1), 1-10

Ninan, J., Sergeeva, N., & Winch, G. (2022). Narrative shapes innovation: a study on multiple innovations in the UK construction industry. Construction management and economics, 40(11-12), 884-902.

Nochta, T., Wan, L., Schooling, J. M., & Parlikad, A. K. (2021). A socio-technical perspective on urban analytics: The case of city-scale digital twins. Journal of urban technology, 28(1-2), 263-287.

O'Dwyer, E., Pan, I., Charlesworth, R., Butler, S., & Shah, N. (2020). Integration of an energy management tool and digital twin for coordination and control of multi-vector smart energy systems. Sustainable Cities and Society, 62, 102412.

olde Scholtenhuis, L., & Soman, R. K. (2025, September). Trapped in technocentric thinking? Revisiting Digital Twins through a pragmatic framework. In Proceedings of the 41st Annual ARCOM Conference (Vol. 1, p. 3).

Papadonikolaki, E., van Oel, C., & Kagioglou, M. (2019). Organising and Managing boundaries: A structurational view of collaboration with Building Information Modelling (BIM). International journal of project management, 37(3), 378-394.

Pan, Y., and Zhang, L., (2021). A BIM-data mining integrated digital twin framework for advanced project management. Automation in construction, 124, 103564.

Sergeeva, N. & Ninan, J. (2023). Comparisons as a discursive tool: Shaping megaproject narratives in the United Kingdom. Policy and Society, 42(2), 197–211.

Solman, H., Kirkegaard, J. K., Smits, M., Van Vliet, B., & Bush, S. (2022). Digital twinning as an act of governance in the wind energy sector. Environmental science & policy, 127, 272-279.

Soman, R. K., Farghaly, K., Mills, G., & Whyte, J. (2025). Digital twin construction with a focus on human twin interfaces. Automation in Construction, 170, 105924.

Tripathi, N., Hietala, H., Xu, Y., & Liyanage, R. (2024). Stakeholders collaborations, challenges and emerging concepts in digital twin ecosystems. Information and Software Technology, 169, 107424.

Uhlenkamp, J. F., Hauge, J. B., Broda, E., Lütjen, M., Freitag, M., & Thoben, K. D. (2022). Digital twins: A maturity model for their classification and evaluation. IEEE Access, 10, 69605-69635.

Williams, R. (2006). Compressed foresight and narrative bias: Pitfalls in assessing high technology futures. Science as Culture, 15(4), 327-348.

Zibuschka, J., Ruff, C., Horch, A., & Roßnagel, H. (2020). A human digital twin as building block of open identity management for the internet of things. In Open Identity Summit 2020 (pp. 133-142). Gesellschaft für Informatik eV.