Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Personal information	
Name	Leonardo Fred Micolta Diaz
Student number	5684773

Studio		
Name / Theme	Theme 8: User perspective	
Main mentor	Prof. mr.dr. EM (Evelien) Bruggeman	Building Law (MBE)
Second mentor	Dr.ir. A. (Ad) Straub	Public Commissioning (MBE)
Third mentor (appointed)	Prof. Moritz Fleischmann-Bergstein	Data Driven Design and Production (Hochschule Düsseldorf)
Argumentation of choice of the studio	The theme of "user perspective" concerning public clients in the built environment presents significant interest, especially regarding how public clients engage with digitalization in the procurement and execution of building projects. With over twelve years of experience as an architect specializing in coordinating, managing, and strategizing BIM-related aspects of building projects, interactions with public clients have revealed varied outcomes. Frequently, public clients face challenges in articulating digital requirements with consistency and clarity, often leading to frustration and disappointment among all project stakeholders. The focus here is twofold: first, to understand the causes of these challenges by identifying common pitfalls in demand formulation, and second, to explore ways to assist public clients in addressing such challenges by drawing on professional expertise and research insights. Observations so far indicate that the issues extend beyond technology to include social factors as well. Although more familiar with technology-oriented perspectives, recent work at TU Delft has deepened an understanding of organizational elements that influence the demand formulation process. These topics align well with Theme 8: User Perspective..	

Graduation project	
Title of the graduation project	Towards comprehensive data demands: A long-term strategy for public clients' asset life cycle data needs.
Goal	
Location:	BLB NRW headquarters in Düsseldorf
The posed problem,	Surveys Surveys consistently show that the Architecture, Engineering, and Construction (AEC) sector lags behind other industries in implementing information technologies (Chan, 2020). Authors Ejohwomu et al. (2021) and Chan (2020) attribute this lag to the

	fragmented nature of the construction industry rather than a lack of technological capability. The AEC sector is often described as fragmented, project-based, and prone to significant budget overruns and scheduling issues (Chan, 2020; Lee & Borrmann, 2020; Siebelink, 2021; Wildenauer & Basl, 2021). Typically, construction projects are large, complex, and long-term, involving temporary project organizations composed of numerous disciplines and stakeholders (Lindblad & Guerrero, 2020; Winch, 2010). Traditionally, these collaborative project organizations operate in "silos," characterized by piecemeal information sharing and unclear task divisions among actors and stakeholders (Siebelink, 2021). This fragmentation is further exacerbated by the one-off nature of construction projects, which limits the broader application of innovative solutions since there are few incentives for market participants to share their competitive advantages (Lindblad & Guerrero, 2020). The project-based mindset, combined with the declining value of project information at each handover stage in the project's life cycle (Eastman, 2011), leads to a loss of information value during phase transitions. Consequently, the negative aspects of fragmentation extend beyond the AEC sector to affect O&M, as they are inherently interconnected. Furthermore, given the emerging value of facility data, Eastman's assumption that the value of information levels off during the O&M phase is no longer applicable. In addition to the loss of information value due to compartmentalized information transfers throughout the asset life cycle, the AECOO sector has been notably resistant to technological change and reluctant to adopt knowledge from other industries (Chan, 2020; Ejohwomu et al., 2021; Wildenauer, 2023). This resistance is often attributed to social factors, such as individual behavior, self-efficacy for change, and organizational support for change (Shirish & Batuekueno, 2021). Research by Shirish and Batuekueno (2021) found that in the cost-benefit analysis of technology adoption, an individual's behavioral intention to use the technology

	mediates the relationship between IT adoption and IT resistance. Therefore, they argue that addressing individual behavior is a key component of effective change management strategies and interventions. Capturing facility data throughout the asset life cycle is influenced by these individual behaviors, further complicated by the fact that information capture spans up to 30 years, during which both technology and personnel are likely to change. Currently, a long-term strategy for capturing and managing emerging facility data is not well established within the AECOO sector. Moreover, individual behavior is not always consistent when it comes to implementing new technologies, as hybrid approaches that combine new practices with old habits are common (Chan, 2020; Lindblad, 2019). Therefore, it is important to periodically evaluate the actual use of information technologies in relation to their perceived future value (Shirish & Batuekueno, 2021). This evaluation helps determine whether individual behavior aligns with the intended use of the technology, which is crucial for successful adoption. The gap between intended and actual behavior is described by Miles (2017) as a "practical-knowledge gap." This gap occurs when professionals' actions do not align with their advocated practices (Miles, 2017). Kuitert et al. (2019) illustrate this gap in the public sector, noting that while procedural obligations are formally well-defined in public construction organizations, clients often revert to old patterns and behaviors. Unfortunately, this practical-knowledge gap hinders public clients' ability to fully leverage digitalization in the AECOO sector (Kuiper, 2021; Wildenauer & Basl, 2021). In response, an increasing number of authors argue that a socio-technical approach is essential for successful technological adoption in the AECOO sector, including BIM. Some even suggest that greater emphasis on social factors may be needed to bridge the practical-knowledge gap (Abbasnejad et al., 2021; Chan, 2020; Ejohwomu et al., 2021; Lee & Borrmann, 2020; Lindblad & Karrbom

	Gustavsson, 2021; Siebelink, 2021; Wildenauer, 2023). While previous foundational research focused on defining technical standards, such as the ISO 19650 series, addressing the practical-knowledge gap now requires developing explicit "game plans" tailored to meet specific client data needs (Wildenauer, 2023). Historically, research emphasized generalized concepts and standards to expand the use of information technology capabilities—a process-driven technological approach. However, many public clients across Europe are still struggling with their initial digitalization efforts, despite the availability of guidelines and standards (Charef et al., 2019; Fiamma & Biagi, 2023; Meins-Becker & Kaufhold, 2021). Additional research focusing on practical managerial aspects is needed to address these current challenges. There is limited research on explicit BIM implementation guidelines that envision a comprehensive and holistic utilization of Project Information Models (PIM) in conjunction with Asset Information Models (AIM) throughout a building's life cycle (Abbasnejad et al., 2021; Godager et al., 2021; Siebelink, 2021; Wildenauer, 2023)—in other words, deploying "winning game plans." Therefore, this research shifts focus from an industry-wide perspective to an inward, intra-organizational approach. The goal is to develop a method that considers an organization's goals, identifies its specific data needs, accounts for the barriers it faces, and aligns these factors to formulate comprehensive and holistic data demands. Thus, the research problem statement is: The lack of a well-defined, long-term strategy for capturing and managing facility data across the asset life cycle in the AECOO sector impedes public clients from formulating comprehensive and holistic data demands, limiting the impact of digitalization efforts.

research questions and	To address the research problem, specific managerial actions are explored. This exploration aligns with suggestions by Kuitert et al. (2019), as these actions can be integrated into a continuous improvement approach that aims to break down information "silos" while addressing prevailing social factors. Therefore, the main research question derived is as follows: RQ: How can public clients develop a comprehensive and holistic framework for data demand formulation that aligns with their asset life cycle needs, organisational goals, and desired public values? To answer the main research questions, the following sub-questions will be answered: SQ1: What theoretical framework can be used to evaluate an organization's current state in relation to its desired state in digital transformation adoption efforts? SQ2: What are the organization's data needs, and how do they relate to its short- and long-term goals? SQ3: What internal barriers, shortcomings, or peculiarities should be considered when formulating demands in accordance with the needs? SQ4: What are the organization's data demands, and how are they communicated to market parties? SQ5: What are the (mis)alignments between the needs, barriers, and demands in relation to the organization's short- and long-term goals? SQ6: What are the essential elements needed to align organizational needs and barriers into effective data demands for public clients?

design assignment in which these result.	The purpose of this research is to design a continuous improvement approach for managing public client's data demand formulations that accounts for intra-organizational process and methods change and inter-organizational dependencies. However, rather than emphasizing on technological adoption, this research focuses on systemic change, where people, process, policy, and technology are considered in a socio-technical networked approach.

Process

Method description

This research investigates two case studies: Germany's Bau- und Liegenschaftsbetrieb NRW (BLB NRW) and the Netherlands' Central Government Real Estate Agency (Rijksvastgoedbedrijf, or RVB). The cases were chosen based on three factors: each organization's engagement in digitalization efforts, which provided relevant data and experienced personnel; secured access to these organizations through mentor-facilitated networks; and the limited scope of a master's project, which constrained the study to two cases. While each case is treated as a standalone project with its own empirical research, both share a theoretical framework and research tools. The main focus of this study is BLB NRW, whereas the RVB case forms part of a separate initiative, with findings from both cases compared in the discussion section. A comprehensive report on the RVB case will be produced separately.

The research uses a mixed-method exploratory sequential design, involving semi-structured interviews, document analysis, and internal and external validation through focus groups to collect both qualitative and quantitative data. The methodology follows retroductive logic, aiming to uncover underlying structures or mechanisms that explain observed patterns, as illustrated in Figure 1 (Blaikie & Priest, 2019). The study is grounded in depth realism ontologically and adopts a neo-realist perspective epistemologically. The research paradigm is that of critical realism, which is defined by Blaike and Priest (2019) as:

> *"Reality consists not only of events that are experienced but also of events that occur whether experienced or not, and of the underlying structures and mechanisms that produce these events. The aim of science is to discover these structures and mechanisms, some of which may be reasonably accessible using instruments that extend the sense. This is done by building hypothetical models of them and then searching for evidence of their existence."*

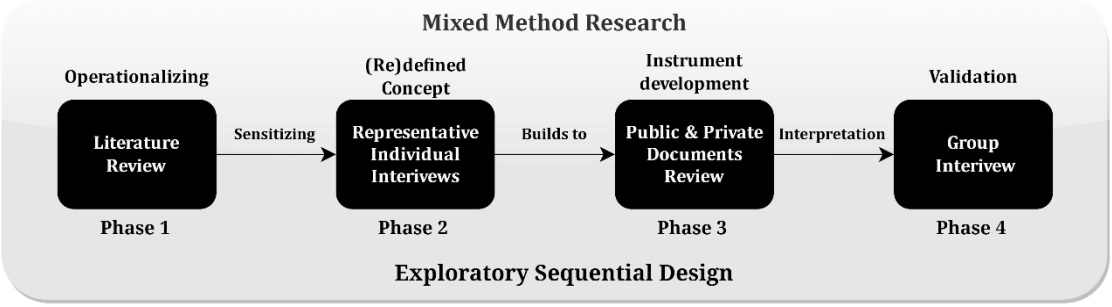

Figure 01 | Visualization of research methods, exploratory sequential design (by author)

The research is conducted in four phases.

Phase 1: Literature Review and Theoretical Framework Development

This phase establishes the theoretical foundation, defines research concepts, and develops tools for data analysis, primarily addressing Sub-question 1 (SQ1) on the appropriate theoretical framework for evaluating an organization's digital transformation from current to desired states.

Phase 2 and 3: Empirical Research on Current and Desired States

These phases focus on defining two constructs for digital transformation: the *current state* (Concept 1), based on tacit knowledge, and the *desired state* (Concept 2), based on explicit knowledge. Through semi-structured interviews and document analysis, data needs, barriers, and demands are identified for both tacit (Variables 1A, 1B, 1C) and explicit knowledge (Variables 2A, 2B, 2C). These phases address Sub-questions 2–5 by exploring data needs, identifying implementation barriers, evaluating data demands, and assessing (mis)alignments between needs, barriers, and demands in relation to organizational goals.

Phase 4: Validation and Essential Elements Identification

Internal validation occurs via a focus group to prioritize identified (mis)alignments, synthesizing them into *essential elements* (Concept 4). This phase addresses Sub-question 6 (SQ6), identifying the necessary components to align organizational needs and barriers with effective data demands for public clients.

Final Analysis: Framework Development and External Validation

The main research question (RQ) is addressed by integrating the essential elements into the theoretical framework, creating critical paths to guide managerial solutions for effective data demand formulation. The solutions are tested in an external focus group to validate the practical application of the framework.

Literature and general practical references

The literature review is organized into four main themes: People, Policy, Process, and Product. For the "People" theme, research on applying Actor-Network Theory within the AECOO sector is drawn from Lindblad (2019), Lindblad and Guerrero (2020), and Lindblad and Karrbom Gustavsson (2021). Additionally, concepts of knowledge transfer and knowledge brokerage are explored through the works of Soda et al. (2018), Bernhard (2018), and Clement et al. (2018), highlighting the dynamics of knowledge exchange within and across organizations.
The "Policy" theme is heavily influenced by Kuiper's (2021) dissertation, which examines key aspects of policy implementation, including uncertainties, challenges, and BIM qualification, providing a robust framework for understanding policy dimensions in digital transformation efforts. The "Process" theme primarily draws on the dissertation research of Siebelink (2021), which investigates the impact of inter-organizational BIM maturities on Design and Construction phases, and Wildenauer (2023), which explores the advancements of Digital Twins in Facilities Management through BIM. Both authors discuss limitations in the ISO 19650 series, which led to a closer examination of these standards for the current research.
Finally, the "Product" theme focuses on the outputs of these processes, encompassing both explicit demands (information requirements) and the resulting information models. Here, the ISO 19650 series provides foundational definitions and structure. To contextualize the broader paradigms of BIM and Industry 4.0, additional sources were consulted, including Al Ahbabi & Alshawi (2016), Eastman (2011), May et al. (2023), Stange (2020), Chan (2020), Bruggeman (2020), as well as relevant regional guidelines. Together, these themes offer a comprehensive basis for understanding the multiple facets involved in digital transformation within the AECOO sector.

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?

This graduation project aligns with the User Perspective studio, focusing on the concept of "internal commissioning" as defined by Hermans et al. (2018). Internal commissioning addresses the organizational integration of responsibilities related to the built environment, including strategic needs assessment, need specification, demand formulation, and supplier selection. This project specifically examines two of these processes: need specification and demand formulation, exploring how data needs are translated into data demands for procuring digital information in construction and asset management.

The Management in the Built Environment (MBE) track at TU Delft's Faculty of Architecture (BK) is among the few programs in the region that extensively covers this emerging topic, which was a primary factor in selecting this university and program. Residing in Germany and working with a company based there, I found that most comparable programs within a similar distance from my home in Düsseldorf focused mainly on technical aspects. I sought a program that would provide a solid theoretical foundation for my research interests and allow me to develop research skills. The research methods courses at TU Delft and the option to join the Honors Master Program have offered valuable academic exposure, reaffirming my decision to pursue this program. Furthermore, I deeply appreciate the enthusiasm, energy, dedication, and support my mentors have provided, making this process not only enriching but also highly enjoyable.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.

I. Professional relevance

This research explores how public clients can improve intra-organizational information flow and knowledge transfer, aiming for a more comprehensive and holistic understanding of their information needs. The goal is to develop a management process that can be activated when formulating demands for procuring construction works and services. The practical relevance of this research lies in optimizing internal processes for public clients. This optimization results in more transparent communication, reduces redundant efforts in sourcing building data, saves time, and improves the quality of outcomes. It aims to break down intra-organizational communication "silos" and serves as a tool to set a vision for using information models throughout a building's life cycle.

Managers in public client organizations, at both strategic and operational levels within projects and CRM teams, can benefit from the findings of this research by highlighting their data needs early in the process. They can engage in a process that ensures information delivery meets their expectations and standards. Additionally, this research is relevant for policymakers looking to enhance digitalization and address the challenges associated with Industry 4.0 technologies in the built environment. While much has been written about BIM implementation in client organizations, limited knowledge exists about how the Industry 4.0 paradigm impacts the established BIM paradigm and its related policies. Understanding the interaction between these two paradigms from a public client perspective may offer new insights for policymakers aiming to advance digitalization in the built environment.

II. Societal relevance

The quality of our built environment plays a crucial role in mitigating the effects of climate change, as highlighted by the United Nations' 2030 Agenda for Sustainable Development and its

17 Sustainable Development Goals (SDGs) (UN, 2015). Notably, SDG 11 focuses on sustainable cities and communities. To achieve these SDGs, the concept of a Circular Economy (CE) has been proposed, which is defined as "an economic system based on the reusability of product components, recycling of materials, and the conservation of natural resources while creating added value in every link of the system" (Potting et al., 2017).

A foundational element of transitioning to a circular built environment is sustainable procurement, often referred to as Green Public Procurement (GPP). The European Commission defines GPP as "a process by which public authorities seek to procure goods, services, and works with a reduced environmental impact throughout their life cycle compared to alternatives with the same primary function" (Bidin et al., 2022; Finamore & Oltean-Dumbrava, 2022). GPP requires public clients to formulate demands that include information on the desired sustainability aspects. This information is essential for quality control, validation, and effective asset life cycle management (Bougrain, 2020; Finamore & Oltean-Dumbrava, 2022).

The societal relevance of this research lies in its contribution to improving the demand formulation process, which enables more effective delivery of public values, including fostering a sustainable built environment.

III. Scientific relevance

Despite the extensive literature on the slow and challenging adoption of digitalization in the AECOO sector, the emphasis on digitalization in the built environment, particularly within the public sector, remains an important research focus. The role of public clients in driving industry change is widely regarded in the literature as a key strategy to address fragmentation in the construction industry (Al Ahbabi & Alshawi, 2015; Kuitert et al., 2019; Lee & Borrmann, 2020; Lindblad & Guerrero, 2020). Kuitert et al. (2019) further elaborate on this by stating that "[public] clients have no tools, except stimulation or dedicated managerial actions, to actively implement new [public] values" in the delivery of public services such as construction projects. Since the industry is already highly regulated and mature, there are limited alternative avenues for exploring solutions.

This research contributes to the academic discourse on the significance of the role and policy positioning of public clients when promoting initiatives that realize public values.

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