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TOWARDS DIGITAL TRANSFORMATION

– UNPACKING SENSING, SEIZING AND RECONFIGURING PROCESSES IN MODEL BASED PROJECT DELIVERY

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KORTRAPPORT OM FORSKNING | 2025: #1

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INTRODUCTION

This research examined the role of dynamic capabilities in facilitating digital transformation (DT) within the construction sector, with a particular focus on the transition from traditional project delivery processes to model-based project delivery. In general terms, digital transformation refers to fundamental changes in the organizational processes by which an organization operates, delivers value, and engages with stakeholders. In the context of the construction sector, digital transformation can be studied in two ways: focusing on the use of various technologies to improve processes or examining the organizational processes and practices required to integrate these technologies effectively. This research adopts the latter approach and examines what capabilities were developed, and, more importantly how they were developed for model-based project delivery based on two pioneering projects in Sweden that implemented model-based construction.

The increasing use of digital data and technologies creates opportunities for project stakeholders to communicate through a unified interface, enabling the integration of design, construction, and management processes in construction projects. Recently in Sweden and other Nordic countries, "model-based construction" has gained attention by extending the use of Building Information Modeling (BIM) into the construction phase, demonstrating that BIM can serve as a single, legally binding source of project information throughout both the design and construction stages. Such a shift introduces a new project delivery process, requiring a reconfiguration of traditional business processes and practices among various stakeholders. As a result, developing new capabilities to address this digital transformation has become essential. This research aims to understand how these capabilities can be developed to address the impacts of digital transformation on traditional business processes in the construction sector.To understand how such transitions are achieved in the case projects, this research applies the dynamic capabilities view (DCV), a framework from strategic management that explains how organizations adapt to changes in their environment—particularly in relation to technology. Capabilities research distinguishes between ordinary capabilities (which focus on routine operations and efficiency, enabling organizations to operate successfully and sustain their current performance) and dynamic capabilities (which focus on adapting to environmental changes, with the capacity to create, expand, and modify existing capabilities). According to DCV, dynamic capabilities are developed through three processes: sensing opportunities, seizing them, and reconfiguring existing structures and practices: see Fig. 1.

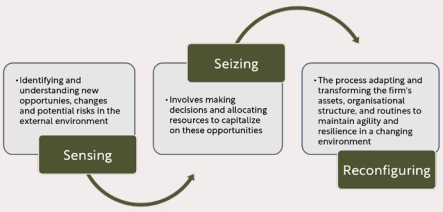


Figure 1. Sensing, seizing, and reconfiguring processes in capability development (Developed from Teece et al, 2007)

Drawing on DCV, the aim of this project is to explore and explain how sensing, seizing and reconfiguring processes happen in the transition from traditional processes to model-based construction. To fulfil this aim, three research questions were posed:

1. How do sensing and seizing processes manifest in a shift towards model-based construction?
2. What do these processes (sensing and seizing) transform and how?
3. What capabilities emerge from these three processes and how can they be proactively refined/improved?

METHOD

This study focused on two case projects, New Slussen in Stockholm and Celsius in Uppsala – both of which have implemented model-based project delivery.

The New Slussen Project was the first example where a "drawing-less" project narrative became the driver for change from traditional processes to model-based construction in Sweden. In the Celsius project, BIM was accepted as the single and legally binding source of information across the design and construction phases, enabling model-based project delivery.

A qualitative case study was conducted to explore how project stakeholders develop new capabilities when transitioning from traditional processes to model-based project delivery. The empirical data was collected in two phases. In the first phase we carried out 14 in-depth interviews from the New Slussen Project and 9 in-depth interviews from the Celsius project. The interviewees included project managers, Virtual Design and Construction (VDC) managers, designers and engineers. Figure 2 describes the data collection and analysis process:

The interviewees were asked to describe their experiences, focusing on several key areas:

→ How the initial idea of model-based construction emerged: Understanding the source/origins of this new approach and why stakeholders/organizations decided to adopt it.

→ Reactions/responses of different stakeholders: Exploring how various parties' (such as project managers, contractors, designers, and clients) responded to the shift from traditional methods to model-based design delivery and construction.

→ Organizational changes: Investigating what adjustments or transformations had to happen within the participating organizations to support model-based project delivery.

→ Challenges and opportunities: Uncovering the obstacles and advantages that stakeholders experienced during the transition (to model-based project delivery)

→ Current progress: Investigating where these organizations stand in their journey toward fully adopting model-based project delivery.

→ Future expectations: Exploring assumptions and hopes about how digital work processes will shape the future of the industry.

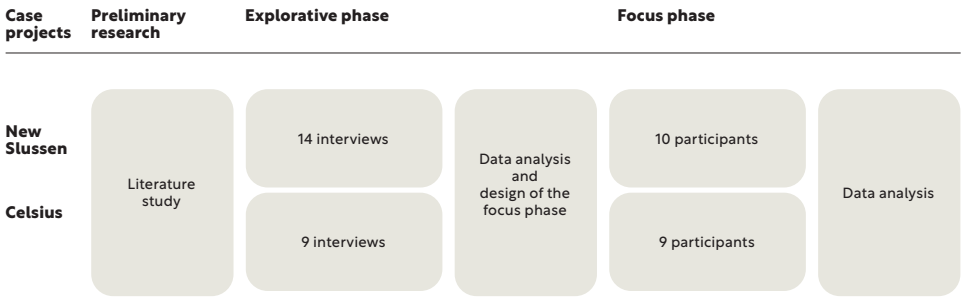


Figure 2. Data collection and analysis process.

The interviews were transcribed and analysed using thematic analysis. This allowed us to identify the main themes indicating how the transition towards model based project delivery (model based design delivery + model based construction) was experienced in both projects. We then created story boards in Miro representing the identified themes or episodes that explained how the model-based project delivery was recognised as a useful strategy, how different stakeholders made sense and adopted the change so that digital transformation was achieved in both projects.

The second phase consisted of focus-group meetings, one for each case project. The focus-group meetings discussed three issues:

1.Do the identified themes in the storyboards reflect the development of digital project capabilities and processes? If not, how do they describe these developments?

2.If starting a new project with a model-based delivery approach, what strategies would you adopt based on your experiences in the previous project?

3.What key knowledge or lessons has your organization gained from the case project, and how has this knowledge been or will be applied in other projects?

The focus group meetings were organised as 3 hours Teams meeting for each project. The researchers used Miro as the digital platform to organise group discussions for each question. Both meetings were recorded, transcribed and analysed using thematic analysis. The analysis of the data collected within focus group meetings enabled us to refine the flowcharts highlighting key themes /factors that support the gradual transition to model-based project delivery in both case projects. Additionally, we identified which strategic processes/practices could be adapted to other projects requiring model-based delivery and examined the knowledge transferred from individual projects to the broader organization. The focus group discussions allowed us to observe interactions among project members, including contradictions and potential conflicts related to the research phenomena. The discussions provided us with insights into how stakeholders, based on the unique nature of their practices and business models, perceive the value and impact of model-based construction differently.

RESULTS

Below, we present our findings in three sections. First section illustrates the themes identified in the interview data analysis, which were discussed and edited following the focus group meeting.

1. MICRO-PROCESSES SHAPING DIGITAL CAPABILITY DEVELOPMENT FOR MODEL-BASED PROJECT DELIVERY

These themes, represented in Figures 3 and 4, are the micro-processes that sequentially shaped the sensing, seizing, and reconfiguring phases toward the shift to model-based project delivery in the case projects. The themes and quotations presented in Figures 3 and 4 are briefly described below, section 1.1 and 1.2.

1.1 THE NEW SLUSSEN PROJECT

As illustrated in Figure 3, the shift towards model-based project delivery occurred progressively through interconnected factors and processes. Initially, project complexity and the limitations of 2D representations, particularly in cross-sections, highlighted the need for better solutions to understand the existing site conditions and propose new design. To address this, the engineering company partnered with a technology consultant to develop 3D representations, which helped in explaining the new design and facilitating communication with decision-makers on the client side and the public. The advantages of using 3D representations in the early phase led the client to request an increased use of 3D models, ultimately leading to a demand for BIM-based design delivery. When planning the tendering process, stakeholders realized that reverting to 2D drawings while also following to generate model-based data would create parallel workflows, increasing costs and risks, resulting discussions on adopting a model-based construction approach.

Model-based construction was a new concept for stakeholders, requiring further learning. VDC managers leading the process from the client and technology consultant facilitated this by inviting experts, having model-based construction experience, to share insights, which, in turn, resulted in the client approving a model-based delivery. A pause in the project, due to the 2014 local elections, provided the client, engineering team, and technology consultant an opportunity to explore how to develop a model-based delivery platform. They collaborated across 12 disciplines, experimenting with model-based processes despite the absence of established policies or standards, fostering a collective sense-making effort for contractor procurement.

The empirical data shows that weekly VDC meetings became a platform where VDC managers from all disciplines updated project information and aligned practices towards model-based delivery. These meetings were described as key enablers, fostering a hub for collective digital capability development, with VDC managers bridging the project and stakeholder organizations to facilitate the change. Two prominent *digital leaders* (D's) from the technology consultant and client sides were described as crucial actors driving the transformation, with *followers* (d's) within stakeholder organizations progressively adopting model-based workflows across various disciplines. This gradual and collaborative process of sensing, seizing, and reconfiguring transformed design and construction practices, enabling stakeholders to develop digital capabilities for model-based project delivery.

Figure 3. Micro processes shaping the transformation towards model-based project delivery in the New Slussen project.

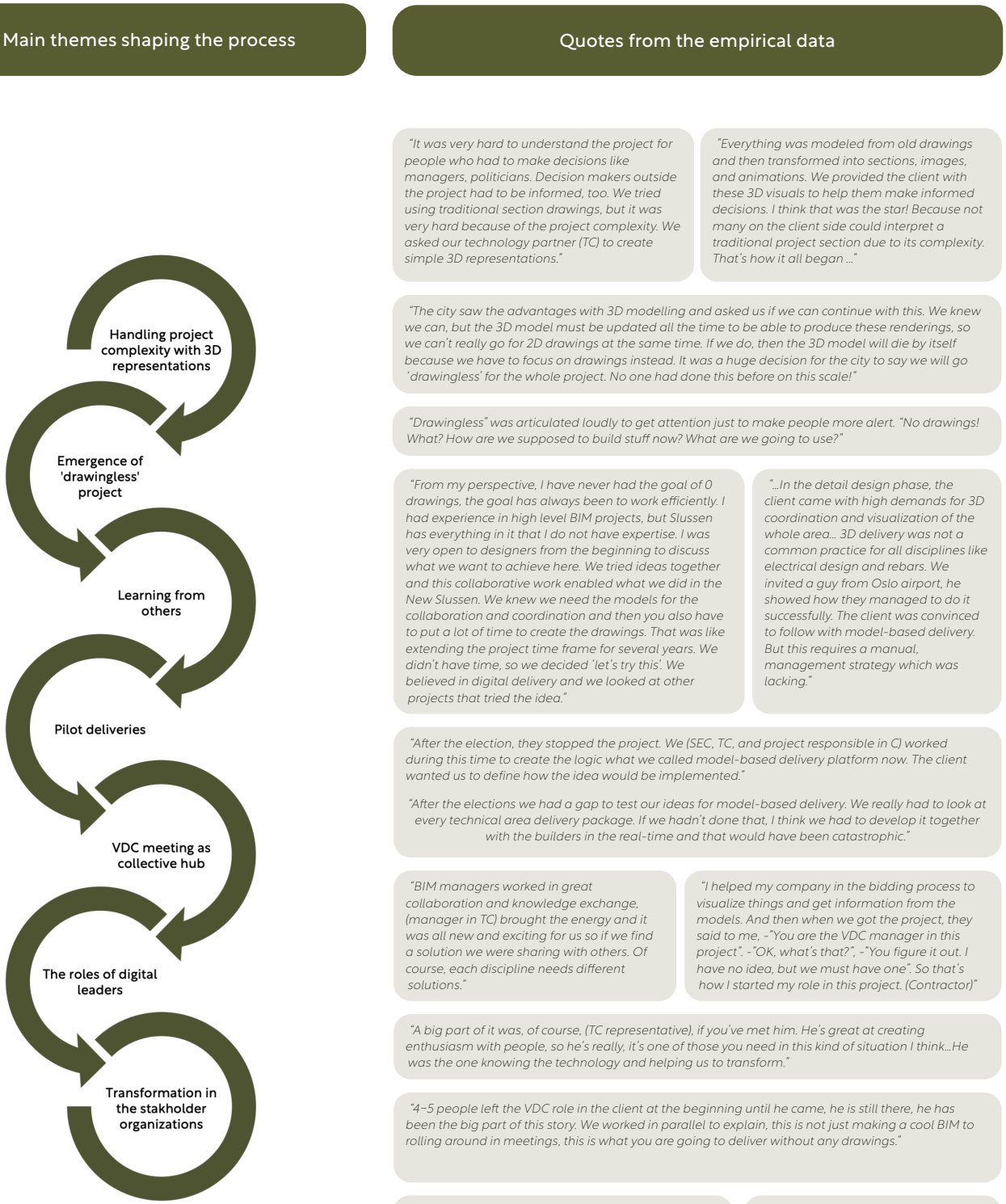
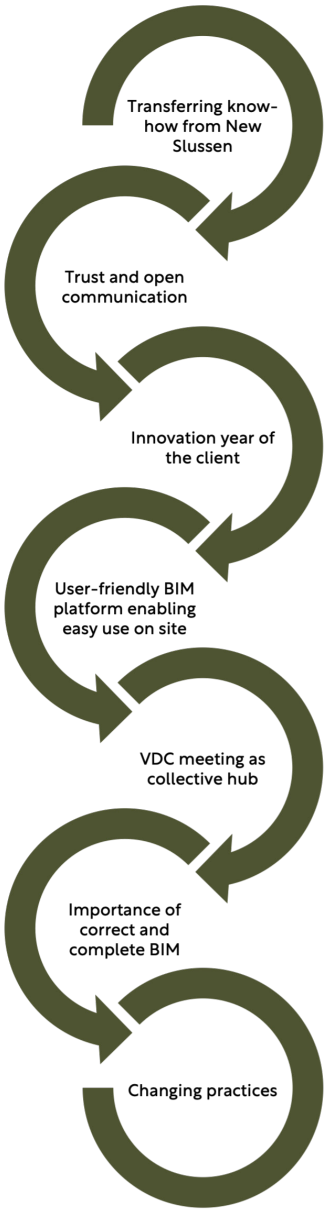


Figure 4. Micro processes shaping the transformation towards model-based project delivery in the Celsius Project.

Main themes shaping the process



Quotes from the empirical data

"He was always in who and talking like he had a dream of having some bubbles in the model that tell him how to do this stuff now and then so that it begins to the discussion about that."

"We haven't really changed the scope for the models, the object parameters, or the way we split and design the models. We've used this as a guideline and then added some additional elements on top of that... It essentially looks the same, but we've added some new functions and processes that we've developed. We've used Slussen as the main core in structuring the design."

"Kjell from Byggstyrning had heard about the Slussen project and how we used models for construction. He expressed frustration with traditional drawings (as he called raggarCading), saying they're often full of errors and result in building from unreliable information. He wanted to test if it was possible to build without relying on drawings. So, he reached out to me, asking how we managed it in Slussen. After some discussions, he approached me again and said, 'I have a project in Uppsala, and I want to do it without drawings. Can you help us?' That's how I became involved in the project."

"Rather than a one step large change, a gradual, step-by-step approach is needed. We focused on one thing at a time, maintaining ongoing dialogue and being present throughout the process. I truly believe this is the key. Moving step by step, without rushing, helps reasure people. I understand that it can feel unsettling to approach things in a new way, and this isn't about age or experience, whether you're a designer or a contractor. It's about building confidence, knowing that you can take this step with support along the way, and trusting that it will work out."

"We had a good environment where we can speak openly, it was new to all. When you are testing mistakes can happen. Alright, don't send that to the construction site.' Then, I inform everyone, acknowledging that something went wrong and that we'll correct it by next week. This mode helped us to manage it succesfully."

"We had an innovation year, so the decision was made to pursue some innovations, and this project felt like a perfect fit. I quickly developed a strong trust in Kjell and Johannes—Johannes for his expertise and Kjell for his drive and commitment. I think my background as an athlete taught me that you have to dare to win. It's a phrase we coined, meaning that when striving to be better than others, you often have to venture into unknown territory. This mindset helped me feel less afraid to try new things."

"Our main goal was simple: have the 3D model on-site to take measurements and build from it. In 2018, however, the available software wasn't as advanced for field use on mobile devices. The Slussen project had used Navisworks, but its engineering-focused interface was too complex for efficient site use. I considered Autodesk BIM 360, but it presented similar issues—complex navigation, measurements in inches, and lack of support for simple field measurements. Seeing the limitations, I searched alternatives and found StreamBIM. This tool allowed easy measurement on 3D models, simplifying our workflow. That's how we transitioned to StreamBIM. With time, it was developed to be a platform that we now manage our comminication and many other functions."

"We had a design studio twice a week to discuss details extensively, including material coordination and scheduling. Every Wednesday, a representative from each design team met on-site. This setup allowed contractors to consult with their designers, make adjustments, and address issues collaboratively. It fostered collaboration among the site crew, management, design teams, and contractors, with everyone meeting for an hour each week. I believe it was a true collaboration among all project stakeholders, focusing on the necessary tasks."

"We felt of losing control over the design time to time but at the end we had more control oover details and we felt good." (Architect)

"What was new for us in Celsius was that they were building directly from our models. Everything in the model had to be accurate, because if we only used 3D or 2D PDFs, it wouldn't matter as much. Since the builders were going to use the actual model, they would see everything that we might normally skip to develop. We also had to put much more effort into quality-checking our models—not just for geometry but also for the parameters used in quantity estimates and measurements. It was essential to ensure everything was modeled correctly."

"Things became much more challenging for everyone on my design team. They couldn't just suggest ideas, put them on paper, and assume issues would be solved later. Instead, they had to dig in and assess: is this feasible? Is it buildable? This became the production project leader's mission, given their focus on production. It was exhausting because, every day, we felt like we were doing things wrong. But this was because we were tackling every question mark and difficulty during our phase, rather than leaving them to be discovered on the production site. We invested our time and resources early on so that production would run smoothly—and it did, even coming in under budget. We did far more work than usual and often felt like we were repeating steps, moving in the wrong direction. But this was because we were solving issues early on, changing roles and responsibilities."

"One of the challenges was how to use the model after putting such high earlier cost, whether could the client benefit from it? Modelling the project for using in facility management is different than traditional thinking. Also, accepting the model as the legal document was the challenging issue."

"In traditional practice, subcontractors used drawings to extract quantities and based their bid calculations on those figures. Now, quantities can be extracted directly from the model, allowing subcontractors to focus solely on bidding for the work itself. Extracting quantities directly from the model is also beneficial for purchasing and logistics, and it creates opportunities for using prefabricated elements more."

1.2 THE CELSIUS PROJECT

As illustrated in Figure 4, The Celsius project advanced model-based project delivery by building on the foundational learning from New Slussen. Two VDC managers came from New Slussen and applied their knowledge to a building project enhancing information distribution, object parameter management, and contractor coordination workflows, while adding new layers of functionality to improve efficiency. The empirical data highlights the significant role of prior collaboration between the client, CM company, and design team in establishing a foundation of trust and open communication, which seems to encourage stakeholders to pursue model-based design delivery and construction. As emphasized by the interviewees, this trust led them to view model based delivery as the only viable path, accepting challenges and potential failures as part of the process.

The Celsius project also benefited from the client's "innovation year", which was described as the important factor encouraging experimentation and creativity. Antoher important factor shaping the successful implementation of model-based delivery was finding a user-friendly BIM platform designed for site use, addressing a key problem faced in the New Slussen project where technology had limited accessibility for site teams. In Celsius, on-site teams could access project data directly from the model using mobile devices, reducing the need for printed production oriented views (POVs) from 3D models.

Similar to the findings from the New Slussen project, regular VDC meetings were recognized as a central hub for collaboration. Stakeholders met twice weekly on-site to exchange information and address the requirements—or challenges—of model-based project delivery, such as determining the appropriate level of detail needed to use BIM for construction without relying on 2D drawings. These VDC meetings were highlighted as the key factor facilitating knowledge transfer between design and production teams, helping designers understand the needs of the site teams to realize the design on site and ensuring the model's completeness. The high level of detail required in the Celsius project's 3D model was crucial, as the model was used not only for visualization but also for extracting measurements and other details for production, cost estimation, and ordering prefabricated elements. Using the 3D model as the single source of information and legally binding document was a new process for all stakeholders. This increased the demands during the design phase, requiring precise modeling even for minor construction details.

Adopting model-based project delivery also redefined the boundaries of stakeholder roles. Designers had to produce additional details beyond their traditional scope to create a very detailed BIM, and subcontractors received precise quantities for bidding, eliminating the need for independent quantity extraction from 2D drawings. Similar to the New Slussen Project, the role of digital leaders (D's) and followers (d's) was described as a critical factor in enabling the shift from sensing to seizing and initiating the reconfiguration of project processes to support further digitalization through small steps and adjustments. Factors such as 'the role of teamwork,' 'daring to fail together,' and 'focusing on solving problems and unknowns collectively rather than assigning blame' were identified as essential for fostering the shift toward model-based project delivery. The empirical data clearly demonstrates how the decision to adopt model-based delivery (seizing), such as using BIM as the legally binding document, facilitated the recognition (sensing) of the need for accurately developed details within the model. This sensing-by-seizing enabled the reconfiguration of design development and adjustments in construction processes. Furthermore, the new features added to the BIM platform used in the Celsius project enabled the CM company to utilize digital data for additional purposes, such as communication through online platform, issue reporting, and data-based systems for health and safety.

The findings presented in sections 1.1 and 1.2 provide brief project narratives describing the shift towards model-based project delivery, highlighting key factors shaping the process. These narratives were written based on the findings from the interviews which were

subsequently discussed and refined through focus group meetings. The next section outlines the findings from the second question posed during the focus group meeting: If you were starting a new project that follows a model-based delivery approach, what strategies would you use based on your experience in the previous project?

2. STRATEGIES FOR IMPLEMENTING MODEL-BASED PROJECT DELIVERY IN FUTURE PROJECTS

When asked about what lessons learned from the New Slussen project will be implemented in future projects requiring model-based delivery, participants highlighted the following key factors:

EARLY CONTRACTOR INVOLVEMENT TO INTEGRATE PRODUCTION INFORMATION INTO THE DESIGN PHASE

One of the major challenges in the New Slussen project was implementing model-based construction while using the traditional design-bid-build delivery method. Several design changes requested by the contracting firms had to pass through the client before reaching the designer, creating delays and inefficiencies. As noted by a representative from the engineering company:

"To get a model-based delivery method to function in practice, it's crucial that we know what needs to be delivered to production, what information is needed, and how it should be presented most effectively. So involve production much earlier to get help."

Participants emphasized that model-based construction requires early contractor involvement to integrate production data into the design phase, ensuring the development of an accurate BIM that could directly serve as the primary project information source for production.

CLEAR DEFINITION OF ROLES AND RESPONSIBILITIES IN MODEL-BASED PROJECT DELIVERY

The transition to model-based construction within a design-bid-build project delivery framework led to confusion about roles and responsibilities. Model-based design delivery and construction requires a reconfiguration of these roles and responsibilities, necessitating a departure from traditional procurement methods. To ensure smooth implementation and effective collaboration, these roles and responsibilities must be clearly defined early in the project.

DEVELOPMENT OF A COMPREHENSIVE INFORMATION MANAGEMENT

The shift toward model-based project delivery in the New Slussen Project was driven by emergent decisions and processes. Stakeholders developed the model-based delivery platform

through trial and error. However, since it was their first time implementing such an approach, the information included in the BIM model was not well-organized. This resulted in challenges and time losses during the construction phase. As one participant emphasized:

"A well-defined information strategy at the start of the project, including standards for labeling, classification, and data management is a must to prevent confusion and ensure smoother project execution."

The participants also noted that, despite the initial lack of standards to establish a clear strategy, their experience with the New Slussen project has provided them with a better understanding of information management within the model.

TRAINING IN DIGITAL TOOLS AND SOFTWARE BY ENABLING PEOPLE TO RECOGNIZE BENEFITS

One of the biggest challenges in the New Slussen project was the lack of digital capabilities, particularly on-site. To address this, a key practice involved bringing digitally skilled personnel from the design office to the site to provide support. A common strategy for overcoming resistance from site personnel, who were hesitant to adopt digital information, was to demonstrate how the use of a 3D model could create efficiencies in their own practice, as opposed to relying on traditional 2D drawings. Participants all agreed that training should be implemented in small steps, rather than expecting people to adopt a new method all at once.

ENSURING USER-FRIENDLY SOFTWARE INTERFACES

Another key challenge faced in the New Slussen project was the lack of user-friendly software to enable the use of BIM on-site. In the early stages, Navisworks was used through BIM kiosks, with design office personnel brought to the site to assist. However, since Navisworks is not a BIM software specifically designed for site use, it led to inefficiencies in utilizing model data on-site. Participants emphasized that technology has since evolved, and there are now various software solutions available that make it easier to use BIM on-site without requiring significant technological investment.

FOSTERING A POSITIVE PROJECT CULTURE AND BUILDING TRUST AMONG STAKEHOLDERS

A common emphasis was that model-based project delivery requires greater collaboration among stakeholders compared to traditional project delivery methods. As it is an evolving process through collective sensing, seizing, and reconfiguring, the role of leadership (with the important roles of D's and d's) in building trust and overcoming resistance was highlighted as a key factor for successful implementation.

UTILIZING OPEN DATA FORMATS (SUCH AS IFC)

Lastly, all stakeholders emphasized the importance of using open data formats as the only way to break information silos among stakeholders and achieve the successful implementation of model-based delivery.

When reflecting on the lessons learned from the Celsius project, participants identified the following strategies they have already adopted for the next model-based delivery:

A COLLABORATIBE APPROACH WHERE PROBLEMS CAN BE ADDRESSED TOGETHER

Similar to the New Slussen project, participants of the Celsius project emphasized the collaboration among key stakeholders (the CM company, project manager on the client side, and design team leaders) as the critical success factor enabling model-based delivery. They emphasized that it is very difficult to implement a successful transition toward model-based delivery without having a strong agreement that it is the only way to move forward.

DESIGN TEAM NEEDS TO ACCESS WHAT INFORMATION IS REQUIRED ON SITE PRODUCTION

Participants in the Celsius project emphasized the importance of collaboration between the design and construction teams. They suggested implementing a clear information management strategy that outlines what data should be delivered, to whom, for what purposes, and in what format, between the design and production teams.

CONTINOUS INFORMATION EXCHANGE THROUGH REGULAR MEETINGS

Weekly VDC meetings that enable continuous information exchange and common agreement between key stakeholders were identified as an important practice that should be applied to other projects.

ENHANCED USE OF THE INFORMATION IN THE MODEL

Participants in the Celsius project described how they improved model-based delivery in subsequent projects by adding additional functions related to CO2 emissions, issue management, and commissioning. However, they also added that in order to use project information for such purposes, the data should be standardized and structured through a clear information management strategy.

ACHIVING EFFICIENCY THROUGH AUTOMATED PROCESSES

The key suggestion was that model-based delivery can be improved through automation, scripting, and cloud-based working practices. For example, while information exchange among different disciplines was achieved through weekly meetings and updates in the New Slussen Project, it was automated every night in the Celsius project. Representatives from the CM and design teams emphasized that automated processes helped eliminate inefficiencies in developing and sharing digital project information. These discussions were followed by an emphasis on the important role of using open data formats such as IFC.

In summary, the findings from both projects underscore the importance of collaborative practices, early stakeholder involvement, an information management strategy, fostering open communication and trust, and using open data formats as crucial practices that should be implemented in other projects to achieve successful model-based project delivery. Additionally, both projects highlight the advancement toward using digital project data for purposes beyond construction, such as CO2 emissions, purchasing, and logistics management. There was also strong emphasis on the new possibilities provided by automation, scripting, and the use of cloud-based platforms to implement model-based project delivery more efficiently.

3. KNOWLEDGE TRANSFERRED FROM THE CASE PROJECT TO STAKEHOLDER ORGANIZATIONS

The last question in the focus group meetings asked what lessons learned from model-based project delivery had been transferred from the project to the organization. Participants of the New Slussen project highlighted the following learnings:

- → Actors having digital project capabilities to implement model-based project delivery
- → Enhanced use of digital tools and 3D models on site
- → Insights for developing a robust information delivery strategy
- → The importance of fostering collaboration and clear communication
- → Eliminating inefficiencies through streamlined processes
- → Turning vision into reality is possible – they saw the importance of being proactive rather than waiting for industry-wide adoption of digital processes.
- → Embracing open formats for data accessibility
- → The need of developing data security strategies

When asked about what lessons learned had been transferred from the project to the

organization, participants in the Celsius project emphasized the following parameters:

- → Adoption of data-driven construction practices by using the BIM platform to manage health and safety, CO2 emissions tracking, and commissioning
- → The importantce of having a single source of project information (in digital form)
- → Enhanced technical capabilities for using digital tools
- → Improved understanding of production needs, specifically regarding what information is needed by whom and when in a project

CONCLUSIONS AND RECOMMENDATIONS

Developing digital project capabilities for model-based project delivery through collective sensing-by-seizing.

This research has examined the transition from traditional to model-based project delivery in two pioneering projects in Sweden. It explored how the processes of sensing, seizing, and reconfiguring interact, evolve, and facilitate capability development for digital project delivery over time. The findings highlight three key insights:

(i) The identified themes representing micro-processes that enable the shift to model-based project delivery (Figure 3 and 4) do not follow a linear sequence or exhibit distinct boundaries between sensing, seizing, and reconfiguring processes, as often described in the literature.

(ii) Different stakeholders seem to undergo different sensing and seizing processes, where what constitutes sensing for one stakeholder may represent seizing for another (or vice versa, where one stakeholder's seizing process triggers sensing for another).

(iii) The transformation toward model-based project delivery emerges through a "sensing-by-seizing" process at the interface between project and stakeholder organizations, rather than following a predetermined digital strategy.

The findings from the New Slussen project shows that the technology consultant was initially the only stakeholder with digital capabilities for model-based work processes. The structural engineering consultant recognized (sensed) the advantages of 3D modeling and collaborated with the technology consultant to seize these opportunities by adopting digital work practices, such as transitioning to Revit specifically for the New Slussen project. Similarly, the partnership between the technology consultant and the engineering company enabled the client to sense the value of using 3D models, not only for gaining a better understanding of project details but also for effectively communicating the project to the public.

These initial sensing and seizing processes among the client, the engineering company, and the technology consultant led the client to request BIM-based design delivery. Later in the project, the three main stakeholders faced an critical decision: whether to continue using BIM as the primary source of project information during construction or revert to traditional delivery processes with 2D drawings. As illustrated in the findings, representatives of the client, technology consultant and engineering firm collectively went through a long process of sensing and seizing, where learning from others and testing pilot deliveries played a crucial role in moving further to approve model-based construction, eliminating 2D drawings from the construction phase. Following this decision, weekly VDC meetings became central hubs where project stakeholders with varying levels of capabilities related to digital work collaborated. These meetings facilitiated "sensing-by-seizing" processes, enabling them to develop digital project capabilities. Especially important was the role of a small group of digital champions (D's) who were instrumental in creating compelling narratives to persuade stakeholders and in mobilizing junior champions or followers (d's) to lead their organizations toward model-based workflows. Key micro-practices for building digital capabilities included pairing younger and older generations, integrating experienced professionals with tech-savvy designers and

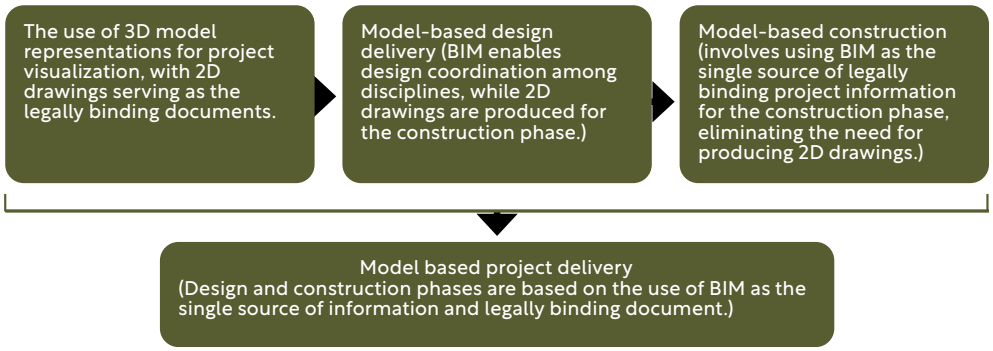


Figure 5. The shift from using 3D model for visualization to model-based project delivery.

engineers, and adopting a step-by-step approach to teaching digital tools. These practices were identified as critical for fostering digital capability development across the project.

The identified collective "sensing-by-seizing" process was also evident in the Celsius project. Key learnings from the Celsius project include how digital project capabilities can be transferred through individuals, laying the foundation for digital transformation in other project settings, and the critical role of trust and collaboration among the client, designers, and the construction management (CM) company. The availability of user-friendly software improved the process and enabled stakeholders work in a cloud-based platform in which they can reach the most recent design, change requests, and manage project communication. Unlike the New Slussen project, findings from Celsius highlight how the scope of work, roles, and responsibilities among stakeholders evolved to meet the requirements of model-based project delivery. The increased demand for detailed design information in BIM led to higher initial time and budget investments during design phase. However, this upfront effort resulted in significant efficiencies during construction, ultimately allowing the project to be completed earlier and at a lower cost than originally estimated.

Overall, findings from both projects illustrate how the advantages of using 3D design representations initiated changes that gradually led to the emergence of the concepts of "model-based design delivery" and "model-based construction," contributing to the development of digital project capabilities for "model-based project delivery". The themes representing the micro-processes/practices that enable this transformation (shown in Figures 3 and 4) highlight how sensing, seizing, and reconfiguring processes unfold at the interface between the project and its stakeholders, driving the development of digital project capabilities for model-based project delivery. Figure 5 illustrates the transformation from using 3D model representations for visualization to model-based project delivery in time.

LEARNINGS TRANSFERRED FROM THE NEW SLUSSEN AND CELSIUS PROJECTS

The lessons from the New Slussen and Celsius projects highlight essential strategies for the successful implementation of model-based project delivery in future projects. Key practices include early contractor involvement, clear definition of roles and responsibilities, and structured data management strategies to ensure accurate and timely information flow. Both projects emphasized the importance of collaboration, continuous information exchange, and fostering trust among stakeholders. Adopting user-friendly digital

tools and open data formats, such as IFC, proved crucial in enhancing accessibility and interoperability.

Additionally, participants noted the significance of a single source of project information and the potential of cloud-based environments to streamline communication and coordination. These findings illustrate a shift toward data-driven practices, integrating health, safety, and environmental data, and underscore the importance of an accurate BIM model that meets production and facilities management needs. The cumulative knowledge from both projects provides a roadmap for organizations to refine their processes, increase technical and organisational capabilities, and proactively embrace model-based project delivery as an industry standard.

This research describes how sensing, seizing, and reconfiguring emerge as emergent, collective processes in practice, supporting capability development for model-based project delivery. It highlights how digital transformation towards model-based project delivery is achieved at the interface between project and project stakeholders where each stakeholder following slightly different internal processes.

Based on two case projects in Sweden, this study contributes to research on digital transformation and project capabilities in construction, emphasizing the role of sensing-by-seizing and interface between project and stakeholder organisations. Future research should explore the mechaninsms of these processes across varied projects and assesss how digital project capabilities may influence an organisational digital transformation.

Based on these conclusions, we would like to offer five recommendations:

1. Facilitate continuous knowledge transfer across projects and stakeholder organisations: Capabilities for model-based project delivery are continuously developed by transferring know-how at the interface between projects and stakeholder organisations, as well as from one project to another. Individual actors play a crucial role in driving this development, carrying lessons learned and practical insights that contribute to successful transitions across projects.
2. The transformation towards model-based project delivery is a collaborative journey where diverse stakeholders learn from one another through a process of sensing-by-seizing. This shared learning process enables stakeholders to enhance their digital project capabilities and and reconfigure business processes to align with new practices driven by the use of digital project data.
3. Recognise the role of digital leaders - both big leaders (D's) and followers (d's)-: Creating an environment that values small wins and embracing lessons from pilot projects can create a culture of continuous improvement and significantly accelerate the development of digital capabilities.
4. Build and strengthen cross-generational and multi-skilled teams: Assemble diverse teams that bring together experienced professionals with tech-savvy individuals across different generations. This collaboration creates synergy and fosters innovation and resilience. By offering structured training on digital tools -focused on simple, step-by-step learning rather than overwhelming, intensive sessions-, organizations can enhance knowledge sharing, bridge skill gaps, and accelerate capability building for digital project processes, paving the way for broader transformation across the organization.
5. The main barrier to adopting model-based project delivery is not the technology itself but rather people's readiness and willingness to adapt. Overcoming this challenge requires fostering a culture of openness, providing targeted training with step-by-step processes to avoid overwhelming individuals with change, and promoting a mindset of continuous learning. These elements are essential to addressing resistance and fully realizing the potential of digital transformation.

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