2025 European Conference on Computing in Construction

CIB W78 Conference on IT in Construction

Porto, Portugal
July 14-17, 2025

INTEGRATING LOIN-DRIVEN INFORMATION EXCHANGE CONNECTED TO CONSTRUCTION PRODUCTION PLANNING

Jonatan Lindholm[1], Torbjörn Jansson[2], Peter Johansson[1], and Ibrahim Yitmen[1]
[1]Jönköping University, Sweden
[2]IT - Data Foundation, Skanska, Sweden

Abstract

In construction projects, frequent changes to time planning result from unforeseen events, impacting both timing and scope of information exchanges (IE). Currently, IE planning and production planning are performed independently with limited integration between the two, leading to inefficiencies when changes are needed. This study proposes a unified approach facilitating Level of Information Need (LOIN) to systematically identify and link to required IEs for the production phase. The mapping was co-developed with and evaluated by industry professionals to ensure practical relevance. Integrating LOIN-driven IE mapping into production planning enhances responsiveness to schedule changes by providing structured guidelines for information delivery.

Introduction

The production phase of a construction project requires information in a variety of forms, and the information that is required changes based on the activities that are performed. Koch et al. (2018) found that a large part of cost overruns in Swedish projects are due to problems related to poor information quality from the design stage, which indicates that the information delivery process needs to be improved. Adopting a building information modelling (BIM) approach was previously seen as the solution to some of these problems, as more information would be integrated into the model. However, different actors federate different models and need different information at different stages of the project, and the BIM-based information exchanges have mostly focused on individual disciplines (Khudhair et al., 2022). Additionally, if the BIM model is not used on site, the information it contains is lost and tasks such as quantity take-offs will have to be redone based on the 2D drawings (Alhava et al., 2024). New and upcoming regulations from the European Union (EU), such as the Construction Products Regulation (European Commission, 2025), have further increased the demand for accurate, traceable information to achieve standardized design data and harmonized product information (Alhava et al., 2024, Kebede et al., 2023).

To standardize the information flow, the ISO 19650 series introduce several concepts and processes that aid in specifying and structuring information requirements. One such concept is the “level of information need” (LOIN), which has the purpose defining what information should be delivered, to make sure that the appointing party get the information they need, and only the information they need (ISO 19650-1, 2019). LOIN has more recently been given an updated standard in the ISO 7817 series and contributes to exchange requirements between different parties (ISO 7817-1, 2024). However, as seen in studies by Soman and Whyte (2020) and Jaskula et al. (2024) most companies have yet to adopt LOIN and do not fully follow the information workflow described in ISO 19650. While large companies generally have more expertise and funds to employ new working methods, small and medium size companies might not have the necessary resources to adopt methods described in the standards. In an attempt to aid companies in adopting LOIN, this paper presents a mapping of LOINs, which identifies all major information exchanges during the production phase. This mapping could then act as a guideline for establishing a library of standardized LOINs, which could act as a repository from which companies could extract the LOINs they need at different points in a project. If a semantic connection is also established, the extraction could happen automatically based on production planning.

The next chapter contains existing literature on Information Exchange, LOIN, Scheduling/Procurement, Information Delivery Manual and BPMN. The method section then contains a description of how the mapping was done. The results and discussion chapters then present the resulting models and analyze the main findings from the process. Finally, the conclusions give a summary of the work and an outlook into possible future adaptations.

Theoretical Framework

Information exchange

LOIN defines requirements on construction information based on purpose (why?), milestone (when?), actor (who) and object (what?), and should be used to discuss and agree on the information exchange between two or more actors (ISO 7817-1, 2024). These prerequisites enable identification and analysis of requirements for all purposes at a single milestone (Oliveira et al., 2024). While the LOIN is informed by the aforementioned prerequisites, it does not include them (ISO 7817-1, 2024).

LOIN can also be used to describe the exchange requirements between several parties in a process as described in ISO 29481-1 (ISO 7817-1, 2024). ISO 29481-1 (2016) contains the definition of information delivery manual (IDM), which should describe the need for information exchange, identify sending and receiving actors and specify the information being exchanged to satisfy the requirements at each point in a project (ISO 29481-1, 2016). An IDM process map sets the boundary for the information contained in the process and shows the logical sequence of activities to give a comprehensive overview of the overall process (ISO 29481-1, 2016). This can help increase the in-depth understanding of all actors and their responsibilities, requirements and information exchanges, which is also needed to increase interoperability (Petrova et al., 2017). Lack of understanding about the IDM process can make it difficult to adopt but using it long term should be beneficial for industry adopters, since much of the information created in one process can be reused in subsequent processes (Costin et al., 2021).

Most IDMs are created in document formats, and while efforts to develop standardized, machine-readable formats exist, they have not been widely adopted by the industry (Jeon et al., 2021). Formalizing information requirements for direct import into modeling environments can ensure project deliverables automatically comply with exchange information requirements (Mellenthin Filardo et al., 2024). Detailed construction documentation provides valuable data for companies reliant on accurate schedules for contract documents (Lauble et al., 2024). System-level data harmonization is critical for transferring information between systems and enriching it from other sources (Alhava et al., 2024). Engineering Bills of Materials (eBoMs) must be integrated into BIM objects, and the standardization of design data within MEP models is essential for generating eBoMs (Alhava et al., 2024). However, BIM workflows often lack a knowledge base that incorporates non-geometrical information, and stakeholder knowledge gaps across domains can delay decision-making processes. Semantic web technologies could address this by creating comprehensive knowledgebase systems (Khudhair et al., 2022). Despite the availability of standards like IFC and IDM, early collaboration is discouraged, and performance analyses are often delayed to minimize information exchanges (Arayici et al., 2018). Moreover, no universal solution for interoperability exists, even with available standards (Arayici et al., 2018). ISO 19650-1 (2019) defines information requirements as specifications detailing what, when, how, and for whom information should be produced. Exchange information requirements pertain to appointments, while information exchange refers to satisfying such requirements. Key decision points and trigger events guide critical decisions and changes in an asset's lifecycle, respectively. Metadata should align with downstream requirements and address the needs of procurement or customers to maximize its utility (Alhava et al., 2024).

Information Delivery Manual (IDM)

ISO 29481-1 (2016) defines essential concepts and structures for effective information exchange in building projects. An information unit refers to an individual information item, such as a window identifier or room depth, while an exchange requirement is a defined set of information units exchanged to support specific business needs at particular project stages. The IDM provides documentation that captures business processes and specifies the information a user, fulfilling a particular role, must provide at specific project points. The IDM content must describe the business context for information exchange, identify the sending and receiving actors, define the exchanged information, and ensure the information is useful, clear, and relevant to local practices. It also creates detailed specifications of exchange requirements to support BIM software development. A process map within IDM sets boundaries for the information process, establishes activities, and outlines their logical sequence. It includes administrative details such as exchange requirements and an overview of the process, often illustrated with diagrams. An exchange requirement links processes and data, describing the information an initiator actor provides to enable a downstream actor to execute subsequent processes. This ensures clarity in addressing the information needs of downstream actors. Overall, ISO 29481-1 provides a framework for aligning business processes, technical specifications, and software development with clear, actionable information exchange requirements to facilitate efficient project collaboration.

Jeon et al. (2021) proposed a relational framework for an IDM data schema, addressing the challenge that most IDMs are developed in document format rather than as machine-readable datasets suitable for exchange or reuse. The IDM schema typically includes a use case, process map, and exchange requirements, although not all specifications incorporate process maps and exchange requirements from the outset. Successful IDM development requires the formation of industry working groups (Costin et al., 2021) and involves defining information processes and data exchanges for information systems (Sacks et al., 2018). However, the mapping processes in IDM development can be complex, leading to various challenges (Lee et al., 2013). While exchange requirements are designed for reuse, understanding requirements specified by others can be difficult, suggesting that reuse might be more practical within a single IDM (Lee et al., 2013). Additionally, effective IDM implementation must consider human and process dimensions (Arayici et al., 2018). Although the IFC schema can support the IDM process, many use-case-specific attributes still require definition (Petrova et al., 2017).

Level of Information Need (LOIN)

ISO 7817-1 (2024) provides standardized methods for describing information to be exchanged in accordance with exchange information requirements. These requirements specify the desired information exchange, with the resulting delivery termed as an information delivery. Scheduled events for predefined exchanges are identified as information delivery milestones. Effective information exchange relies on specifying the level of information need, which caters to varying purposes and serves as a basis for discussion and agreement between two or more actors. Although informed by prerequisites like purpose, milestone, actor, and object, the level of information need itself does not include these elements. It can describe exchange information requirements between parties, as per ISO 19650-1, or among multiple parties within a process, as outlined in ISO 29481-1 (IDM). This specification is applicable regardless of formal appointments and contributes to both exchange information requirements and exchange requirements, which collectively define the information exchange.

Alphanumerical, geometrical, and documentation information can be derived from one another. For example, alphanumerical data like dimensions can generate geometrical representations, while geometrical information can define alphanumerical details, such as a road's nominal width. When specifying the level of information need, the roles of actors providing and receiving information must be considered. A client may request a specific level of information need for an object at an agreed milestone without assigning responsibilities, allowing the supply chain to allocate roles as necessary.

Alphanumerical data should align with data templates according to ISO 23387, encompassing required properties, documentation for processes, and verification of deliverables. Documentation may include diverse information containers and must be clear to avoid misinterpretation. Verification against the level of information need supports checking object presence (e.g., buildings or spaces), alphanumerical properties (e.g., fire resistance), geometrical attributes (e.g., location), and documentation (e.g., building permits). This approach ensures precise and unambiguous information exchanges.

Information Exchange in Construction Planning

Information exchange in construction planning and scheduling is a critical component that influences the efficiency and success of construction projects. The complexity of modern construction projects necessitates effective communication and information sharing among various stakeholders. Collaborative planning in construction involves integrating subcontractors' expertise into the planning process, which can be facilitated by BIM tools. These tools enhance the visualization and coordination of information, although their adoption at construction sites is limited due to process alteration challenges. (Tallgren et al., 2015). BIM-based workflows have been developed to address information exchange challenges, by ensuring that information exchange is planned, agreed upon, and verified from the project's inception (Xue et al., 2015). Standards like Industry Foundation Classes (IFC) enable seamless integration of scheduling, cost, resource, and risk information, promoting interoperability across software applications (Mashali and El Tantawi, 2022).

Business Process Modeling Notation (BPMN)

Process modeling for IDM development is less error-prone when only essential symbols and rules are used (Lee et al., 2013). While BPMN effectively describes the logical sequence of activities, it does not account for their timing (Avogaro et al., 2024). A limited subset of BPMN symbols and rules proves most useful for IDM development (Lee et al., 2013). Despite project variability, many work processes remain consistent, making it beneficial to retain graphs of these processes for reuse in future projects (Avogaro et al., 2024). This streamlined approach enhances clarity and efficiency in IDM modeling and process management.

Integrating LOIN-driven Information Exchange Connected to Construction Production Planning

Integrating LOIN into construction production planning enhances information exchange and project efficiency. LOIN specifies the required detail, dimensionality, and documentation for Building Information Modeling (BIM) elements at various project stages, ensuring stakeholders access pertinent information when needed. Recent studies highlight the significance of LOIN in streamlining production management. For instance, implementing LOIN principles within a Common Data Environment (CDE) facilitates collaborative information production, enabling efficient gathering, analysis, and sharing throughout project stages (Godager et al., 2022). Moreover, integrating BIM with production planning and monitoring systems, improves information exchange between planning and execution phases. This integration allows for real-time visualization, enhancing planning and control by providing up-to-date information on project status and facilitating proactive decision-making. However, challenges persist in implementing LOIN-driven information exchange. Disruptive information exchange requirements that deviate from established routines can hinder project progress. Firms may perceive, interpret, and act upon these requirements differently, leading to misalignment and inefficiencies (Abdirad et al., 2021). To address these challenges, standardizing information requirements and ensuring system-level data harmonization are crucial. This standardization facilitates seamless data transfer between systems and enriches data from various sources, supporting accurate and timely information exchange throughout the construction process.

Method

This study adopts a methodology informed by the "Livscykelprocess" (Life Cycle Process) model developed by Nationella Riktlinjer (2020), which visualizes the complete lifecycle of construction projects in Sweden. The model is primarily based on the EN 16310 (2013) standard and outlines the main phases of the construction process alongside suggested subprocesses. For this paper, the focus is specifically on the "Produktion" (Production) phase, a critical component of the construction lifecycle.

The ISO 12006-2 (2020) standard provides the foundational definition of a construction process as a "process which uses construction resources to achieve construction results". These construction resources encompass a wide range of elements necessary for project completion, including humans, tools, products, and information. By integrating this standard with the Nationella Riktlinjer model, this study investigates how LOIN-driven information exchange can enhance the production phase of construction planning. This approach ensures a systematic alignment with international standards while addressing the specific requirements of the Swedish construction industry. A mapping of all information deliveries during the production phase was performed internally by a Swedish contractor. The foundation for this mapping was the model from Nationella Riktlinjer and information exchanges identified by the Swedish non-profit organization BEAst (BEAst, 2024) developing standards for the construction industry's electronic business. The resulting model was then translated and adapted into BPMN format, see Figure 1. A conceptual framework of a methodology for LOIN driven information exchanges aligned with construction production planning was then developed based on the model developed by the contractor.

Results

Figure 1 shows the results of the information delivery mapping, where each data object represents an information delivery. However, this mapping does not consider the amount or type of information that is to be delivered, as that will vary depending on the project. The information deliveries shown in the figure therefore only represent the types of information deliveries that occur throughout a project. For example, there will always be self-checks and inspections that occur regularly through the project process, but the number and interval of inspections depends on project size and need. As can also be seen in Figure 1, some of the deliveries, such as purchasing and call-offs, are connected to each other. This is because, depending on their relationship, some information deliveries might require information from previous deliveries, or that the previous deliveries have been completed.

The methodology for integrating the LOIN into construction production planning is structured around the model in Figure 1. Presented in Figure 2, the resulting systematic framework provides a methodology for managing and delivering information across the various stages of a construction project, ensuring that information requirements align with production planning needs. The approach is grounded in international standards such as EN 16310 and ISO 12006-2, while adapting LOIN principles to enhance precision and clarity in information exchange. The conceptual framework of LOIN-driven information exchange for managing and delivering information aligned with construction production planning needs is structured as below and presented in Figure 2.

1. Stage-Based Information Structuring

The construction process is divided into distinct stages, each with specific information requirements and deliverables.

2. Integration of LOIN into Production Planning

LOIN principles are applied to align the level of detail, granularity, and documentation with the specific needs of each stage to specify information requirements at key milestones.

3. Process-Oriented Information Management

The Swedish model emphasizes a process-oriented approach to information delivery. LOIN is integrated into this process through mapping of information deliverables and the definition of information delivery milestones.

4. Validation and Quality Assurance

To ensure compliance with LOIN and the Swedish model, a verification process is needed, where continuous feedback loops aid refinement of information requirements.

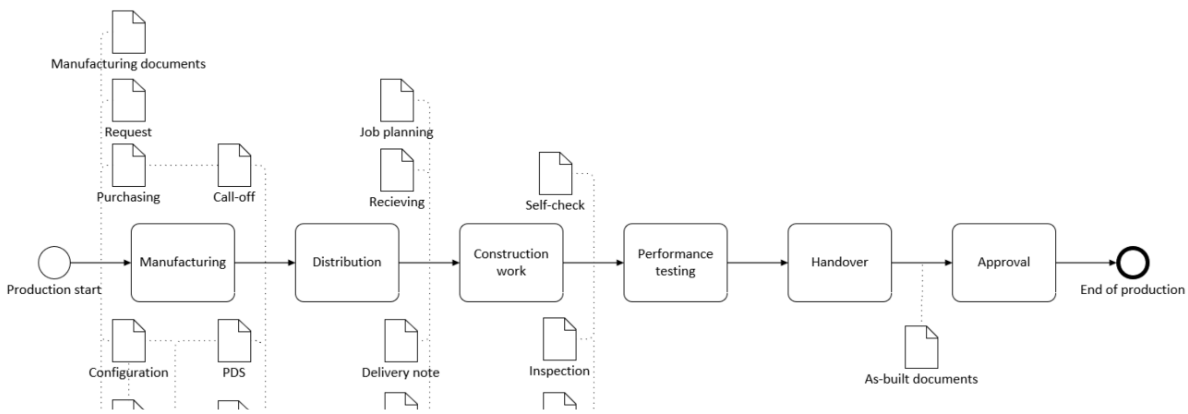

Figure 1: Map of information deliveries in the production phase.

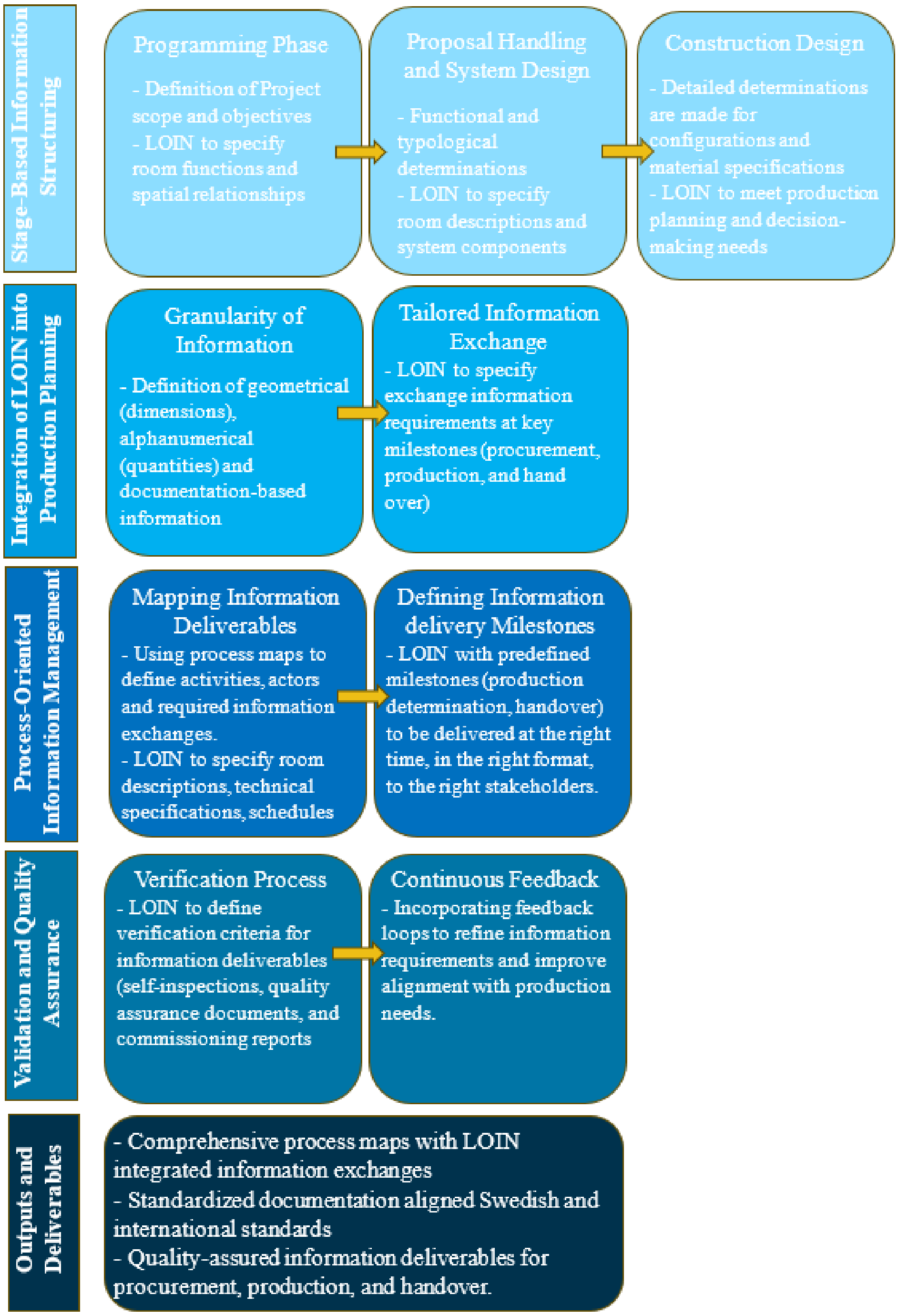

Figure 2: Conceptual framework of LOIN-driven information exchange for managing and delivering information aligned with construction production planning needs.

5. Outputs and Deliverables

The methodology results in a structured, LOIN-driven information delivery process that enhances collaboration, reduces errors, and supports efficient production planning. Key deliverables include:

- Comprehensive process maps with LOIN-integrated information exchanges.
- Standardized documentation aligned with Swedish and international standards.
- Quality-assured information deliverables for procurement, production, and handover.

A sample of a LOIN-driven information exchange for managing and delivering information aligned with construction production planning needs is illustrated in Figure 3. In order to carry out an activity, information linked to that particular activity is required, and to ensure that the right information is delivered at the right time, LOIN is therefore also linked to production planning. This would also open up possibilities for automatic changes to LOIN based on changes in the planning.

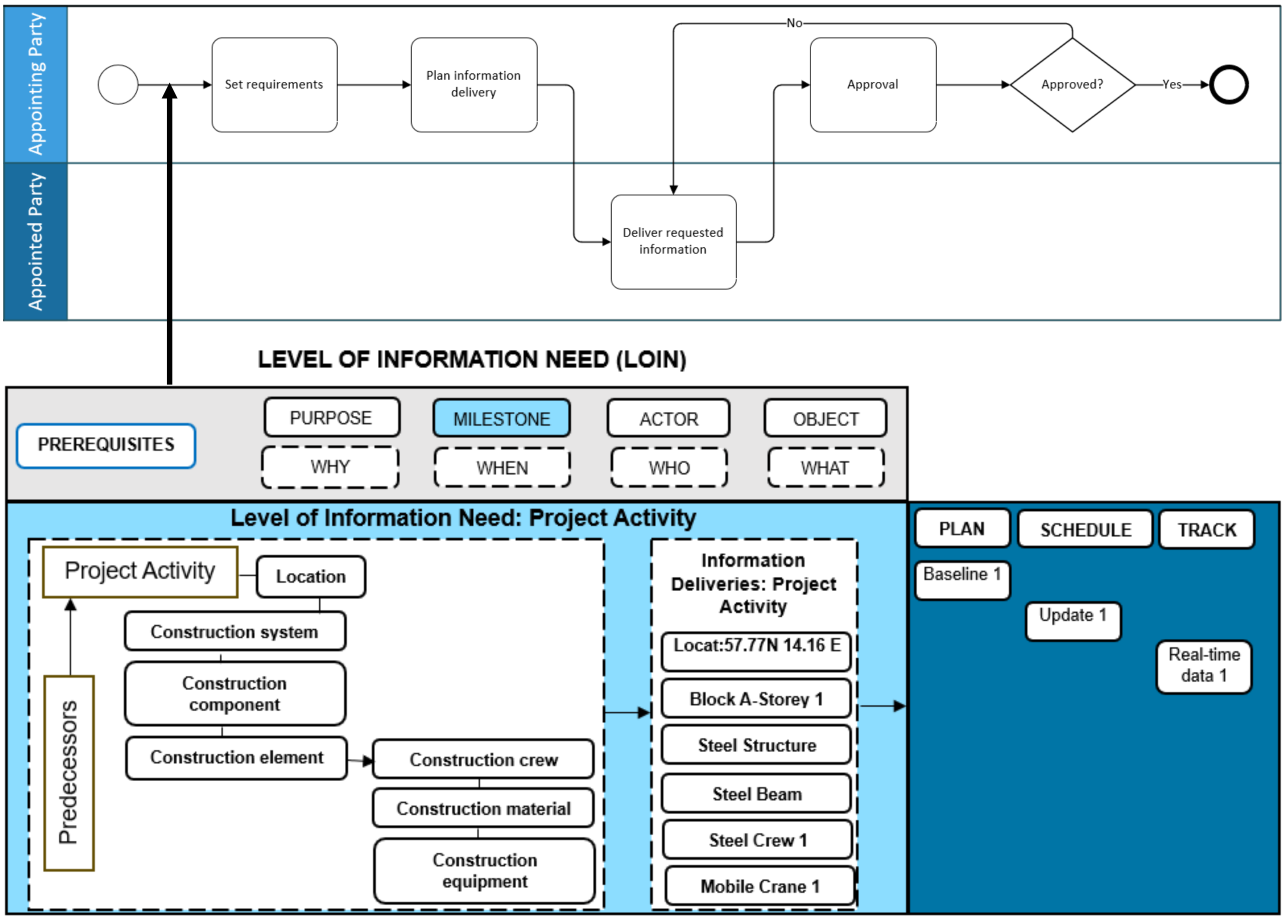

Figure 3: Sample of a LOIN-driven information exchange for managing and delivering information aligned with construction production planning needs.

Discussion

Integrating LOIN into production planning provides a robust framework for specifying and standardizing information exchanges. LOIN ensures stakeholders receive the right information at the right time, avoiding redundant or irrelevant data (ISO 7817-1, 2024). However, adoption remains limited, particularly among small and medium-sized enterprises (SMEs), who usually lack resources for implementing standards like ISO 19650. This paper's mapping of LOIN identifies key information exchanges during the production phase, offering a practical guideline to establish standardized LOIN libraries, facilitating easier adoption. If developed and maintained properly, such a library could be used by SMEs even if they lack the knowledge or resources to produce LOINs of their own. To ensure industry cohesion and maximum usefulness, the library should be established on national level, since this would enable a unified understanding of the LOINs and ensure that they adhere to standards.

Additionally, integrating LOIN with the Swedish "Livscykelprocess" model enhances alignment with both national and international standards, such as EN 16310 and ISO 12006-2. This approach enables process-oriented information management, mapping deliverables, milestones, and validation processes to ensure compliance and improve efficiency. Such advancements promote collaboration, reduce errors, and align with digital transformation goals in construction.

By leveraging these efforts, this approach establishes a method that not only aligns with EU regulations but also enhances the traceability and reliability of information across stakeholders. This approach addresses the industry's reliance on separate planning processes for production and information delivery, streamlining workflows and improving project efficiency.

Recent studies emphasize the importance of aligning information flows with standardized frameworks. For instance, Godager et al. (2022) demonstrated that incorporating LOIN principles into a CDE facilitates collaborative information production, enabling efficient gathering, analysis, and sharing of data throughout project stages. This integration also supports real-time visualization, allowing stakeholders to monitor project status dynamically and make proactive decisions. Additionally, combining BIM with production planning and monitoring systems bridges the gap between planning and execution, ensuring seamless transitions and better control of construction activities. Alhava et al. (2024) highlights the role of LOIN in creating consistent information delivery processes, while Kebede et al. (2023) underscore the necessity of traceability for compliance with upcoming EU directives. By connecting

LOIN with production planning, this approach provides a comprehensive solution to longstanding inefficiencies in information management. The proposed method enhances traceability, reduces delays, and ensures compliance with international standards, offering a practical and scalable framework for improving construction project outcomes.

Despite these advantages, implementing LOIN-driven information exchange is not without challenges. Deviations from established workflows can disrupt project progress, as firms may interpret and act upon information requirements differently, leading to misalignment and inefficiencies (Abdirad et al., 2021). Addressing these issues requires standardizing information requirements and harmonizing systems at the data level. This ensures seamless data transfer across platforms, enriching the information ecosystem with inputs from various sources and supporting accurate, timely exchanges.

Conclusions

Standardization not only facilitates smoother integration but also strengthens interoperability among diverse tools and stakeholders, which is crucial for the successful implementation of LOIN. As the construction industry moves toward greater digitalization, the ability to adapt to new workflows and integrate advanced tools like BIM and CDE becomes increasingly important. By overcoming the challenges associated with LOIN implementation, firms can achieve enhanced efficiency, reduced errors, and better alignment of project objectives, ultimately driving progress in the construction sector.

While the maps and frameworks were developed together with industry to ensure their relevance, the work is still ongoing. The next step in this research will include further validation and evaluation of these frameworks. Future work should also focus on developing user-friendly tools (APIs) and frameworks (Knowledge-graph based) that support LOIN integration, particularly for small and medium-sized enterprises (SMEs), which may lack the resources to adopt complex standards. Providing training and creating open-access resources could further promote widespread adoption and ensure that the benefits of LOIN-driven information exchange are realized across the industry.

Acknowledgments

This research is funded by Jönköpings Läns Byggmästareförening (Sweden). The authors would like to acknowledge the project industrial partners for their contribution to the project.

References

Abdirad, H., Dossick, C. S., Johnson, B. R., & Migliaccio, G. (2021). Disruptive information exchange requirements in construction projects: perception and response patterns. Building Research & Information, 49(2), 161-178.

Alhava, O., Ruottinen, B., Peltokorpi, A., Siren, M., Aaltonen, A. & Pitkäranta, T. 2024. Advancing Digitalisation in Construction Through Automated Metadata Management and Machine Data Processing.

Arayici, Y., Fernando, T., Munoz, V. & Bassanino, M. 2018. Interoperability specification development for integrated BIM use in performance based design. Automation in Construction, 85, 167-181.

Avogaro, D., Berlato, M. & Zanchetta, C. 2024. Implementation of IFC-based process models for collaborative management of temporal scheduling through Linked Data.

BEAst. 2024. *About BEAst*. https://beast.se/om-beast/. Available: https://beast.se/om-beast/ [Accessed 30-01-2025 2024].

Costin, A., Hu, H. & Medlock, R. 2021. Building information modeling for bridges and structures: Outcomes and lessons learned from the steel bridge industry. Transportation Research Record. SAGE Publications Ltd.

EN 16310 2013. Engineering services - Terminology to describe engineering services for buildings, infrastructure and industrial facilities. SS-EN 16310:2013. International Standards Organization.

European Commission. 2025. Construction Products Regulation (CPR). https://single-market-economy.ec.europa.eu/sectors/construction/construction-products-regulation-cpr_en. Available: https://single-market-economy.ec.europa.eu/sectors/construction/construction-products-regulation-cpr_en [Accessed 29-01-2025 2025]

Godager, B. Mohn, K., Merschbrock, C., Klakegg, O. J., & Hauang, L. (2022). Towards an improved framework for enterprise BIM: the role of ISO 19650. Journal of Information Technology in Construction, 10.36680/j.itcon.2022.053

ISO 7817-1 2024. Building information modelling - Level of information need - Part 1: Concepts and principles (ISO 7817-1:2024(en)). International Standards Organization.

ISO 12006-2 2020. Building construction – Organization of information about construction works – Part 2: Framework for classification (SS-EN ISO 12006-2:2020). International Standards Organization.

ISO 19650-1 2019. Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – information management using building information modelling – Part 1: Concepts and principles (SS-EN ISO 19650-1:2019 (E)). International Standards Organization.

ISO 29481-1 2016. Building information models – Information delivery manual – Part 1: Methodology and format (ISO 29481-1:2016). International Standards Organization.

Jaskula, K., Kifokeris, D., Papadonikolaki, E. & Rovas, D. 2024. Common Data Environments in construction: State-of-the-art and challenges for practical implementation. Construction Innovation.

Jeon, K., Lee, G., Kang, S., Roh, H., Jung, J., Lee, K. & Baldwin, M. 2021. A relational framework for smart information delivery manual (IDM) specifications. Advanced Engineering Informatics, 49.

Kebede, R., Moscati, A., Tan, H. & Johansson, P. Circular economy in the built environment: a framework for implementing digital product passports with knowledge graphs. EC3 Conference 2023, 2023. European Council on Computing in Construction, 0-0.

Khudhair, A., Li, H., Bower, T. & Ren, G. 2022. A theoretical holistic decision-making framework supporting collaborative design based on common data analysis (CDA) method. Journal of Building Engineering, 46.

Koch, C., Shayboun, M., Manés, A. & Nordlund, T. 2018. Produktivitetsläget i Svenskt Byggande 2018. SBUF.

Lauble, S., Zielke, P. & Haghsheno, S. 2024. A Literature Review on Analytical Methods in Construction Master Scheduling to Generate a Competitive Advantage.

Lee, G., Park, Y. H. & Ham, S. 2013. Extended Process to Product Modeling (xPPM) for integrated and seamless IDM and MVD development. Advanced Engineering Informatics, 27, 636-651.

Mashali, A., El Tantawi, A. (2022). BIM-based stakeholder information exchange (IE) during the planning phase in smart construction megaprojects (SCMPs). International Journal of BIM and Engineering Science, 5(1), pp. 08-19. https://doi.org/10.54216/IJBES.050101.

Mellenthin Filardo, M., Debus, P., Melzner, J. & Bargstädt, H.-J. 2024. Enhancing Information Requirement Compliance Through Automated Integration in a Modelling Environment.

Nationella Riktlinjer. 2020. Livscykelprocess. Available: https://www.nationella-riktlinjer.se/innehall/processer/livscykelprocess/ [Accessed 10-12-2024 2024].

Oliveira, A., Granja, J., Bolpagni, M., Motamedi, A. & Azenha, M. 2024. Development of standard-based information requirements for the facility management of a canteen. J. Inf. Technol. Constr., 29, 281-307.

Petrova, E., Romanska, I., Stamenov, M., Svidt, K. & Jensen, R. L. Development of an information delivery manual for early stage bim-based energy performance assessment and code compliance as a part of dgnb pre-certification. In: BARNABY, C. S. & WETTER, M., eds., 2017. International Building Performance Simulation Association, 638-647.

Sacks, R., Kedar, A., Borrmann, A., Ma, L., Brilakis, I., Hüthwohl, P., Daum, S., Kattel, U., Yosef, R., Liebich, T., Barutcu, B. E. & Muhic, S. 2018. SeeBridge as next generation bridge inspection: Overview, Information Delivery Manual and Model View Definition. Automation in Construction, 90, 134-145.

Soman, R. K. & Whyte, J. K. 2020. Codification challenges for data science in construction. Journal of Construction Engineering and Management, 146, 04020072.

Tallgren, M. V., Roupé, M., & Johansson, M. (2015). An empowered collaborative planning method in a Swedish construction company-A case study. In Proceedings of the 31st Annual Association of Researchers in Construction Management Conference, ARCOM (pp. 793-802).

Xue, W., Wang, Y., & Man, Q. (2015). Research on information models for the construction schedule management based on the IFC standard. Journal of Industrial Engineering and Management (JIEM), 8(3), 615-635.