Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Architecture and Design
Department of Architecture and Planning

Elias Lauen Singstad

Unlocking the Potential of Digitalization in Facility Management

Bridging the Gap between Technology and Practice

Master's thesis in Real Estate and Facilities Management
Supervisor: Carmel Lindkvist
Co-supervisor: Toomaj Ghalandar

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Preface

This master's thesis marks the culmination of a challenging and rewarding learning journey. Over the course of this project, I have had the privilege to grow both academically and professionally while delving into the digital transformation of Facility Management. Conducting my research as part of the Bridging the Gap project provided a unique opportunity to work closely with professionals in the FM industry and the proptech sector, as well as with a team of researchers. This experience allowed me to witness first-hand the dynamic interface between theoretical research and practical application. Collaborating with facility managers and technology providers not only enriched the content of my thesis, but also significantly contributed to my personal and professional development. I am grateful for the chance to engage with a research community dedicated to innovating the future of FM, and this has reinforced my passion for bridging the gap between academia and industry. Writing this thesis has deepened my understanding of research methodology, interdisciplinary collaboration, and the transformative potential of digital technologies. The process has at times been demanding – from coordinating workshops to analyzing complex data – but it has also been immensely instructive and fulfilling. I have learned to navigate the complexities of academic inquiry while keeping sight of real-world implications, which I believe will serve me well in my future career. Overall, I feel that this journey has prepared me for new challenges, whether in further research or in professional practice. I am proud to present this work as a reflection of my learning journey and as a modest contribution to the ongoing conversation about digital innovation in Facility Management.

Acknowledgement

This thesis was written as part of the research project Bridging the Gap – Information Management Platforms Across the Lifecycle (project number 328730), which was funded by the Research Council of Norway. I am grateful to all the participants and collaborating partners in the project for their valuable contributions and insights throughout my work. I also wish to thank the technology providers who participated in interviews and the participants of the second workshop – even though the data from these interviews and the second workshop were not directly used in this thesis – for their time and the perspectives they shared. Their willingness to engage provided me with a broader understanding of the FM digitalization landscape. I am especially thankful to Professor Carmel Margareth Lindkvist – my academic supervisor and now colleague – for her guidance, support, and encouragement. Her expertise and feedback were important in shaping this thesis, and her mentorship has been invaluable to my growth as a researcher. I also extend my deep gratitude to Toomaj Ghalandar for co-facilitating the workshops with me and for being a supportive mentor throughout this process – always with an open door for questions, discussions, and guidance. His insights and advice helped me navigate challenges at every stage of the project.

Beyond the academic circle, I would like to acknowledge the importance of moral support from friends and family. Livets glade gutter aka. Ukekoret Pirum, as well as Trondhjems studentersangforening, has been a source of joy, camaraderie, and much-needed balance during my time as a graduate student; the laughter and music we shared greatly enriched my student life. Finally, I am deeply grateful to my parents for their unwavering emotional support and encouragement. Their belief in me has been a pillar of strength, and I could not have accomplished this journey without their love and support.

Abstract

Facility Management (FM) is undergoing a digital transformation with the potential to greatly enhance efficiency, sustainability, and user satisfaction in building operations. Modern technologies such as BIM, IoT, AI, and digital twins offer significant opportunities to optimize facility management processes, yet many FM organizations struggle to realize these benefits in practice. This study addressed that gap by conducting a qualitative scenario-based backcasting workshop in March 2024 with participants from FM practice and academia. In the workshop, 15 participants envisioned the state of the FM sector in 2030 and worked backwards to identify the steps needed to achieve that future, focusing on technology, people, and organizational processes.

Findings: The participants recognized numerous benefits of FM digitalization – including streamlined operations and maintenance, data-driven decision-making, improved collaboration and communication, cost savings, and enhanced sustainability and innovation capacity. At the same time, they identified key challenges impeding digital transformation in FM. These challenges are largely organizational and cultural: limited digital skills and training gaps among FM staff, resistance to change and entrenched work culture, resource and budget constraints, fragmented data silos and lack of system integration, and usability issues with complex FM software. To bridge the gap between digital potential and actual implementation, the workshop participants suggested several strategies. High priorities include investing in staff training and competence development, fostering an open and innovation-friendly organizational culture, improving data integration and interoperability of systems, and ensuring new technologies are user-friendly. A critical insight was the importance of aligning digital tools with the real needs and workflows of end-users in FM. In particular, involving FM professionals early in the development or adoption of new solutions – for example, through pilot projects or co-creation with technology providers – was highlighted as vital for achieving solutions that are both technically effective and embraced in practice. While these findings offer valuable insights for the FM sector, they are based on a single workshop with a limited sample. The results should thus be viewed as exploratory and context-specific rather than universally generalizable, underscoring the need for further research as digitalization in FM progresses.

Sammendrag

FM-sektoren (Facility Management) står overfor en digital transformasjon som har potensial til å forbedre effektivitet, bærekraft og brukeropplevelse i forvaltning og drift av bygninger. Moderne teknologier som BIM, tingenes internett (IoT), kunstig intelligens (AI) og digitale tvillinger kan gi betydelige gevinster i FM, men mange organisasjoner opplever at disse mulighetene ikke utnyttes fullt ut i praksis. Denne studien tar tak i dette gapet ved å gjennomføre en kvalitativ, scenario-basert backcasting-workshop i mars 2024 med deltakere fra både FM-praksis og akademia. I workshopen deltok 15 personer som sammen forestilte seg FM-sektoren slik den ideelt kan se ut i 2030, for deretter å jobbe bakover og identifisere hvilke tiltak som må til for å oppnå denne fremtiden – med særlig fokus på teknologi, mennesker og organisatoriske prosesser.

Funn: Deltakerne anerkjente en rekke fordeler ved digitalisering av FM, deriblant mer strømlinjeformet drift og vedlikehold, datadrevet beslutningsstøtte, bedre samhandling og kommunikasjon, kostnadsbesparelser samt økt bærekraft og innovasjonsevne. Samtidig pekte de på sentrale utfordringer som bremser den digitale transformasjonen i FM. Disse utfordringene er i stor grad organisatoriske og kulturelle: begrenset digital kompetanse og opplæringsbehov blant de ansatte, motstand mot endring og en innarbeidet "vi pleier å gjøre det slik"-kultur, knapphet på ressurser og budsjettmidler, fragmenterte datasiloer og manglende systemintegrasjon, samt svak brukervennlighet i komplekse FM-systemer. For å bygge bro mellom teknologiens potensial og dagens praksis foreslo deltakerne flere strategier. Høyest på listen står investering i opplæring og kompetanseheving, utvikling av en mer åpen og innovasjonsvennlig organisasjonskultur, bedre integrasjon og flyt av data på tvers av systemer, og sikring av at nye teknologier er brukervennlige. Et gjennomgående tema er viktigheten av å tilpasse digitale verktøy til brukernes faktiske behov og arbeidsprosesser. Spesielt fremheves det at FM-personell bør involveres tidlig i utviklingen og implementeringen av nye løsninger – for eksempel gjennom pilotprosjekter eller tett samarbeid med teknologileverandører – slik at verktøyene som tas i bruk både er teknisk effektive og blir omfavnet i praksis. Funnene fra studien gir verdifull innsikt for digitaliseringen av FM-sektoren, men de baserer seg på én workshop med et begrenset utvalg deltakere. Resultatene bør derfor betraktes som utforskende og kontekstspesifikke heller enn allmenngyldige, noe som indikerer behov for videre forskning ettersom digitaliseringen av FM skrider frem.

Figures

Acronyms

Facility Management / Facilities Management	FM
Building Information Modelling	BIM
Digital Facilities Management	DFM
Internet of Things	IoT
Artificial Intelligence / Machine learning	AI/ML
Computerized Maintenance Management Systems	CMMS
BIM-based facilities management	BIM-FM
Technology Acceptance Model	TAM
Digital maturity models	DMMs
Key Performance Indicators	KPI
Virtual Reality	VR
Augmented Reality	AR
Integrated Workplace Management System	IWMS
Computer-Aided Facility Management	CAFM
IWMS/CAFM - 1	Refers to an anonymized FM system
CAFM/CMMS - 2	Refers to an anonymized FM system

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1 Introduction

Facility Management (FM) has traditionally been viewed as a conservative domain, often lagging behind architecture and engineering in adopting innovative technologies (Wong, Ge and He, 2018). However, the rapid advancement of digital tools is beginning to reshape the FM landscape, offering new opportunities to enhance efficiency, sustainability, and strategic decision-making in building operations. The integration of Building Information Modeling (BIM), Artificial Intelligence (AI), and digital twin technologies is increasingly seen as vital for the evolution of FM (Atta and Talamo, 2019; Mansouri, Castronovo and Akhavian, 2020; Marocco and Garofolo, 2021; Sulaiman *et al.*, 2021; da Silva *et al.*, 2022; Mostafa and Alaqeeli, 2022; Siccardi and Villa, 2022; Schmitter, Shahgholian and Tucker, 2024) One editorial forewarns that *"no segment of the workforce is going to be immune to the impact of IoT and AI,"*(Atkin and Bildsten, 2017, p. 6) with even managerial roles likely to be thinned and semi-skilled jobs rapidly eliminated by smart automation. Such disruptive innovations can *"create new markets and value networks"* (Atkin and Bildsten, 2017, p. 7), displacing established practices and demanding new models of facility delivery unimaginable just years ago. In short, the future of FM will be dramatically different as emerging technologies challenge the status quo of how facilities are managed. The FM sector faces a dilemma: continue along the same trajectory or *"strike out in new directions"* (Atkin and Bildsten, 2017, p. 8) to meet the challenges posed by IoT and AI. There is even the very real prospect of a "false dawn" if FM organizations take their eyes off developments in IoT and AI – an inflated FM sector could see its work *"begin to fall away as change on a major scale takes hold"* (Atkin and Bildsten, 2017, p. 6). These perspectives underscore the imperative for FM to actively engage in digital transformation rather than passively risk obsolescence.

Within the building industry at large, project delivery and asset management practices have *"dramatically changed during the last decades due to technological advancements"* (Elyasi, Bellini and Klungseth, 2023a, p. 2). Organizations across the built environment are *"moving towards digital transformation on different levels"*, introducing new efficiencies throughout the asset lifecycle (Elyasi, Bellini and Klungseth, 2023a, p. 2). Digital transformation in this context refers to comprehensive organizational change enabled by modern information technologies (Elyasi, Bellini and Klungseth, 2023a, p. 2) In essence, it involves strategic and cultural shifts in how an organization operates, not just the deployment of new gadgets. Experts widely agree that adopting digital technologies is a key enabler supporting this transformation process (Elyasi, Bellini and Klungseth, 2023a, p. 2). In the FM domain, digital transformation holds considerable promise. By applying digital technologies, FM can achieve major efficiency gains and cost savings (Elyasi, Bellini and Klungseth, 2023a, p. 2). For example, a recent study noted that for a typical office building in Norway, annual operations (energy, cleaning, security, etc.) account for roughly 66% of total lifecycle costs; thus even modest improvements in FM processes could yield significant savings (Elyasi, Bellini and Klungseth, 2023a, p. 2). Moreover, emerging tools like digital twins applied in the use phase of facilities can bring tangible benefits for sustainable building operation and maintenance (Elyasi, Bellini and Klungseth, 2023a, p. 3). Atkin and Brooks (2021) famously stated that information is the lifeblood of FM – without it, an organization cannot reliably control or account for its assets (Elyasi, Bellini and Klungseth, 2023a, p. 3). Digital transformation directly speaks to this need by leveraging data for better decision-making. Technologies such as BIM, AI, Internet of Things (IoT) sensors, and analytics platforms are converging to provide FM professionals

with unprecedented real-time information about their facilities. The adoption of digital twins in the built environment, in particular, *"needs to be considered in the context of digital transformation" (Elyasi, Bellini and Klungseth, 2023a, p. 2)* because digital twin initiatives often serve as focal points integrating various digital tools and data sources in FM (Elyasi, Bellini and Klungseth, 2023a) A contributing factor is that facility managers often lack the necessary training, digital skills, and IT infrastructure to exploit BIM-based workflows in maintenance and asset management. Similarly, AI and data analytics tools hold enormous promise for automating routine tasks, optimizing energy use, and predicting equipment failures before they happen. Research suggests AI could substantially enhance labor productivity and decision accuracy in FM (Atkin and Brooks, 2021)

Yet in practice, the implementation of AI in FM is still in its early stages, hindered by high upfront costs, the complexity of AI systems, and organizational resistance to change. Digital twin technology – dynamic digital replicas of physical assets and processes (Stojanovic *et al.*, 2018, p. 2; Ghalandar, Hansen and Lindkvist, 2023, pp. 6–7) – is another emerging pillar of digital FM. Digital twins facilitate real-time monitoring and predictive management of facilities, enabling data-driven strategies for preventive maintenance and performance optimization (Elyasi *et al.*, 2023). Still, the adoption of digital twins in FM is advancing slowly, as challenges around organizational culture, data governance, and integrating legacy systems pose significant barriers (Errandonea, Beltrán and Arrizabalaga, 2020) In summary, while the FM sector stands to reap considerable benefits from digital transformation, it faces challenges in bridging the gap between technological potential and actual implementation.

In Norway, the imperative for digital transformation in industries like FM is reinforced by national priorities. As one government strategy document put it: *"Digitization and new technology are the key – and artificial intelligence will be absolutely central"* to working smarter and more efficiently in the coming years (Astrup, 2020; moderniseringsdepartementet, 2020). The Bridging the Gap project (BtG) exemplifies a proactive response to this imperative within the FM context. Launched in late 2021 with support from the Research Council of Norway, BtG is a collaborative initiative between academia (NTNU) and industry partners aimed at closing the divide between theoretical research and practical application in FM digitalization. A core focus of the project is exploring how operational data and FM experience can inform the early phases of building design and construction, and conversely how information from capital projects can be leveraged during the FM phase through increased use of digital platforms and digital twin solutions. For instance, the project's case study "Teknostallen" involves partners like KLP Eiendom (a real estate owner), NCC Building Nordics (contractor), and Pir2 (architect) working together to deliver a fully functional digital twin of a new building by 2025. NTNU's role is to observe and analyze these efforts from a lifecycle information management perspective, examining how enhanced collaboration and data-sharing can improve both project delivery and facility operations (Lindkvist *et al.*, 2021; Elyasi, Bellini and Klungseth, 2023a; Lindkvist, no date) This research context provides an opportunity to investigate FM digital transformation in action, examining both the needs of facility managers and the contributions of technology providers in realizing a digitally enabled FM future. Against this backdrop, the present study sets out to explore how facility managers envision the future of their discipline amid digital transformation, and how closer collaboration with technology suppliers might accelerate the adoption of effective digital strategies. By engaging both FM professionals and FM researchers, the research seeks to identify alignment or gaps

between FM needs and proptech offerings, and to develop strategic insights for advancing digital transformation in FM. Ultimately, the goal is to help prepare the FM sector for a future of AI, data-driven decision support, and digitally integrated workflows – moving beyond theoretical potential toward tangible realization of improved facility performance.

2 Research Questions

2.1 Main Research Question

How do facility managers perceive the future of digital transformation in their discipline, and how can collaboration with technology providers improve the adoption and effectiveness of digital strategies?

2.2 Sub-Research Questions:

- **SQ1:** What specific needs and challenges do facility managers face in adopting digital technologies?
- **SQ2:** How do facility managers perceive the potential benefits and risks of digital transformation?
- **SQ3:** What role do technology providers play in shaping digital strategies for facility management?
- **SQ4:** What practical strategies can be implemented to address the gaps between digital technology potential and actual adoption in facility management?

3 Theory

3.1 The Imperative of Digitalization in FM

The realm of FM has undergone a significant evolution, transitioning from its traditional focus on basic operational maintenance to a more strategic role encompassing comprehensive asset management and the enhancement of occupant experiences. Modern FM now integrates place, people, process, and technology to improve the performance of organizational processes and the quality of life for occupants (Naji, Gunduz and Al-Qahtani, 2024a). This expanded responsibility includes ensuring a highly reliable, safe, and sustainable infrastructure for various types of facilities, including critical sectors like healthcare (Schmitter, Shahgholian and Tucker, 2024).

The advent of digital transformation presents both substantial opportunities and considerable challenges for the FM sector. The integration of digital tools and systems promises to amplify the efficiency and sustainability of operations, leading to increased occupant satisfaction and significant cost reductions (Whitley, 2023). For instance, leveraging digital transformation can enhance efficiency, accuracy, and overall decision-making processes within FM organizations (Alrubaidi, 2024). However, realizing these benefits requires effectively bridging the gap between the rapid advancements in technology and their practical implementation within FM settings. This report aims to address this critical juncture by providing actionable insights and strategic recommendations for FM organizations seeking to harness the full potential of digitalization.

3.2 Defining Digital Transformation in Facility Management: Concepts and Characteristics

The concept of digital transformation in facility management involves a pivotal process *"that leverages digital technologies to create new or modify existing business processes, corporate culture, and customer experiences to align with evolving market dynamics"* (Bailey and Alvarez, 2024). When applied specifically to facilities management, this results in what is known as Digital Facilities Management (DFM), which involves the integration of multifariousdata-driven tools such as the Internet of Things (IoT), Building Information Modeling (BIM), and Artificial Intelligence/Machine Learning (AI/ML) to optimize facility management practices (Bailey and Alvarez, 2024). This transformation fundamentally changes how projects are planned, executed, and maintained (Alrubaidi, 2024). Technologies such as Computerized Maintenance Management Systems (CMMS), BIM, IoT, AI, smart applications, and interactive dashboards collectively enhance efficiency, accuracy, and decision-making capabilities within FM (Alrubaidi, 2024).

While the term digital transformation is widely used, a universally agreed-upon definition remains somewhat elusive (Schmitter, Shahgholian and Tucker, 2024). Nevertheless, the fundamental premise is that technology serves not as the primary focal point, but rather as an enabler of broader organizational change (Schmitter, Shahgholian and Tucker, 2024). This integration of technology into service delivery processes leads to significant alterations in the entire value creation process, associated value chains, and the underlying business model, necessitating the adoption of a comprehensive digital business strategy (Schmitter,

Shahgholian and Tucker, 2024). In essence, digital transformation in FM goes beyond mere digitization, ushering in a wave of tools and systems designed to amplify the efficiency and sustainability of operations (Whitley, 2023). Digital FM can be simply understood as the strategic utilization of technology to streamline facility management processes, encompassing the use of software, IoT devices, sensors, data analytics and reporting, AI, and other cutting-edge digital solutions (Datta, 2023).

Several key characteristics and components underpin digitalization in facility management. A central aspect is data-driven decision-making, where insights derived from the collection, analysis, and interpretation of various data sources inform operational and strategic choices (Cacoveanu, 2023). Automation of routine tasks and processes is another critical component, leading to improved efficiency and reduced labor overhead (Datta, 2023). Enhanced connectivity through integrated systems and the IoT facilitates real-time monitoring and control of building assets and environments (Whitley, 2023). Furthermore, a focus on enhancing the user experience for building occupants through user-friendly technologies and optimized spaces is a defining characteristic of digital transformation in FM (Cacoveanu, 2023).

It is crucial to distinguish between digitization and true digital transformation. Digitization refers to the process of converting analog information into a digital format (Schmitter, Shahgholian and Tucker, 2024). In contrast, digital transformation involves a more profound and holistic change, fundamentally altering business processes and models through the strategic application of digital technologies (Schmitter, Shahgholian and Tucker, 2024). The current landscape of FM literature often reveals a tendency to focus on specific digital technologies rather than adopting a comprehensive digital transformation approach that aligns with broader digital transformation theories (Schmitter, Shahgholian and Tucker, 2024). Therefore, FM organizations must move beyond simply implementing digital tools and embark on a journey of rethinking their core processes and strategic objectives in the digital age.

3.3 Exploring the Landscape of Digital Technologies in Facility Management

The digital transformation of facility management is propelled by several key technologies, each offering unique capabilities and benefits.

3.3.1 Building Information Modeling (BIM)

Building Information Modeling (BIM) represents a collaborative process that transforms the capturing, sharing, and development of construction project information, which is essential for the planning, design, and construction of buildings (Yieu *et al.*, 2025). BIM serves as a repository model integrated with a database, storing all relevant information about a facility throughout its entire lifecycle, with the ultimate goal of transferring this data into FM operations (Aziz, Nawawi and Ariff, 2016). While BIM has become an integral part of the architecture, engineering, and construction (AEC) sectors, its adoption and integration into facilities management remain relatively underexplored and are still in the early stages of development (Yieu *et al.*, 2025).

The adoption of BIM in FM offers numerous benefits, contributing significantly to operational efficiency and sustainability. BIM-enabled FM models drive a shift towards predictive maintenance, supporting proactive decision-making and dynamic integration with other building systems (Yieu *et al.*, 2025). The advantages of integrating BIM into FM include effective operational cost management, shorter timeframes for decision-making, readily available resources for informed choices, improved documentation systems, enhanced collaboration, and access to updated information for clash detection (Aziz, Nawawi and Ariff, 2016). Furthermore, BIM-based facilities management (BIM-FM) plays a crucial role in achieving sustainable construction practices by improving communication and collaboration among stakeholders, enhancing the efficiency of building operations, reducing maintenance costs, and optimizing energy consumption (Adillah *et al.*, 2023). Using BIM for FM technology is feasible across various scenarios, with the most effective approach being the inclusion of FM functionalities during the initial design phase of a building project (Nawrot, 2022). BIM data proves useful in various FM tasks such as commissioning, space management, locating building components, quality control, energy management, security management, and maintenance and repairs (Dixit *et al.*, 2019). Research indicates that BIM adoption in FM can lead to a substantial 25% reduction in project completion time by improving communication and minimizing errors (Alrubaidi, 2024).

In practice, however, the adoption of BIM in FM has been slow and remains in the early stages of development (Yieu et al., 2025). Many FM departments struggle to fully leverage BIM data after handover, and studies note that substantial value often remains untapped. Common barriers include incompatibility between BIM outputs and FM software, lack of training for FM personnel to use BIM tools, and the extra effort needed to keep BIM models updated to reflect changes in the facility (Volk, Stengel and Schultmann, 2014). Nonetheless, there is active research and development aimed at closing this gap. For example, scan-to-BIM technologies and standardized information exchange formats (like COBie) are being explored to make it easier for FM teams to obtain accurate as-is BIM models of existing buildings. Stojanovic et al. (2018) demonstrate a service-oriented platform that uses consumer-grade 3D scanning devices to generate semantically rich as-is BIM data of indoor environments (Stojanovic *et al.*, 2018, p. 2).Their prototypical web-based application showed the feasibility of creating up-to-date digital representations of a facility with relatively low-cost tools, which can then serve as a basis for FM tasks and even as input for developing digital twins (Stojanovic *et al.*, 2018, p. 9). Such approaches have the potential to increase FM stakeholder engagement with BIM and enhance decision-making, as facility managers can visualize and interact with current building data more easily (Stojanovic et al., 2018). Going forward, improving the interoperability between BIM and FM systems and building the digital skills of FM professionals will be key to unlocking BIM's promised benefits in the operational phase.

3.3.2 Artificial Intelligence (AI)

Artificial Intelligence (AI) is rapidly revolutionizing facility operations by enhancing efficiency, productivity, and decision-making processes while simultaneously reducing bureaucratic burdens (Adepoju and Fowowe, 2025). The integration of AI and Digital Twin technologies into BIM frameworks, utilizing IoT sensors for real-time data collection and predictive analytics, has demonstrated significant potential. Key findings from research

show substantial reductions in maintenance costs (up to 25%) and energy consumption (up to 20%), alongside increased asset utilization and overall operational efficiency (Abdelalim *et al.*, 2025). AI tools enable proactive decision-making and operational agility in FM, addressing challenges such as resource wastage and inefficiencies in workforce management (Adepoju and Fowowe, 2025).

AI applications in FM are diverse and impactful. In maintenance, AI powers predictive systems that analyze historical and real-time sensor data to forecast equipment failures, allowing for scheduled maintenance during planned downtime and reducing costly disruptions (Sanders, 2025). In energy management, AI-driven systems can analyze energy consumption patterns and recommend optimizations, leading to significant cost savings (Adepoju and Fowowe, 2025). For security, AI enhances monitoring capabilities by analyzing data from various sources, improving threat detection and response (Sanders, 2025). Leading organizations recognize the importance of readily accessible facility management data (covering capital planning, lease, space, sustainability, maintenance, and operations) to fully exploit the potential of AI (Sanders, 2025). The future of AI in FM, particularly with the advent of Generative AI, holds immense potential for revolutionizing core activities such as lease profile comparisons, energy efficiency optimization, capital planning, space optimization, maintenance, and sustainability initiatives (Sanders, 2025).

3.3.3 Internet of Things (IoT)

The Internet of Things (IoT) represents a network of physical devices and objects embedded with electronics, software, sensors, and network connectivity, enabling these objects to collect and exchange data (IoT Technology Working Group, 2018). For Facilities Management, IoT offers the unprecedented ability to understand in real-time what is happening throughout every aspect and component of a building and its operation, providing valuable contextualized data for comprehensive analytics (IoT Technology Working Group, 2018). The integration of IoT devices and systems in FM signifies a significant shift from traditional building management practices towards a more data-driven and integrated approach (Dimitrov, Dossick and Ccarita Cruz, 2024).

IoT applications in FM are transformative across various domains. Beyond enabling predictive maintenance of assets, IoT can significantly improve space management by providing a better understanding of how a facility is being used and interacted with by its occupants, allowing FM professionals to make informed decisions for optimal efficiency (IoT Technology Working Group, 2018). Smart sensors and connected building systems, powered by IoT, facilitate the continuous monitoring of critical parameters such as temperature, humidity, lighting, and occupancy, enabling maintenance engineers to enhance energy management and occupant comfort (Poyyamozhi *et al.*, 2024). IoT-based services in FM (IoTbs FM) involve the application of critical decision-making that considers environmental impact, safety issues, and challenging situations within building management (Sidek, Ali and Alkawsi, 2022). This technology also supports the creation of "as-is" Building Information Models (BIMs) in a more feasible and economical manner (Sidek, Ali and Alkawsi, 2022). Furthermore, IoT plays a crucial role in improving energy efficiency in smart buildings, potentially decreasing energy consumption by as much as 30% and operating expenses by 20% (Poyyamozhi *et al.*, 2024).

3.3.4 Digital Twins

Digital Twin technology is an emerging paradigm in facility management, recognized for its ability to enable a multitude of applications through real-time monitoring, predictive maintenance assessment, and evidence-based decision-making capabilities (Shi, 2025a). By creating virtual replicas of physical assets, Digital Twins assist stakeholders in optimizing operations, working towards enhanced energy efficiency, and improving overall sustainability (Shi, 2025).

The integration of BIM with the Internet of Things (IoT) serves as a robust addition to FM, empowering in-depth data analysis for better building asset management and more informed decision-making, particularly in large-scale projects (Abdelalim et al., 2025). Moreover, Digital Twins facilitate smart building management through functions such as service monitoring, energy optimization, and the enhancement of occupant comfort (Shi, 2025).

The use cases for Digital Twins in FM are compelling. They enable real-time data gathering and monitoring, supporting data-based decision-making and predictive management strategies (Elyasi et al., 2023). This capability allows for the simulation and optimization of building operations in a virtual environment, leading to improved performance, reduced operational costs, and more effective decision-making processes (Akinshipe et al., 2022) . A key application lies in performance monitoring, where Digital Twins provide real-time insights into building systems and asset performance (Asare et al., 2024) .25 Additionally, they significantly enhance predictive maintenance capabilities by allowing for the simulation and forecasting of potential equipment failures, enabling proactive interventions and minimizing downtime (Abdelalim et al., 2025).

Even though digital twins have emerged as a prominent concept in the built environment, yet their definition remains a subject of ongoing academic debate (Elyasi, Bellini and Klungseth, 2023a; Ghalandar, Hansen and Lindkvist, 2023) Researchers across domains have not reached a consensus on a single definition of "digital twin," and the term is interpreted in multiple ways. For instance, (Kritzinger *et al.*, 2018) observe that *"in literature there is no common understanding"* of the term due to its use in disparate disciplines. Similarly, (Ghalandar, Hansen and Lindkvist, 2023, p. 4) note that the digital twin concept is still "being defined within the industry", indicating its evolving nature in practice. A recent study by Elyasi et al. (2023) compiled numerous DT definitions from different fields and found that while many share similarities, there are notable variations in emphasis and scope. This lack of a unified definition has led to confusion in distinguishing digital twins from related concepts like simulations or ordinary 3D models (Emmert-Streib, 2023).

Nevertheless, for the purposes of this thesis, the following working definition will be applied: digital twin technology refers to dynamic digital replicas of physical assets and processes (Stojanovic et al., 2018, p. 2; Ghalandar, Hansen and Lindkvist, 2023, pp. 6–7). This definition emphasizes both the physical-digital connection and the continuous flow of information that characterises true digital twin systems, distinguishing them from static models or digital shadows.

3.4 Navigating the Adoption of Digital Technologies: Barriers and Drivers

The integration of digital technologies into facility management, while promising significant benefits, is often met with various barriers. Understanding these hindrances, as well as the drivers that facilitate implementation, is crucial for organizations seeking to successfully navigate this digital transformation.

3.4.1 Barriers Hindering Adoption

One of the primary obstacles to the adoption of digital technologies in FM is organizational resistance and cultural challenges (Alrubaidi, 2024). This includes a general reluctance to embrace change within established organizational structures and a potential lack of the necessary digital skills among FM professionals (Alrubaidi, 2024). The complexity of implementing new technologies across diverse organizational settings and business types further compounds this challenge (Elyasi et al., 2023).

High implementation costs and budgetary constraints pose another significant barrier, particularly for small to medium-sized organizations with limited financial resources (Alrubaidi, 2024). The perceived high upfront investment in administration, software acquisition, and training programs associated with technologies like BIM can be a deterrent (Yieu et al., 2025). Furthermore, there might be a lack of a clear understanding of the return on investment (ROI) associated with these technologies, especially concerning the operational phase of a building (Vigren et al., 2024).

A lack of awareness, skills, and adequate training among FM professionals to effectively utilize new digital tools and technologies is also a substantial impediment (Schmitter et al., 2024) .2 Many practitioners may lack the necessary know-how and instruments required for successful digital transformation (Schmitter et al., 2024). The limited availability of BIM-experienced FM personnel, for example, contributes to the slow implementation of BIM within the industry (Tezel et al., 2022).

Concerns surrounding data security and interoperability present further challenges (Yieu et al., 2025) .10 Integrating different digital systems and ensuring seamless data exchange between them can be complex (Yieu et al., 2025). Additionally, ensuring the privacy and security of the vast amounts of data generated by connected devices and systems is a critical concern that needs to be addressed with robust cybersecurity measures (Alrubaidi, 2024).

Finally, the integration of new digital solutions with existing legacy systems and the overall complexity of upgrading or replacing these outdated technologies can hinder adoption (Bailey and Alvarez, 2024). Many FM organizations rely on established systems, and transitioning to new platforms often requires significant time, resources, and careful planning to avoid disruptions (Bailey and Alvarez, 2024).

3.4.2 Drivers Facilitating Implementation

Despite these barriers, several key drivers are facilitating the implementation of digital technologies in facility management. A significant driver is the increasing demand for operational efficiency and cost reduction. FM firms are prioritizing digital transformation to stay competitive as speed and efficiency become more crucial in the corporate context (Naji et al., 2024) .1 Technology is recognized for its ability to drive improvements in efficiency, responsiveness, and overall cost reduction in FM operations (Property Inspect, 2023). Improved productivity and reduced costs are often the main triggers for investing in FM software and digital solutions (Cacoveanu, 2023).

The growing emphasis on sustainability and energy management in the built environment is another powerful driver. Digital transformation is seen as a way to amplify the sustainability of operations (Whitley, 2023). Modern sustainability efforts and the pursuit of reducing carbon footprints are key motivations for adopting digital FM solutions (Datta, 2023). Technologies like BIM-FM contribute to sustainable construction practices and energy efficiency 12, while IoT plays a crucial role in improving energy efficiency in smart buildings (Poyyamozhi et al., 2024).

The desire to enhance occupant comfort and productivity also fuels the adoption of digital technologies. A digitally transformed facility often translates to heightened convenience and comfort for users, leading to higher occupant satisfaction (Cacoveanu, 2023). Improved environmental controls and user-friendly technologies contribute to a more productive and comfortable workplace (Aziz et al., 2016).

Furthermore, digital technologies offer significant advantages in improved asset management and lifecycle performance. Better data management and predictive maintenance capabilities, enabled by AI and IoT, allow for proactive decision-making and the optimization of asset lifecycles (sclogic, 2020). This shift from reactive to proactive maintenance strategies ensures that property issues are handled before they escalate, reducing equipment downtime and maintenance costs (Property Inspect, 2023).

Finally, regulatory compliance and risk mitigation are facilitated by digital monitoring and reporting tools. Technology assists in monitoring and maintaining compliance with new and established property regulations (Property Inspect, 2023). Improved security measures, enabled by digital transformation, help organizations protect against cyber threats and ensure the safety and security of their facilities (sclogic, 2020).

3.5 Fostering Collaboration: The Synergy Between Technology Providers and Facility Management Professionals

Successful digital transformation in facility management is not a solitary endeavor but rather a collaborative process that necessitates strategic partnerships between technology providers and FM organizations (McNamara, 2025). Effective collaboration between facility managers and technology providers is essential for the successful implementation of digital systems. This collaboration ensures that technological solutions are not only technically robust but also aligned with the practical realities of FM operations. (Kensek, 2015) emphasizes the importance of involving FM professionals in the early stages of technology development, enabling providers to design systems that meet operational needs. The complex and challenging operational environment of modern FM demands that FM processes and technologies are combined and integrated effectively (Schmitter, Shahgholian and Tucker, 2024). FM clients increasingly seek solutions that are not only efficient today but are also adaptable, innovative, and capable of delivering long-term value, making collaboration a key driver for growth and progress in the industry (McNamara, 2025).

However, achieving effective collaboration is not without its challenges. {Citation}Wu et al. (2014) identify a lack of mutual understanding as a key barrier, noting that technology providers often prioritize technical specifications over user experience.

Various models of collaboration and engagement can foster this synergy. Joint development projects, where technology providers and FM professionals work together to create tailored solutions, represent one effective approach. Technology integration partnerships, focusing on seamlessly incorporating new technologies into existing FM workflows and systems, are also crucial. Data sharing agreements, where FM organizations and technology providers collaborate on leveraging data insights for improved performance, can unlock significant value (McNamara, 2025). The necessity to co-create across professional and organizational boundaries is highlighted in research, emphasizing the importance of involving all relevant stakeholders in the digital transformation process (Schmitter, Shahgholian and Tucker, 2024).

Case studies illustrate the positive outcomes of effective collaborations. The introduction of digital monitoring systems in nursing homes, for example, underscored the need for co-creation across different professional and organizational levels (Schmitter, Shahgholian and Tucker, 2024). Another instance involves the integration of BIM with modern technologies like IoT and AR/VR, offering benefits such as improved operational workflows and enhanced decision-making capabilities (Lee, Irisboev and Ryu, 2021). Notably, BIM adoption in FM has been shown to reduce project completion time significantly, demonstrating the tangible benefits of technology integration (Alrubaidi, 2024). A detailed case study of Macerich, a real estate company, showcases a successful collaboration between its IT department and Facilities Management, emphasizing the importance of IT understanding FM needs, acting

as a partner rather than a bottleneck, and building strong relationships based on trust and clear communication (Hanford, 2017). These examples underscore that successful collaboration hinges on a deep understanding of FM requirements by technology providers and a willingness to work in partnership to achieve common goals.

3.6 Theoretical Frameworks Guiding Technology Adoption in Facility Management

In the context of FM, technology adoption often spans multiple disciplines and knowledge domains. Recent research by Ghalandar et al. (2023) underscores the importance of bridging "epistemic knowledge boundaries" between project stakeholders and FM teams to facilitate digital innovation. They argue that industry digitalisation frameworks can serve as boundary objects (Carlile, 2002) – tangible reference points that align disparate disciplinary knowledge and future visions. Such frameworks help translate new technologies (e.g. BIM, Digital Twins) across the design–FM divide, complementing user-focused models like TAM by emphasizing collaboration, communication, and a shared future-oriented roadmap for tech integration (Ghalandar, Hansen and Lindkvist, 2023). In essence, while TAM and similar models explain individual acceptance, boundary-spanning frameworks provide the organizational context to actually realize that acceptance across all stakeholders.

3.6.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is an influential information systems theory that models how users come to accept and utilize a technology (Davis, 1989; Wikipedia, 2024). The model posits that a user's decision to adopt and use a new technology is primarily influenced by two key beliefs: perceived usefulness (the degree to which a person believes that using the system will enhance their job performance) and perceived ease of use (the degree to which a person believes that using the system will be free of effort) (Davis, 1989; Wikipedia, 2024). These beliefs subsequently influence the user's attitude towards using the technology, which in turn affects their behavioral intention to use it, ultimately leading to actual system use (Davis, 1989; Wikipedia, 2024).

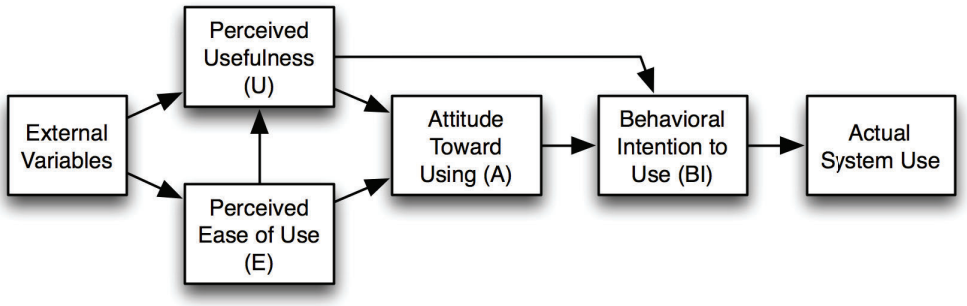

Figure 1: The Technology Acceptance Model (TAM) (Davis, 1989)

Research examining the adoption of information technology in facilities management has found that perceived ease of use and perceived usefulness of FM systems significantly and positively influence their acceptance and use by FM practitioners (Nortey *et al.*, 2025).Factors such as the availability of IT resources and the usability of the FM system play a crucial role in shaping the perceived ease of use, while the security and functionality of the system significantly impact its perceived usefulness (Nortey *et al.*, 2025). Studies in related fields, such as healthcare, have also shown that perceived ease of use and perceived usefulness are major factors influencing the usage of personal health record systems (Alsyouf *et al.*, 2023) and the continuance intention of using digital broadcasting services (Li and Lin, 2022). Therefore, TAM provides a valuable lens through which FM organizations can understand the factors that drive the acceptance of new technologies by their professionals. By focusing on enhancing the perceived usefulness (e.g., by demonstrating improved efficiency and productivity) and perceived ease of use (e.g., through user-friendly interfaces and comprehensive training) of digital tools, FM organizations can increase the likelihood of successful technology adoption.

3.6.2 Innovation Diffusion Theory (IDT)

While TAM focus on individual acceptance, Rogers' Innovation Diffusion Theory provides a complementary macro-level perspective on how new technologies spread through organizations and social systems (Rogers, 2003). IDT identifies factors like relative advantage (the perceived benefit of the innovation), compatibility (fit with existing processes and values), complexity (ease of use), trialability, and observability that influence the rate of adoption. In an FM context, these attributes are highly pertinent – for example, the adoption of a new CMMS or BIM-based tool will accelerate if it clearly improves maintenance efficiency (relative advantage) and aligns with current FM workflows (compatibility). Moreover, because Facility Management involves many stakeholders (from owners to service providers), social influence and network effects play a role in diffusion. By considering the organization-wide uptake of technology, IDT complements TAM's user-level focus. It also resonates with Ghalandar et al.'s (2023) emphasis on future-oriented frameworks – ensuring an innovation not only appeals to individual users but is visible, beneficial, and contagious across the broader FM community."

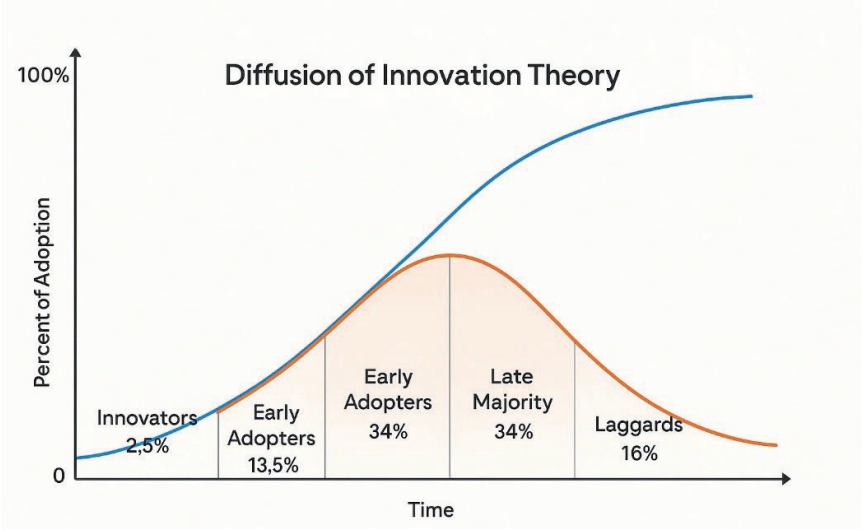

Figure 2:Diffusion of innovation illustration inspired by (Rogers, 2003)

3.6.3 Sociotechnical Systems Theory (STS)

Another essential perspective for FM technology adoption is the sociotechnical systems approach. Originating in organizational theory (Trist and Bamforth, 1951), STS posits that successful implementation of technology requires joint optimization of the technical and social systems. In other words, the introduction of a new tool or digital process must be accompanied by appropriate changes in people's workflows, roles, and collaboration practices. In the FM domain, this theory reminds us that a technology (e.g., a Digital Twin platform) will yield benefits only if the FM organization's structure, culture, and processes adapt in tandem with the technical change. Key STS principles include ensuring organizational readiness, training, and aligning the technology with users' actual work practices (Baxter and Sommerville, 2011). This broader lens complements models like TAM by moving beyond user perception to examine workplace integration: for instance, an FM team might find a new software acceptable (high TAM scores) but still struggle to use it effectively if reporting structures or communication channels aren't adjusted (an STS issue). Ghalandar et al. (2023) similarly highlight the role of "technological culture" and inter-organizational collaboration in shaping outcomes. By acknowledging the socio-technical context – the networks of people, knowledge, and processes surrounding the tool – STS provides a framework to guide holistic technology adoption in FM.

3.7 Assessing Digital Maturity and Charting Strategic Approaches

To effectively leverage the potential of digitalization, facility management organizations need to assess their current digital maturity and develop strategic approaches to guide their transformation journey.

3.7.1 Digital Maturity Models for Facility Management Organizations

Digital maturity models (DMMs) provide a valuable framework for organizations to benchmark their current digital capabilities, identify areas for improvement, and guide their progress towards higher levels of digital transformation (Aliu *et al.*, 2024). While numerous DMMs exist across various sectors, there is a growing recognition of the need for models specifically tailored to the unique context of facility management (Aliu *et al.*, 2024). A conceptual Facilities Management Digital Maturity Model (FM-DMM) has been proposed, encompassing crucial dimensions such as strategy and leadership, organization, technology, process, client (end-user), people, and data management (Aliu *et al.*, 2024). These dimensions provide a comprehensive view of the key areas that FM organizations need to consider in their digital transformation efforts. For instance, the technology dimension assesses the adoption and integration of various cutting-edge solutions like BIM, IoT, digital twins, and AI, while the people dimension emphasizes the skills and competencies of the workforce necessary to drive digital transformation (Aliu *et al.*, 2024). In the context of BIM, maturity models like the BIM Maturity Index help organizations evaluate their level of BIM adoption and integration, considering factors such as technology adoption, process integration, and data utilization (Aliu *et al.*, 2024).

3.7.2 Stages of Digital Transformation Maturity

Digital transformation is not an overnight process but rather a journey that unfolds in distinct stages, ranging from initial adoption to optimization and innovation (Vigren *et al.*, 2024). Understanding these stages allows FM organizations to gauge their current position and plan their progression. For example, in the context of BIM, maturity levels typically progress from basic 3D modeling to more advanced stages involving information sharing, collaboration, and integrated workflows (Gsingh, 2025). Similarly, digitalization in a broader sense can be viewed as having different levels of scalability and sophistication (Vigren *et al.*, 2024). Organizations might start with basic digitization efforts, such as converting paper records to digital formats, and then gradually move towards more complex stages involving automation, data analytics, and the integration of advanced technologies like AI and Digital Twins. Recognizing their current stage of maturity helps FM organizations set realistic goals and develop a phased approach to their digital transformation initiatives.

3.7.3 Developing a Strategic Roadmap for Digitalization in the FM Sector

A well-defined digital transformation strategy and roadmap are essential for guiding FM organizations through the complexities of digitalization and ensuring that technology investments are aligned with overall business objectives (Cacoveanu, 2023). Developing this roadmap involves several key steps. Firstly, organizations need to clearly define their objectives and the tangible outcomes they expect from digital transformation, along with measurable Key Performance Indicators (KPIs) (Whitley, 2023). This requires a thorough assessment of current facility management processes, identifying inefficiencies and areas for potential improvement (Cacoveanu, 2023). Creating a detailed roadmap involves outlining the specific technologies to be adopted, the timelines for implementation, and the resources required (Cacoveanu, 2023). This roadmap should also consider the organization's existing IT infrastructure and plan for necessary upgrades or replacements (Cacoveanu, 2023). Furthermore, it is crucial to foster stakeholder collaboration throughout the process, ensuring that the needs and expectations of all relevant parties are considered (Cacoveanu, 2023). A key aspect of successful strategy implementation is effective change management, addressing potential resistance and ensuring that employees are adequately trained to utilize the new technologies (Cacoveanu, 2023). The development of a digital transformation roadmap is also the focus of a new standard being developed by CEN TC 348 WG 10, which aims to provide a methodology for FM organizations to select appropriate digital technologies and create a phased plan for their implementation (CEN/TC 348, 2023). Continuous evaluation and refinement of the strategy are also necessary to adapt to evolving technologies and changing business needs (Cacoveanu, 2023).

3.8 The Influence of Standards on Digital Transformation in Facility Management (Norwegian Context)

Standards play a crucial role in shaping the landscape of digital transformation within facility management, providing frameworks for ensuring consistency, quality, and interoperability. In the Norwegian context, the ISO 41000 series on facility management and the work of CEN TC 348 on Building Information Modelling are particularly relevant.

3.8.1 ISO 41000 (Facility Management)

The ISO 41000 series provides a globally recognized framework for developing, implementing, and maintaining effective facility management systems across various sectors (*ISO 41001 Ledelsessystemer for fasilitetsstyring (FM)*, no date; *BSI*, no date). This series, with ISO 41001 as its flagship standard, aims to ensure consistency in FM practices, minimize unnecessary costs, and deliver tangible value to businesses (*ISO 41001 Ledelsessystemer for fasilitetsstyring (FM)*, no date; *BSI*, no date). By establishing a common language and framework for FM professionals worldwide, the ISO 41000 series facilitates global transferability, aligns industry practices, and promotes a logical approach to facility management (Duggan, 2024). For Norwegian FM organizations, adopting the ISO 41000 framework can provide a solid foundation for integrating digital processes and systems in line with international best practices (Lok *et al.*, 2023).

While ISO 41001 does not explicitly detail clauses specifically focused on digital transformation, several aspects of the standard have direct relevance to the implementation and management of digital technologies in FM. The standard emphasizes the need for adequate resources, including technological infrastructure, for the establishment, implementation, maintenance, and continuous improvement of a facility management system (ISO 41001 Facility Management Systems Implementation & Training, no date). It also highlights the importance of competence, ensuring that individuals assigned roles within the FMS possess the necessary skills to utilize digital tools effectively (ISO 41001 Facility Management Systems Implementation & Training, no date). Furthermore, clauses related to communication and documented information necessitate the effective management and sharing of data, which is inherently linked to digital systems (ISO 41001 Facility Management Systems Implementation & Training, no date). The "Operation" clause of ISO 41001 addresses operational planning and control, coordination with interested parties, and the integration of services, all of which can be significantly enhanced through the use of digital technologies (ISO 41001 Facility Management Systems Implementation & Training, no date). Notably, BSI, the originator of several ISO standards, recognizes "Digital Trust in the Built Environment" as a key area, indicating the growing importance of digital aspects within facility management standards (*ISO 41001 Ledelsessystemer for fasilitetsstyring (FM)*, no date; *BSI*, no date). The new CEN standard being developed by WG 10 will even use ISO 41001 clauses to define an organization's current business compliance as a prerequisite for digital transformation (CEN/TC 348, 2023).

3.8.2 CEN TC 348 (Building Information Modelling)

CEN TC 348 is the European committee responsible for the preparation of European standards for FM covering operational, tactical, and strategic levels to support primary processes (CEN/TC 348, no date). Recognizing the increasing importance of digital transformation in FM, CEN TC 348 recently approved the creation of a new working group, WG 10, specifically focused on "FM digital transformation" (CEN/TC 348, 2023). The scope of WG 10 is to develop a new standard that will specify a methodology for FM-related organizations or departments to identify and define requirements towards selecting the most appropriate digital technologies to manage their FM operations cost-effectively and efficiently (CEN/TC 348, 2023). This standard will provide recommendations on the digital transformation roadmap as the output of this methodology, aiming to bridge FM standards, particularly ISO 41001, to digital technology (CEN/TC 348, 2023). The methodology being developed will likely include phases such as organizing FM stakeholders, identifying and analyzing organizational needs, evaluating FM processes against ISO 41001 clauses, performing gap analysis, formulating requirements specifications, promoting awareness of digital technologies, mapping requirements to technologies, and defining a digital transformation roadmap (CEN/TC 348, 2023). This initiative by CEN TC 348 signifies a strong European-level commitment to providing practical guidance for FM organizations, including those in Norway, to navigate their digital transformation journey.

3.8.3 Interplay Between ISO 41000 and CEN TC 348

The interplay between ISO 41000 and CEN TC 348 in the context of digital transformation in the Norwegian FM landscape is significant. ISO 41000 provides the overarching management system framework for effective facility management, setting the requirements and guidance for establishing, implementing, maintaining, and continually

improving an FMS (*ISO 41001 Ledelsessystemer for fasilitetsstyring (FM)*, no date; *BSI*, no date). CEN TC 348, through its WG 10, is specifically addressing the "how-to" of integrating digital technologies within this framework. The methodology being developed by WG 10 will likely leverage the clauses of ISO 41001 to assess an organization's current state and then guide the selection and implementation of appropriate digital technologies to enhance FM operations (CEN/TC 348, 2023). Therefore, Norwegian FM organizations should consider both sets of standards as complementary resources in their pursuit of digital transformation. Adhering to ISO 41000 provides a robust foundation for FM management, while the upcoming standard from CEN TC 348 will offer specific guidance on leveraging digital tools and technologies to achieve greater efficiency, sustainability, and overall performance within that framework.

3.9 The Current State and Future Trends of Digital Transformation in Facility Management (European and Norwegian Context)

The landscape of digital transformation in facility management is rapidly evolving, with significant advancements and trends emerging across Europe and specifically within Norway. Recent academic research and industry reports offer valuable insights into the current state and future trajectory of this transformation.

3.9.1 Recent Academic Research (2023-2025)

Recent academic research conducted between 2023 and 2025 highlights a growing focus on various aspects of digital transformation in facility management within both European and Norwegian contexts. Studies indicate that digital transformation is indeed revolutionizing building facility management across Europe (Naji, Gunduz and Al-Qahtani, 2024b). A significant area of research in Norway specifically centers around the implementation of digital twins, analyzing the challenges and benefits associated with their adoption in the use phase of buildings (Elyasi, Bellini and Klungseth, 2023b). Furthermore, investigations into the drivers, capabilities, and challenges for adopting digital twins in FM continue to be a prominent theme in academic discourse (M. Shuhaimi, Mohamed Yusof and A. Rahman, 2024). Researchers are also exploring the perceptions of FM professionals regarding digital twins as intelligent realities, seeking to understand their perspectives on this emerging technology (Asare *et al.*, 2024). Bibliometric reviews are being conducted to map the trends and future development directions of digital twin applications in FM and related industries (Shi, 2025b). Additionally, theoretical frameworks like UTAUT are being applied to understand the factors influencing facility managers' acceptance of digital FM services (Ahmad and Alshurideh, 2024). These academic endeavors collectively underscore the increasing importance of digital transformation in the FM sector and the active exploration of its various facets by researchers.

3.9.2 Insights from Recent Industry Reports and Market Analyses

Recent industry reports and market analyses corroborate the findings from academic research, emphasizing the growing significance of digital transformation in the European and Norwegian FM markets. A 2024 report on the European facility management market

highlights substantial growth opportunities driven by technology, sustainability, workplace optimization, and user experience (Raspin, 2024). The report notes that while the market is recovering, many FM companies have been slow to innovate their technology and service business models, indicating a pressing need for change. Within Norway, the facility management market is experiencing robust growth, fueled by the increasing demand for efficient and sustainable facility management solutions and the growing adoption of advanced technologies such as IoT and AI (Fernandes, 2025). These reports suggest a strong market impetus for digital transformation in FM, with technological advancements being a key driver for improved efficiency and sustainability.

3.9.3 Emerging Technologies and Their Potential Impact (2023-2025)

Several emerging technologies are poised to significantly impact the FM sector in the near future. AI is expected to continue reshaping FM through applications in predictive maintenance, energy efficiency, and the convergence of traditionally separate hard and soft services (de Santiago, no date). Trends for 2025 indicate a rise in AI-optimized FM, the proliferation of connected FM technologies, and the increasing importance of data and insights for decision-making (CBRE, no date). Other impactful technologies include the IoT, which enables real-time monitoring and data collection for optimized building performance, and Digital Twins, which provide virtual replicas for simulation and predictive capabilities (Veerappan, no date). Virtual and augmented reality (VR/AR) are also gaining traction for applications in maintenance guidance, training, and real-time visualization of facility data (Cacoveanu, 2023). Furthermore, there is a growing emphasis on cybersecurity to safeguard increasingly connected building systems (Gonçalves, no date). These emerging technologies collectively offer the potential to drive greater automation, efficiency, sustainability, and enhanced user experiences within the facility management sector.

3.9.4 Specific Trends and Advancements in the Norwegian Facility Management Market

The Norwegian facility management market exhibits specific trends and advancements in the realm of digital transformation. There is a clear increasing demand for efficient facility management practices, with a particular focus on optimizing operational costs and improving energy efficiency (Fernandes, 2025). The adoption of technologies like IoT and AI is on the rise within the Norwegian FM sector (Fernandes, 2025). Notably, there is significant interest and ongoing research concerning the implementation of digital twins in Norwegian buildings, aiming to enhance building operations and maintenance (Elyasi, Bellini and Klungseth, 2023b). Experiences with the digitization of FM are being explored among Norwegian property managers, highlighting both the benefits and challenges of this transition (Støre-Valen, 2019). Collaborative initiatives are also emerging, such as the partnership between Toma and Energy Control to launch smart tools for the digitalization of buildings using sensors and AI (Toma, no date). These trends indicate that the Norwegian FM market is actively embracing digital transformation, with a particular emphasis on leveraging data-driven technologies to improve building performance and sustainability.

3.10 Conclusion: Unlocking the Full Potential of Digitalization in Facility Management

In conclusion, this report has explored the multifaceted potential of digitalization in facility management, emphasizing the critical need to bridge the gap between technological advancements and practical implementation. Key findings reveal a strong academic and industry consensus on the transformative power of digital technologies such as BIM, AI, IoT, and Digital Twins in enhancing efficiency, sustainability, and occupant satisfaction within FM. However, the adoption of these technologies is often hindered by organizational resistance, high implementation costs, lack of skills, data security concerns, and integration challenges. Conversely, drivers such as the demand for operational efficiency, growing emphasis on sustainability, the need for enhanced occupant comfort, improved asset management, and regulatory compliance are propelling the digitalization of the FM sector.

Strategic partnerships between technology providers and FM professionals are crucial for successful digital transformation, with various collaboration models facilitating innovation and value creation. Theoretical frameworks like TAM and UTAUT offer valuable insights into understanding and predicting technology adoption by FM professionals, highlighting the importance of perceived usefulness, ease of use, social influence, and facilitating conditions. Assessing digital maturity using tailored models and charting strategic roadmaps are essential steps for FM organizations to systematically approach their digital transformation journey. Furthermore, the influence of standards, particularly the ISO 41000 series and the ongoing work of CEN TC 348, provides a framework for ensuring quality and interoperability in digital FM processes, especially within the Norwegian context. Recent trends in the European and Norwegian FM markets indicate a strong movement towards digitalization, with emerging technologies like AI and Digital Twins garnering significant attention and investment.

To unlock the full potential of digitalization, facility management organizations should consider the following strategic recommendations:

- **Develop a clear digital transformation strategy:** This strategy should be closely aligned with overall business goals, outlining specific objectives, timelines, and resource allocation.

- **Prioritize data management and interoperability:** Establishing robust data management practices and ensuring seamless data exchange between different systems are crucial for leveraging the full power of digital technologies.

- **Invest in employee training and change management:** Addressing the skills gap and fostering a digital-first culture through comprehensive training programs and effective change management strategies are essential for successful technology adoption.

- **Explore collaborations with technology providers:** Strategic partnerships can provide access to specialized expertise and innovative solutions tailored to the specific needs of FM organizations.

- **Utilize relevant theoretical frameworks:** Applying models like TAM and UTAUT can help organizations understand user acceptance factors and tailor their technology implementations accordingly.

- **Assess digital maturity and develop a phased implementation roadmap:** Understanding the current level of digital maturity and developing a step-by-step roadmap will ensure a systematic and effective approach to digitalization.

- **Consider the implications of ISO 41000 and CEN TC 348 standards:** Aligning digital transformation efforts with these standards can provide a framework for best practices and ensure compliance.

- **Stay informed about emerging technologies and trends:** Continuously monitoring the advancements in technologies like AI, IoT, and Digital Twins within the European and Norwegian markets will enable organizations to capitalize on new opportunities.

By adopting a holistic approach that integrates technology, people, and processes, facility management organizations can effectively bridge the gap between the potential of digitalization and its practical application, ultimately leading to more efficient, sustainable, and occupant-centric facilities.

4 Methods

4.1 Research Design and Strategy

This research followed a qualitative, exploratory design appropriate for investigating emerging practices in digitalization within FM (Tjora, 2018). Rather than testing predefined hypotheses, the study aimed to generate insights from practitioners, making an inductive approach suitable – deriving patterns and concepts from the data itself. In an abductive approach, the researcher moves back and forth between data and literature to develop the most plausible explanations, allowing unexpected findings (such as broader digitalization issues beyond just AI) to reshape the inquiry. This flexible strategy aligns with an exploratory research ethos, where the design can adapt as insights emerge (Tjora, 2018).

Initially, the project's focus was narrowly on artificial intelligence adoption in FM. However, after reviewing existing litterature and preliminary engagement with industry practitioners, the scope evolved to a broader examination of digitalization in FM. This shift exemplifies the adaptive nature of the research design – the inquiry was refined to address the most salient questions that arose, rather than rigidly sticking to the original plan. Such evolution is common in qualitative research and reflects emergent design principles (Andersen, 2013; Tjora, 2018). In this case, early findings indicated that AI could not be meaningfully studied in isolation, but had to be situated in the wider context of digital transformation in FM organizations. The research questions were therefore adjusted to explore how FM professionals envision digital transformation generally, including but not limited to AI. This ensured the study remained relevant and grounded in the participants' reality.

The study was conducted as part of the Bridging the Gap (BtG) project – a larger Norwegian research initiative (2021–2025) focused on integrating FM operational knowledge into design/construction phases and delivering a digital twin for a real estate case Teknostallen. Being embedded in this project provided a real-world context and access to industry participants, effectively making the thesis a focused case study within the broader project. The research strategy can thus be seen as a case study of FM digitalization in a Norwegian context, using the BtG workshop as the primary case event. The involvement in BtG influenced the data collection scope – for instance, two scenario workshops were planned in the project, but only the first workshop's data was leveraged for this thesis (more on this below). Within this context, the design had to balance academic objectives with the project's practical goals, exemplifying a pragmatic approach to inquiry (Andersen, 2013).

The scenario-based workshop was chosen as the main data collection strategy because it allowed exploring participants' visions of the future in an interactive setting. Scenario planning is well-suited for such exploratory strategic inquiry, as it uses creative thinking to anticipate multiple possible futures and to formulate response strategies (Lindgren and Bandhold, 2010). Lindgren and Bandhold (2010) describe scenario planning as a foresight methodology to construct "interesting and enlightening" future narratives that stakeholders can engage with, which helps in grappling with uncertainty (Lindgren and Bandhold, 2010). Scenario planning is "a methodology used to describe one or more possible futures" (Lindgren and Bandhold, 2010) and is commonly employed to navigate uncertainty in strategic contexts. In particular, this study utilizes a backcasting approach: participants were asked to envision the state of the FM sector in the year 2030 and then work backwards to discuss how that future could be achieved. This approach differs from forecasting in that it starts with a desired future and traces back to the present, encouraging creative thinking

unconstrained by current limitations. Such a strategy is well-suited for exploring digital transformation, as it allows stakeholders to imagine ideal outcomes first and then consider the steps needed to "bridge the gap" from today's practices. According to Lindgren and Bandhold (2010), scenario planning can be a powerful tool to link future visions to present decisions, which in this context means linking the 2030 vision of FM to current strategic choices in digitalisation.

The Bridging the Gap project context influenced the research design in important ways. Professor Carmel Lindkvist, the project leader (and also the thesis supervisor), provided strategic oversight during the design phase to ensure the workshop would produce relevant and coherent data for their project. Although Professor Lindkvist did not attend the workshop in person, her input shaped the structure, alignment, and purpose of the session. The study's design was thereby vetted to fit the project's research aims. The researcher and the project's PhD candidate co-planned a workshop that not only served the thesis needs but also contributed to the project's broader inquiry into digital FM. Overall, the research design is interpretive and exploratory – it does not test a hypothesis, but rather seeks to surface themes and insights about the future of FM digitalisation from the perspectives of professionals in the field. This design prioritizes depth, context, and participant engagement, consistent with case study strategy (Andersen, 2013) and qualitative futures research.

By adopting this approach, the research design ensured that insights about digital futures in FM emerged from the participants' collective imagination and discussion, rather than from the researcher's preconceived notions.

In summary, the study's research design was qualitative, exploratory, and adaptive. It combined inductive generation of insights with abductive refinement using theory, and it leveraged a real-world workshop within an industry-academia project as a case context. This strategy was appropriate for the study's aim of understanding FM practitioners' perspectives on digitalization, an area with limited prior theory and much ongoing development. The design allowed the researcher to capture rich, contextual data and remain open to new directions as the study unfolded.

4.2 Data Collection: Backcasting Workshop

All empirical data analyzed in this thesis come from a single scenario workshop (Workshop 1) held in March 2024. The workshop was conducted in Trondheim, Norway, as part of the Bridging the Gap project's activities. It brought together a group of facility management professionals (approximately 15 participants) who are involved in or impacted by digitalisation in the FM sector. This workshop format was chosen to foster interactive discussion, idea generation, and collaborative scenario building among practitioners. By using a group discussion setting, the study could capture a range of viewpoints and spur participants to build on each other's ideas about the future of FM.

4.2.1 Workshop focus

The session was structured around three main thematic areas that had been identified as critical in a prior forecasting exercise within the project (an earlier workshop conducted before the researcher joined). These themes were:

- Technology – e.g. digital tools, systems, and innovations in FM.
- People – e.g. skills, culture, and human factors in digital transformation.
- Organisation & Process – e.g. workflow, policies, and structural changes in FM organizations.

These predefined themes provided a guiding structure for discussions, ensuring that the conversation covered technological, human, and organizational dimensions of digitalisation. Participants were instructed at the outset to envision the FM sector in 2030 within each of these thematic lenses. For instance, they were prompted to imagine what kinds of technologies might be in use by 2030, what skill sets the FM workforce would need, and how organizations and processes might be organized differently in that future scenario. This clear focus helped channel the broad topic of "digitalisation in FM" into manageable and relevant subtopics.

Workshop planning: The workshop was meticulously planned and facilitated by the researcher (thesis author) in collaboration with a PhD candidate, Toomaj Ghalandar. Planning began weeks in advance and involved designing activities that would engage participants in the backcasting approach. Under the supervision of Prof. Lindkvist, the researcher and PhD candidate developed the workshop agenda, discussion questions, and supporting materials (such as presentation slides, worksheets, or scenario description prompts). Professor Lindkvist's role in this phase was to review and approve the plan, ensuring it fit the project's aims and maintained a high level of academic and practical relevance.

4.3 Participants

A total of 15 FM professionals/researchers participated in the workshop, all of whom were actively involved in digitalization efforts within their organizations or researchers within the field. These participants were drawn through the networks of the BtG project partners, ensuring they had relevant domain experience. Many worked as facility managers, property managers, or FM consultants in large organizations, and all had a stake in the future development of FM practices. In addition, several researchers from NTNU (including the thesis author) were present as facilitators and observers. The participants represented a diverse mix of roles in FM – for example, some were operational managers dealing with day-to-day building operations, while others were strategic FM planners or advisors. This diversity was important to capture a range of viewpoints (from technical to managerial) on digital transformation. However, all participants shared a familiarity with digital FM concepts (such as BIM, CAFM systems, IoT, etc.), given that they were recruited specifically for their engagement with the topic of digitalization. Recruitment was done via the BtG project's industry contacts and stakeholders. An invitation was sent to partner organizations explaining the workshop purpose and topic, and asking them to nominate individuals in FM roles who could contribute. Participation was voluntary, and invitees were informed that the workshop discussions would be used for research. The relatively small

group size (15) was not something the researcher for this project could change, however a relatively small group size is aligning with qualitative best practices for focus group-type sessions – it was large enough to provide varied insights, yet small enough to allow everyone to contribute to discussions.

4.4 Facilitation and Researcher Role

The workshop was co-facilitated by the author of this thesis (the primary researcher) and another experienced researcher from NTNU. While facilitating and participating, the researcher also observed and took notes on participant interactions, key points raised, and non-verbal dynamics (such as levels of enthusiasm or hesitation on certain topics). All participants had signed informed consent forms prior to engaging, so the discussion was audio-recorded with their permission to ensure an accurate record of what was said. This recording was essential given that the researcher's active facilitation role meant it would be impractical to capture everything through notes alone. By recording the session, the researcher ensured that no important details would be lost and that a verbatim transcript could later be produced for analysis. After the workshop, the audio was transcribed by a student assistant, producing a text document of the full conversation.

It is worth noting that although participants were encouraged to think as far ahead as 2030, in practice many discussions remained near-future focused. This has been described as a common occurrence in foresight exercises, as suggested during supervision discussions: participants might naturally gravitate to issues and ideas that feel more immediate (the next 1-5 years) before extrapolating further. For example, if a participant raised a concern about current software usability, the conversation might dwell on that current-state issue rather than imagining a distant 2030 solution. The facilitators gently reminded the group of the future timeline when needed, but also allowed the conversation to flow organically, as near-term concerns often segue into long-term considerations. This nuance is acknowledged in the data collection – the raw data reflects a mix of present challenges and future aspirations, which is valuable for backcasting because understanding today's challenges is key to figuring out how to overcome them by 2030.

In summary, the data collection was accomplished through a single, well-prepared backcasting scenario workshop. The researcher's involvement was hands-on, from co-designing and facilitating the session to ensuring a faithful capture of the dialogue. Operating under the Bridging the Gap project's umbrella lent the workshop credibility and access to willing participants, and it situated the data collection within an ethically approved and professionally relevant setting. The outcome of this workshop was a rich transcript of participant-generated insights about technology, people, and process in future FM – the foundation for the thesis analysis.

4.5 Data Analysis Techniques

The analysis of the workshop data was conducted using qualitative thematic analysis, performed manually by the researcher. Given that the study relied on a single workshop transcript, the volume of data was sufficiently manageable to allow for manual coding without specialized software. The approach taken aligns with recommended practices for inductive qualitative analysis (Braun and and Clarke, 2006; Tjora, 2018), emphasizing immersion in the data and iterative coding to identify patterns.

The researcher read through the entire transcript multiple times to become deeply familiar with the content. This familiarization phase is crucial in qualitative analysis, as it allows the researcher to gain an initial sense of recurring topics and the overall flow of the discussion. During these readings, the researcher began jotting down preliminary notes and reflections in the margins (for instance, noting whenever a participant highlighted a particular challenge or mentioned a specific technology). These notes later informed the coding process.

4.5.1 Coding process

Next, the researcher undertook a systematic coding of the transcript. A line-by-line analysis was performed, where each meaningful segment of text (a phrase, sentence, or short exchange related to a single idea) was marked with a code. Codes are short labels or summaries that denote what that segment is about (e.g., "lack of digital skills," "data silo issue," "leadership support needed"). To organize this process, the researcher used a color-coding scheme on a printed copy of the transcript: different highlighter colors were assigned to broad categories of interest. For example, all content related to Technology might be highlighted in blue, People in green, and Organisation & Process in orange, reflecting the workshop's thematic structure. Within those color groupings, additional notation was used to differentiate sub-themes. For instance, under a broad People theme, segments about "skills and training" might be marked with a specific symbol or code (like "People-Skills"), whereas segments about "culture and resistance to change" might be marked as "People-Culture." This multi-level coding allowed the researcher to break down the data ("dismantling" it) and then later gather related pieces together by theme ("reassembling" it).

It is important to note that the initial themes (Technology, People, Organisation & Process) provided an analytic framework, but the coding was not limited to those categories alone. As the researcher coded the data, new themes or insights that cut across these categories emerged. For example, a discussion about "lack of top management support" could be relevant to Organisation & Process (as a structural issue) but also tied to People (leadership being a role played by people). The researcher remained open to emergent themes and was willing to create new codes or reinterpret which category a comment best fit, rather than forcing data into the three pre-set themes. In this way, the coding combined deductive elements (using the three themes as a starting point) with inductive analysis (allowing the data to speak for itself and suggest new themes or sub-themes).

After the first round of coding, the researcher had a long list of codes and colored highlights throughout the transcript. The next step was to cluster these codes into overarching themes. This involved looking at all the excerpts under each broad topic and seeing how they related. For instance, under Technology-related discussions, codes like "legacy systems," "data silos," and "user-friendliness" started to form a cluster indicating challenges with current IT infrastructure and software usability. Similarly, under People, codes such as "training gap," "resistance to change," and "need for new competencies" clustered into a theme around human resource challenges in digitalisation. The researcher used tables and mind-maps to group related codes and to decide on names for the final themes that would be presented in the findings. Each theme was defined clearly in terms of the idea it represented, and supporting quotes were identified from the transcript for use as evidence in the thesis.

Throughout this analysis, the researcher was guided by the principle of maintaining a clear chain of evidence from raw data to conclusions. According to Tjora (2018), qualitative data analysis involves carefully **"**dismantling, segmenting, and reassembling data to form meaningful findings**"** (Tjora, 2018). In practice, this meant the researcher constantly moved back and forth between the transcript (the raw data) and the emerging thematic structure, verifying that each theme accurately reflected participants' contributions. If a theme felt too weakly supported by data or too broad, the researcher revisited the transcript to refine or split it. This iterative refinement continued until a stable set of key themes was reached, each supported by multiple data excerpts.

It should be noted that the researcher did not use software tools like NVivo for this analysis. For future research on digitalisation in FM, especially involving larger datasets or multiple workshops, the use of qualitative analysis software is recommended to enhance efficiency and enable easier collaboration or auditing of the coding process.

4.6 Ethical considerations

This study adhered to standard research ethics protocols to ensure the rights and well-being of participants and the integrity of the research process. Prior to the workshop, all participants were provided with information about the study's purpose, what participation would entail, and how the data would be used. They each signed an informed consent form, consistent with guidelines from the Norwegian Centre for Research Data (NSD) and the university. Participants were made aware that their involvement was voluntary and that they could withdraw from the study at any time without consequence. They also consented to the workshop being recorded for research purposes.

4.6.1 Confidentiality and Anonymity

Given that the FM community in Norway is relatively small and many participants knew each other through the BtG project network, particular care was taken to protect individuals' identities in the research outputs. The workshop transcript was anonymized: names or organizations mentioned were either removed or replaced with generic descriptors. In the thesis, when quoting participants, codes (like *Person A*, *Person B*) or role descriptors (e.g. "a property manager stated…") are used instead of real names. After project, data wil be disposed, printed paper will be shredded.

4.6.2 Use of AI Tools

Another ethical aspect pertains to the researcher's use of AI-based assistance (discussed in its own section below). Briefly, while tools like ChatGPT were used in the research process, the researcher ensured that all substantive content originates from validated sources or original data, not from unverified AI outputs. No AI tools were used on any sensitive data (e.g., the workshop transcript was not uploaded to external AI services), preserving participant confidentiality. The role of AI was limited to aiding the researcher's understanding and writing process, and this is openly disclosed in the methodology to maintain transparency.

Finally, the study complied with the university's ethical research guidelines and was conducted under the supervision of faculty who ensured protocols were followed. In sum, the research was designed and carried out with respect for the participants and a commitment to honesty and rigor, thereby upholding fundamental ethical standards.

4.7 Role of AI Tools in the Research Process

In conducting this research, the author made limited, considered use of AI tools as aids in the research process (but not as sources of research data). Given the rise of AI-driven assistants, it is important to clarify how they were utilized and ensure transparency about their influence on the work. The tools used include ChatGPT-4 (a large language model conversational agent) and Copilot. Sora was utilized, in combination with my creativity, to create the front page. These tools were never used to analyze the empirical data or to replace critical thinking; rather, they served as supportive aids in the following ways

4.7.1 Understanding Complex Concepts

During the literature review and methodology planning, the researcher encountered certain theoretical concepts (for example, the notion of "boundary objects" in interdisciplinary collaboration, or different definitions of abductive reasoning). In these instances, ChatGPT was used as a quick reference to obtain explanations or summaries. For example, the researcher might prompt, "Explain the concept of boundary objects in simple terms" to the AI. This provided a starting point to grasp the concept, which was then followed up by reading original scholarly sources for confirmation and deeper understanding. The AI's role here was akin to asking a knowledgeable colleague for a primer on a concept. Every piece of information obtained from AI was cross-verified against academic literature before being used in the thesis to ensure accuracy.

4.7.2 Brainstorming and Idea Generation

When the researcher felt "stuck" on how to articulate a section or how to connect ideas, ChatGPT was occasionally engaged to brainstorm. For instance, after conducting the analysis, the researcher might query, "What are common themes in digitalization of FM from practitioners' perspective?" to see if the AI surfaced any points that the researcher hadn't considered. This was done to challenge and expand the researcher's own thinking. Importantly, the AI could only provide generic insights based on its training data (which includes many texts up to 2021), whereas the researcher's analysis was grounded in the specific 2024 workshop data. If the AI mentioned something novel, the researcher checked against the transcript or literature to see if it was relevant. In some cases, this led the researcher to discover additional literature or to ensure a theme from the data was not overlooked. However, if the AI's suggestions were not evidenced in the actual data or credible sources, they were not pursued.

4.7.3 Writing Assistance and Proofreading

Clarity and coherence are crucial for a thesis. The researcher used Copilot and ChatGPT in a limited capacity to improve writing. The AI sometimes helped in catching grammar issues or suggesting transitional phrases that improve flow. Essentially, it functioned as an advanced proofreading tool. At no point did the researcher ask the AI to generate substantive content (like "write my methodology section") – the structure, arguments, and content were determined by the researcher. The AI was used more like a writing tutor, offering feedback which the researcher could accept or reject.

5 Workshop Findings | Results

A facilitated workshop with facility management FM professionals revealed insights into how they view digital transformation in their field. The conversation touched on practical needs, challenges, benefits, risks, and the roles of various stakeholders in moving FM toward a more digital future. Participants responses have been coded into themes aligned with four sub-research questions, ensuring each insight directly addresses these inquiries. All findings are grounded in the workshop transcript data, with reasoning contextualizing why certain issues are problematic and why suggested solutions make sense, supported by examples from participants experiences.

Two different FM software solutions have been anonymized in this analysis to protect the identities of the specific companies mentioned in the data.

- IWMS: Stands for Integrated Workplace Management System.
- CAFM: Stands for Computer-Aided Facility Management.
- CMMS: Stands for Computerized Maintenance Management System.

From this point forward, the two anonymized FM software solutions discussed in the subsequent analysis will be referred to as IWMS/CAFM - 1 and CAFM/CMMS - 2. The specific characteristics and user experiences associated with each will be explored in detail within the relevant sections of this analysis.

5.1 Needs and Challenges in Adopting Digital Technologies (SQ1)

Participants identified several critical needs and challenges that impede the adoption of digital tools in facility management. These challenges range from human factors like skills and culture to structural issues like resource constraints and data management. Below are the key themes that emerged, each illustrating why adoption has been difficult and what needs must be addressed

Theme	Description	Key Quotes
Limited Digital Skills and Training Gaps	FM staff lack sufficient digital competence, resulting in underutilization of digital tools. Comprehensive and ongoing training is required to bridge this skills gap.	"the biggest bottleneck is having competence among our people" (Person H, p.7).
Resistance to Change and Cultural Barriers	Organizational culture in FM tends to resist change, with personnel often preferring traditional routines over new digital workflows. Effective change management strategies, communication, and clear job expectations are essential for overcoming resistance.	Employees default to old habits, and "we've always done it this way" mindsets prevail (Person D, p.4).
Resource and Budget Constraints	Limited budgets and resources constrain the adoption of digital solutions. Short-term cost considerations often overshadow potential long-term savings. Strategic funding and dedicated resources are necessary for successful implementation.	"you are met with costs all the time" (Person G, p.6).
Data Silos and Integration Difficulties	Fragmented data and incompatible systems across stakeholders result in data silos, complicating FM processes. Seamless data integration through common data environments or standard interfaces is vital for digital transformation.	Contractors are "still at the CD and USB stick level" in 2024 (Person G, p.4).
Usability and User-Friendliness of Systems	Complex and unintuitive FM software hinders user adoption. User-friendly interfaces significantly enhance user engagement and effective utilization. Prioritizing ease-of-use in FM technology selection or design is essential.	"IWMS/CAFM - 1 can be quite advanced… If you manage to make it more user-friendly, you narrow the gap" (Person H, p.13).
Lack of Strategic Alignment and Leadership Support	Digital transformation initiatives often lack clear strategic direction and top-level leadership support, leading to isolated or ineffective implementation. Clear executive commitment and strategic integration of digital objectives are critical for success.	"It has to be decided by leadership… If not, we just carry on as before" (Person G, p.42).

Table 1: Summary of Needs and Challenges Identified in Workshop Findings Related to SQ1

5.1.1 Limited Digital Skills and Training Gaps

A recurring point was the lack of sufficient digital competence among FM staff. One manager bluntly stated that "the biggest bottleneck is having competence among our people" (Person H, p.7). Digital FM systems (e.g. BIM-based facility models) may be delivered to the organization, but if staff aren't trained and motivated to use them, the value gets lost. For example, when a new building's data is handed over as a digital twin from the contractor, the FM team "must have the software that can use it, and not least, operations staff who are interested in using it" (Person D, p.3). Currently, not all technicians

or operators know how to leverage these tools – some hadn't even heard of the FM software "IWMS/CAFM - 1" during onboarding, leaving them to "figure it out themselves" (Person G, p.6). This skills gap means new digital functions go underutilized. Participants explained that many technicians still prefer familiar routines over learning advanced systems, as "they would rather do things instead of document" in the software (Person D, p.7). The need for comprehensive, ongoing training was emphasized repeatedly, both to raise current employees' capabilities and to prepare new hires. Without deliberate upskilling efforts, even user-friendly technologies won't gain traction. In short, digital tools are only as effective as the people using them, so building human capacity is seen as priority one.

5.1.2 Resistance to Change and Cultural Barriers

Alongside skill deficits, an organizational culture resistant to change is a major challenge. Several participants noted that FM personnel can be set in their ways, hesitant to alter workflows or skeptical of new technology. For instance, one FM team had to push employees continually to upload documentation to the cloud, as people would default to old habits like storing files on local drives or even CDs (Person D, p.4). Another participant observed that some staff don't initially see using a system like IWMS/CAFM - 1 as "part of their job" and must be convinced or required to do so (Person G, p.12). There is also end-user pushback when digital data suggests changing how space is used. One manager shared that sensor data could prove an office is only occupied 60% of the time (a digital insight aimed at improving space efficiency), but removing private offices based on that data meets stiff resistance from employees used to having their own space (Person F, p.13). This example shows a cultural hurdle: people may emotionally resist data-driven decisions (like desk sharing policies) even when the technology demonstrates clear benefits. Such attitudes slow down adoption — technology is available, but people must be willing to embrace new practices. The workshop discussion indicated a need for change management strategies: communicating the value of digital tools, setting expectations that using these systems is part of the job, and addressing fears (e.g. loss of personal workspace or job security). Overcoming the "we've always done it this way" mindsets is crucial so that the workforce doesn't hold back the digital transformation.

5.1.3 Resource and Budget Constraints

Many participants stressed that adopting digital solutions requires resources that are often scarce in FM organizations. Even when long-term savings are expected from digital transformation, upfront costs and limited budgets pose an immediate barrier. "In the short term it's a cost, even if in the long term it's a huge saving," one leader noted, describing how proposals for new systems often get blocked because management focuses on the initial price tag (Person G, p.6). Several attendees echoed that sentiment: it is hard to get digital initiatives approved when "you are met with costs all the time" (Person G, p.6). FM departments frequently operate under tight financial constraints and lean staffing, which means they have little slack to experiment with new tools. One participant pointed out that public sector procurement rules can further slow innovation – you "can't test [new technology] out because there's a set of limitations with procurement," and unless an initiative is clearly budgeted, it won't happen (Person G, p.5). Additionally, maintaining both old and new building systems concurrently is costly and complex. An organization like NTNU's estate has buildings from the 1800s alongside modern smart buildings, "which require different things" (Person G, p.6), making a one-size digital solution impossible. They will need to invest in dual competencies and systems for many years (as one person noted, operating a 100-year-old building versus a brand-new one "would require two

different competences" (Person F, p.44) and toolsets). All these factors translate to a need for more funding, time, and people to successfully implement technology. Without dedicating resources, even well-intended digital projects can stall. Participants suggested that upper management needs to recognize these resource needs and plan for them (e.g. allocate budget for software licenses, hire or contract IT experts, and allow staff time for training and data entry) as part of any digital strategy.

5.1.4 Data Silos and Integration Difficulties

The workshop revealed that fragmented information and lack of system integration are significant pain points. FM teams struggle when data is spread across multiple platforms or file formats, often delivered by different actors in the building lifecycle. One property manager described the difficulty of getting all stakeholders to use a "common data environment" – their team tries to centralize facility documentation in one repository for everyone's benefit, "so that it's not stored in different places," but in practice contractors and even internal colleagues still keep their own copies (Person G, p.4). He lamented that some contractors are "still at the CD and USB stick level" in 2024, and it has taken years of effort "teaching them to upload" documents to the shared system (Person G, p.4). This illustrates a broader challenge: incompatible systems and unwilling partners can prevent seamless data flow. Another participant noted that many digital solutions in use (like different FM software at different organizations) aren't connected, resulting in duplicate or inaccessible data. "Everyone talks about it in their own silo…we need to stitch this together," one said, referring to various technology platforms that don't communicate (Person D, p.8; Person D p.33). The lack of interoperability means facility managers cannot easily aggregate data for insights, undermining the potential of tools like digital twins or IoT sensors. This is why participants expressed a need for integration – "if it's all in one database it's much easier for everyone" (Person H, p.4). They see value in vendors and industry bodies agreeing on open standards or interfaces to link systems. Data integration was also discussed in the context of public vs. private digital twins: a city like Ålesund has created a municipal digital twin, but "communication between technologies from private property to public (systems)" is still missing (Person B, p.8). In summary, FM professionals need solutions that break down data silos – whether through single platforms, better APIs between tools, or agreed data standards – otherwise the digital transformation remains patchy and frustrating. Unintegrated data is a challenge because it prevents the holistic use of information that digitalization promises, leading to inefficiencies and user frustration when they cannot get a complete picture easily.

5.1.5 Usability and User-Friendliness of Systems

Even when digital tools are available, if they are not user-friendly they present a barrier to adoption. Participants highlighted software usability (brukervennlighet) as a crucial factor. One FM software, "IWMS/CAFM - 1," was mentioned as extremely powerful but quite complex, whereas a newer platform "CAFM/CMMS - 2" was praised for its intuitive interface. "When it comes to user-friendliness [CAFM/CMMS - 2] wins a lot of customers," a participant remarked pointedly (Person H, p.13). In contrast, IWMS/CAFM - 1's complexity can discourage users: "IWMS/CAFM - 1 can be quite advanced and then the gap [to adoption] becomes larger. If you manage to make it more user-friendly, you narrow the gap," explained one person (Person H, p.13). This gap refers to the difference between the technology's potential and what is actually used in practice. The comment underlines why usability matters – if staff find a system confusing or cumbersome, they will avoid using it or use only a fraction of its features, widening the gulf between potential and

reality. Indeed, one strategy for successful adoption was "it has to be as simple as possible to use" so that people integrate it into their routine (Person H, p.11; Person C, p.18). The need here is clear: FM tech solutions must consider the end-user (often technicians, maintenance workers, or property managers who may not be IT specialists) in their design. Poor user experience is a challenge because it amplifies other issues like the skills gap and resistance – an unfriendly system requires even more training and patience, which busy staff may not have. Conversely, a well-designed application can entice users to experiment and learn. The participants' experiences show that intuitive tools can accelerate buy-in, whereas clunky interfaces cause digital initiatives to falter. Therefore, improving the usability of digital FM systems (either through selecting better products or working with vendors to refine interfaces) is seen as essential to overcoming adoption hurdles.

5.1.6 Lack of Strategic Alignment and Leadership Support

An underlying issue connecting many of the above challenges is whether top management provides clear direction and support for digital transformation. Some FM managers felt that their organizations lacked an official strategy or mandate for adopting new technologies, resulting in ad-hoc or bottom-up efforts that struggle to gain traction. "At the strategic level, it needs to be set that we shall use [these tools]" (Person G, p.42), one participant argued, otherwise initiatives remain isolated experiments. Another went further, noting that it must come from the top down: "It has to be decided by leadership… it must come from above and not below. If not, we just carry on as before" (Person G, p.42). Currently, because digital transformation isn't always an integral part of FM business strategy, managers on the ground face difficulty securing the time and resources to implement new systems (as discussed earlier). This lack of strategic alignment is a challenge because without executive buy-in, there's no mandate to overcome resistance, invest in training, or insist on common data practices. Participants expressed a need for their senior leadership to "set aside funds for training" and prioritize long-term improvement over short-term cost focus (Person G, p.42). One attendee mentioned their company did announce a "competence lift" initiative – acknowledging the issue – but "at the end of the day the bottom line and return on investment still take precedence", so progress was slow (Person D, p.44). This suggests that even when strategies exist on paper, they need genuine follow-through. In summary, FM professionals need stronger leadership commitment to digital transformation. It is a challenge when digitalization is seen as optional or secondary; making it a strategic goal would empower managers to address the other challenges (skills, culture, resources, data) in a coordinated way. The workshop consensus was that without a clear top-down push, many digital efforts will remain stuck in "pilot purgatory" or isolated successes, rather than scaling up across the organization.

In essence, SQ1 findings portray a situation where the technology itself is often not the limiting factor – the tools exist and participants know the possibilities (some even described them as "genial" or game-changing) – but human and organizational factors are. The needs identified (more training, better change management, sufficient budget, integrated systems, and strong leadership) all speak to enabling the conditions in which digital technologies can be effectively adopted. These challenges explain why facility managers, despite seeing value in digitalization, have struggled to fully implement it. Recognizing these pain points is the first step to addressing them, which ties directly into the subsequent questions about perceived benefits, risks, and strategies to bridge the gap.

5.2 Perceived Benefits and Risks of Digital Transformation (SQ2)

When discussing digital transformation, the workshop participants weighed the advantages they foresee against the concerns or risks that temper their optimism. Their perceptions provide insight into why they consider digitalization worth pursuing (the benefits), and what potential downsides or uncertainties they believe must be managed (the risks). All the benefits they mentioned align with core goals in facility management (like efficiency and better decision-making), while the risks often relate to implementation pitfalls or unintended consequences. Below we outline the key benefits and risks as perceived by the facility managers

Perceived Benefits and Risks of Digital Transformation in Facility Management		
Benefits (Perceived Advantage)	**Risks (Perceived Concerns)**	**References**
Efficiency Automation of routine tasks, operational efficiency improvements.	**Upfront Costs** High initial investment, uncertain ROI.	Person F, p.28; Person D, p.29; Person G, p.11; Person G, p.5,42
Decision-Making Enhanced data-driven decision-making and predictive maintenance.	**Data Reliability and Ownership** Concerns about accuracy, ownership, and data governance.	Person F, p.27,28; Person E; Person B, p.8,39
Enhanced Collaboration Better communication and coordination across teams and stakeholders.	**Privacy and Surveillance** Potential for negative reactions to perceived privacy intrusions.	Person C, p.12; Person D, p.13,15; Person F, p.13
Long-Term Savings & Sustainability Reduced costs and waste through efficient resource management.	**Technology Reliability** Dependency risk if systems fail or malfunction.	Person D, p.13; Person F, p.27,44; Person F, p.28; Person D, p.29; Person H, p.11
Innovation Early tech adoption as a competitive advantage.	**Change Management** Resistance and challenges associated with workforce adaptation.	Person G, p.41; Person I, p.28; Person D, p.29; Person G, p.41; Person D, p.13

Table 2: Perceived Benefits and Risks of Digital Transformation in Facility Management

5.2.1 Benefits of Digital Transformation in FM

Participants clearly recognized numerous benefits from adopting digital technologies in facility management. Many of these benefits are about doing things faster, smarter, and with greater insight than traditional methods allow

5.2.1.1 Efficiency and Time Savings

A dominant theme was improved efficiency in operations and maintenance. Digital tools (e.g. IoT, AI, CAFM's) promise to automate routine tasks and reduce the time required for manual work. For example, one participant noted that while "the job still has to be done" (you cannot eliminate all physical work), there can be "huge time savings [and] efficiencies" by using technology (Person F, p.28). They gave a practical example involving augmented reality smart glasses: even though someone must perform the maintenance task, such technology can streamline it (e.g. by providing hands-free instructions or data instantly), making the work quicker and easier. Another participant lauded how a digital twin platform enabled their team to work "easier and better in a shorter time", by providing at-a-glance information and remote collaboration capabilities (Person D, p.29). As a specific case, using a tool like CAFM/CMMS - 2 (a BIM-based FM system) allows a technician to instantly pull up floor plans and click on a component to get details, rather than flipping through paper manuals – "the possibilities are there", he said, implying tasks that used to take hours can be done in minutes digitally (Person G, p.11). (Person G, p.11). The consensus was that digital systems can greatly speed up maintenance workflows, inspections, space management, and reporting, yielding significant productivity gains. This efficiency is not just about saving labor, but also responding faster to issues (like detecting equipment faults or occupancy changes in real time) which can prevent small problems from becoming big ones. In sum, saving time and effort is a tangible benefit that participants have already started to see in pilot projects and expect to increase with further digital adoption.

5.2.1.2 Improved Data-Driven Decision Making

Facility managers appreciated how digital tools give them better data and analytics to support decisions. Several examples highlighted this benefit. One major advantage is real-time data collection from sensors and IoT devices, enabling optimization of facility usage and environment. A participant discussed using occupancy sensors and booking systems to measure space utilization in offices, noting that such data "is a great tool" for achieving space efficiency (Person F, p.27). By knowing that, say, an office area is only used 60% of the time, FM teams can make informed decisions to consolidate space or adjust allocations, thereby saving costs on unused areas. In the past, these decisions might have been based on rough estimates or infrequent surveys, but now continuous sensor data provides concrete evidence. Additionally, digital twins were praised for their analytical potential. For instance, one FM professional envisioned using a building's digital twin to analyze "traffic flow patterns in parking lots" or other usage patterns, something "much larger than what is utilized today" (Person F, p.28). Such analysis could inform everything from parking policy to where to invest in infrastructure. Predictive maintenance is another data-driven benefit mentioned: AI and sensor integrations can monitor equipment and predict failures before they happen. One participant described a project using AI to read and summarize maintenance contracts and compare them, hinting that AI could also sift through FM

documentation to surface important information automatically (Person G, pp.2-3). Although this was an experimental case, it shows the perceived benefit of letting machines do the heavy data crunching, so managers can act on insights rather than spend time gathering information. Overall, the group sees digital transformation enabling a shift from reactive, intuition-based management to proactive, evidence-based management. The benefit is not just having more data, but making sense of it quickly, leading to smarter decisions about energy use, space allocation, asset replacement, and so forth. This directly ties to long-term gains like cost savings and improved service quality in facilities.

5.2.1.3 Enhanced Collaboration and Communication

Another benefit discussed was the improvement of collaboration both within FM teams and with other stakeholders through digital platforms. Modern FM tools allow multiple people of different expertise to work together more seamlessly. One participant, an architect by background, noted that with a shared digital model "now we can communicate with different specialists… simultaneously work on files", which provides a flexibility and speed that traditional methods (passing drawings back and forth) lacked (Person C, p.12). They were describing how a digital twin or BIM model accessible to all relevant parties (architects, engineers, facility managers, etc.) breaks down silos. Everyone sees the same information updated in real time, reducing misunderstandings and the latency in coordination. This is especially beneficial during renovations or complex problem-solving in a facility – the electrical engineer and HVAC technician can literally be on the same digital page. Some also mentioned communication with building users: for example, advanced visitor management systems that were tried in a high-tech building (Lysgården) gave visitors maps and informed hosts when guests arrived (Person D, p.13). While that specific implementation had challenges, it exemplified the aim of using technology to connect people more effectively within a building ecosystem. Even simple uses of existing tech were cited: one manager quipped that you don't always need new sensors; using an existing CO_2 sensor as an occupancy indicator (high CO_2 implies a room was in use) can help gauge usage without any meeting or manual check (Person D, p.15). This kind of creative use of data encourages more interaction between facility staff and the data outputs, effectively making communication between people and the building's systems better. In summary, participants perceive that digital transformation fosters collaboration: it connects team members via shared platforms and connects systems so information flows to those who need it. The benefit is faster problem resolution and more aligned efforts, as everyone can access the same digital information and contribute their expertise from it.

5.2.1.4 Long-Term Cost Savings and Sustainability

While short-term cost was cited as a challenge, the long-term economic benefit of digital transformation was well understood. Managers believe that optimizing maintenance schedules, energy use, and space utilization through digital tools will save money over time. One participant mentioned energy specifically – digital control systems can adjust HVAC operations based on actual occupancy and environmental sensors, leading to energy efficiency gains. In one anecdote, a property company calculated heat loss from uninsulated pipes to justify investing in insulation (Person D, p.13), demonstrating how data leads to cost-saving actions. Digital systems make such analyses much easier and more routine, potentially reducing waste. Another area is preventative maintenance: by tracking equipment performance data, FM teams can fix issues before they escalate, thus avoiding costly breakdowns and extending asset life. This reduces capital expenditure in the long run. Space management insights also translate to financial benefit – if a faculty is only using 70% of its allocated space, as one manager highlighted with sensor data, then

consolidating space could reduce rental or utility costs (Person F, p.27). Beyond direct costs, participants noted an indirect benefit: better service and user satisfaction. If buildings function more smoothly and are tuned to occupants' needs (comfortable temperature, available space, etc.), organizations benefit from happier, more productive building users. While not always quantified in budgets, this is part of the "value" case for digital FM. Additionally, digital documentation and processes can improve compliance and risk management (reducing the likelihood of costly regulatory breaches or accidents). Taken together, the professionals in the workshop see an overarching benefit: digital transformation makes FM more proactive and efficient, which in turn saves money and adds value over the building lifecycle. This future-oriented outlook (the promise of "enormous savings in the long run" (Person F, p.44) is a key reason they continue pushing for digital tools despite the initial hurdles.

5.2.1.5 Future-readiness and Innovation

Lastly, there was an aspirational benefit discussed – positioning the FM organization for the future. Some participants felt that embracing digital technologies now is essential to remain relevant and effective as the industry evolves. They talked about emerging tech like AI and how it has rapidly become part of the conversation in FM just in the past couple of years (Person G, p.41) (Person G, p.41). By experimenting with these technologies early (for example, one team was piloting AI for document analysis and exploring how generative AI like ChatGPT could be used (Person I, p.28)), facility managers can discover novel applications that give their organization a competitive or operational edge. The benefit here is harder to quantify, but it's about innovation capacity – digital transformation opens the door to radically new ways of managing facilities (such as autonomous building systems, predictive analytics, or even new service models in FM). Participants who were enthusiastic about technology felt that being on the forefront (e.g. participating in pilots with tech providers, trying out IoT solutions) allowed them to shape those tools to their needs and be ready when such tech becomes mainstream. As one person put it, "the technology is here, it's just about wanting to use it [in new ways]" (Person H, p.37). Another noted that by 2050, "we are definitely there" in terms of advanced AI integration (Person D, p.29), so starting the digital journey now is crucial. Overall, the benefit of future-readiness is that the FM function can transition from a reactive maintenance role to a more strategic, data-driven role within organizations, contributing to innovation rather than lagging behind it. Embracing digital tools is seen as investing in the FM department's future capabilities and relevance.

5.3 Risks and Concerns of Digital Transformation

While the mood toward digital transformation was largely positive on benefits, participants also voiced several risks, challenges, or concerns that accompany these changes. These perceived risks help explain lingering hesitation or caution in fully committing to certain technologies:

5.3.1.1 Upfront Costs and Financial Risk

The flip side of long-term savings is the short-term cost risk. Many FM organizations fear investing heavily in a new technology that might not deliver ROI or might become obsolete. As discussed, tight budgets make any expenditure significant – if a digital solution requires a large initial outlay (for software licenses, IT infrastructure, or hiring specialists), the risk is that it strains the budget without yielding enough benefit. One participant gave an example of procurement rules limiting trials: there is a risk in buying something outright due to procurement policy, yet without trying it you can't prove its value – a catch-22 (Person G, p.5). This can result in missed opportunities or, conversely, in sunk cost if a tech doesn't work as hoped. Additionally, the diversity of the building portfolio (historic to modern) means not all assets can equally benefit from high-tech solutions, so spending on digital tools might have uneven returns. Management may worry about "over-investing" in fancy systems for old buildings where simpler methods suffice. The participants acknowledged this by noting companies often ask, what are we actually going to need going forward?, and it's "difficult when you don't quite know what to go for" (Person G, p.42). In short, uncertainty about which technology will become standard and yield benefits makes financial decisions risky. The concern is ending up with expensive systems that aren't fully used – a risk the group clearly wants to mitigate by careful planning and phased adoption.

5.3.1.2 Data Reliability and Ownership Issues

As FM becomes data-driven, questions arise about data quality, ownership, and responsibility. A significant concern mentioned was: who is accountable for maintaining and verifying digital data? If an FM system (like a BIM model or digital twin) is only as good as its data, incorrect or outdated information can lead to errors in decision-making – which is a risk. One discussion point was about "who enters the information and who then takes responsibility that it's correct and important" (Person B, p.39). For instance, if a digital twin is updated by external contractors or vendors, errors or inconsistencies might creep in. If no one clearly owns the process of validating data, the FM team could make a wrong call (imagine a maintenance crew trusting a model that shows a valve in one location, but in reality it was moved and the model wasn't updated – the result is wasted time or even safety hazards). There's also an ownership concern for the digital models themselves. Participants asked, when a comprehensive building model is created, "who owns it, and how can we work across companies with it?" (Person B, p.8). If a technology provider hosts the data or a consultant built the model, the FM organization might worry about being locked in or losing access. Indeed, sharing the model between different firms (e.g. property owner, FM service provider, contractor) raises questions of intellectual property and liability. One participant brought up the possibility of copyright-related issues or risk and responsibility with data sharing (Person B, p.8) – for example, if multiple parties contribute data to a system, do they all have equal rights to use it? Could a vendor restrict access or charge for data export? These uncertainties make some managers cautious about adopting solutions that aren't transparent about data ownership. The risk is investing in

building a digital asset that you don't fully control. To mitigate this, some suggested preferring open systems or at least establishing clear agreements with providers about data governance. Nonetheless, until those norms are established, data ownership remains a perceived risk of going digital.

5.3.1.3 Privacy and Surveillance Concerns

With sensors and tracking technologies, a social risk noted was the potential for privacy invasion or negative perceptions by building occupants. For example, when discussing occupancy tracking, one idea was using employees' mobile phones to track their location in the building for space utilization purposes. Immediately a participant flagged that as problematic: tracking "where you are in the building with the phone" is not well received (Person D, p.15). They implied that while measuring CO_2 in a room to infer presence is innocuous (and "not a big problem" privacy-wise) (Person D, p.15), actively tracking individuals crosses a line. This highlights a risk of pushback from employees or even legal issues (like GDPR compliance) if digital initiatives are perceived as surveillance. Facility managers must balance using technology to optimize buildings with respecting personal privacy. The workshop group seemed aware that some advanced capabilities (like personalized tracking or monitoring of individual behavior) might not be acceptable to implement, even if technically possible. Another participant noted resistance when personal space is affected (like removing private offices based on occupancy data) (Person F, p.13) – while not exactly a privacy issue, it's related to people's sense of autonomy and comfort at work. The risk is that deploying certain digital measures could erode trust or employee satisfaction if not handled sensitively. As a result, FM professionals must consider the human element: they may need to anonymize data, communicate clearly about what is being monitored and why, and ensure that technology is seen as enabling, not Big Brother. Failing to do so could lead to employee complaints, union pushback, or even regulatory fines, all of which are risks that temper how aggressively one might pursue digital tech in a facility.

5.3.1.4 Reliability and Dependence on Technology

Some concerns were raised about relying too much on technology. If FM processes become heavily digital, what happens if the system fails or data is wrong? One participant gave a simple example: with all the automation, "the job still has to be done" by someone (Person F, p.28) – implying that you cannot fully depend on tech to solve everything. For instance, a smart HVAC system might optimize itself, but if a sensor malfunctions and no one notices, it could cause discomfort or damage. There's a risk in assuming the technology will handle situations autonomously; human oversight is still needed. In the workshop, a few participants were actually skeptical that AI or advanced tech would replace human judgment by 2050 – one said "I don't think that so much will have happened by 2050, unfortunately" in terms of a total revolution (Person D, p.29), because many tasks will still require human intervention. This caution reflects a risk awareness: over-reliance on digital systems could be dangerous if those systems are not robust, or if staff lose traditional skills. Another angle is business continuity – if all building plans are digital and the system goes down, do you have backups? One participant jokingly (but earnestly) recounted moving from paper to digital and noted "it takes time to see the benefit" (Person H, p.11), hinting that during that transition you might run parallel systems or face inefficiencies. The risk of outages, cyberattacks, or simply software bugs is something FM teams have to consider. A digital twin is great, but if the network is down and you can't access it when needed, operations could be paralyzed. Likewise, a heavy dependence on a vendor's platform means if that vendor has issues or goes out of business, the FM organization could

be stuck. These reliability and dependency risks make facility managers advocate for backup plans and phased adoption – keeping critical knowledge accessible in multiple forms and ensuring that staff retain the ability to "revert to manual" if needed. Essentially, participants want the benefits of tech without putting all their eggs in one basket, acknowledging that a blend of analog and digital resilience is important.

5.3.1.5 Change Management and Workforce Impact

While not overly fearful of job losses, the group did note that workforce dynamics will change, which carries some risks if not managed. As new technology is introduced, some roles will evolve. There is a risk of alienating or overwhelming older employees who may feel left behind. One participant noted bluntly that change often happens by the old guard retiring: "changes happen as people are replaced… we get young people in who are much better with digital things" (Person G, p.41). This is not so much a desired strategy as an observation, but it hints at a risk: if current staff don't or can't adapt, valuable experience could be lost or individuals could become disengaged. Nobody explicitly talked about layoffs due to digital tools (in fact, the sentiment was that you will still need plenty of staff, just with different skills, but they did worry about how to bring everyone along. The risk is a divide in the workforce: tech-savvy employees versus those who continue doing things the old way, which can create internal friction and inconsistent practices. Moreover, without proper change management, digital tools might be seen as imposed or irrelevant, leading to poor adoption (a risk realized in some examples we've already seen, like systems not being used fully). There's also a risk of "initiative fatigue" – if leadership pushes too many new systems without supporting them, staff could become cynical and resist further changes. To mitigate these people-related risks, participants stressed communication, training, and involving the end-users in the process (for instance, getting feedback in pilots so they feel ownership and the solution fits their needs (Person D, p.13)). In essence, the concern is not that digital transformation will eliminate FM jobs – rather the risk is failing to manage the human transition, which could lead to low adoption or loss of institutional knowledge if veteran workers are not included in the journey.

In summary, SQ2 findings show that facility managers have a balanced view: they are excited about the benefits (efficiency, better decisions, collaboration, cost savings, innovation) which explain why they want to pursue digital transformation. At the same time, they are mindful of risks (cost hurdles, data governance, privacy, over-reliance, and change management issues) that explain why the transformation is not straightforward. These perceived benefits and risks directly influence how FM professionals approach digitalization – they seek to maximize the upsides while finding ways to mitigate the downsides. This perspective sets the stage for discussing how technology providers factor into the equation (SQ3) and what strategies can help bridge the gap between the potential of technology and the reality of adoption (SQ4).

5.4 Role of Technology Providers in Shaping Digital Strategies (SQ3)

The interaction between facility management teams and technology providers (vendors of FM software, IoT devices, digital twin platforms, etc.) emerged as an important factor in how digital transformation unfolds. Participants discussed how providers influence their digital strategies, for better or worse, and what kind of relationship works best to realize the value of new technologies. The role of technology providers can be summarized in two main dimensions: providers as partners (collaborators) and providers as vendors (sellers of products). The workshop insights suggest that when providers act more like partners, actively engaging with FM needs, they significantly help shape and improve digital strategies. Conversely, if the relationship is purely transactional, the burden falls on the FM organization to drive adoption. Key points on the role of providers include:

5.4.1 Driving Innovation Through Partnership

Several participants gave examples of close collaboration with tech providers in pilot projects, which proved highly beneficial. In one case, a facility management unit was piloting a new system (CAFM/CMMS - 2, a digital platform) and had "regular meetings every 14 days" with the provider (Person D, p.13). In these meetings, they would test new features and give feedback, and the provider would adjust the product or answer questions in real-time. This two-way exchange meant the product evolved with the FM team's input, and the team learned the system's capabilities directly from the developers. The participant noted "it works really well", highlighting that such collaboration allowed them to influence the tool so it better fit their workflows (Person D, p.13). This example illustrates the ideal role of a technology provider as a development partner who listens to end-user needs. By shaping the software together, the FM organization's strategy can incorporate the technology more deeply (since they understand it and have tailored it to their processes). Another participant from a different organization said they actively seek out tech and are curious in the FM domain, implying they engage providers proactively rather than waiting for sales pitches (Person G, p.12). This proactive stance often leads to early adoption trials and partnerships. The benefit of such partnerships is that they reduce the mismatch between what technology offers and what the FM practice needs – providers learn the on-the-ground challenges and can tweak their solutions, while FM teams gain expertise and confidence in using the new tools. Thus, technology providers, when engaged collaboratively, play a significant role in shaping digital strategy by co-creating solutions and ensuring the FM team is prepared to implement them.

5.4.1.1 Solutions Shaped by Provider Capabilities

The features and focus of available products inevitably shape what ends up in an FM digital strategy. Participants observed that different providers have different strengths, and those can dictate what technologies are adopted. For example, one person contrasted two software products: IWMS/CAFM - 1 (which originated from an internal project at NTNU) and CAFM/CMMS - 2 (a commercial product). IWMS/CAFM - 1 was described as very powerful ("enormously many possibilities") but not very user-friendly, whereas CAFM/CMMS - 2 had become the "best system" by 2020 largely because "they have more developers than salespeople" and improved the usability and functionality dramatically over a few years (Person H, p.13) (Person H, p.13). This comment reveals how a provider's approach (investing in R&D vs. aggressive sales) can influence FM technology adoption. A

product that continuously improves in response to user needs (like CAFM/CMMS - 2) naturally becomes a preferred choice and thus shapes the strategy (e.g. an organization might standardize on that platform). On the other hand, if a widely used tool is complex (like IWMS/CAFM - 1), FM managers have to strategize around that – perhaps by providing extra training or limiting the tool to expert users – which in turn affects digital outcomes. In essence, the quality and user-focus of technology providers' offerings can either enable or hinder adoption. Participants essentially said "better products get used more," implying providers indirectly determine how far the FM digital transformation can go by how well they design their solutions. Additionally, providers often introduce new ideas and possibilities to FM teams. Many vendors approach FM departments to demonstrate the latest tech (one mentioned companies "knocking on our door" to present their solutions) (Person D, p.7). These pitches can spark new strategic initiatives if the FM team sees potential. However, there's a flip side: FM professionals have to discern hype from reality. Because providers are selling, sometimes "they have to try to convince you to use it" (Person H, p.5), which implies not every offered solution aligns with actual needs. Facility managers must filter and choose tech that aligns with their strategy, but the menu of options is set by what providers develop. Thus, providers shape strategies by defining the cutting edge – whether it's IoT sensors for space management or AI analytics for maintenance, those become part of the FM digital roadmap largely because the tech industry made them available.

5.4.1.2 Support and Training Roles

Technology providers also play a role in training users and supporting implementation, which can make or break a digital strategy. When asked about working with vendors, one participant described that in their pilot project the provider was very responsive, answering questions "then and there" and presumably helping troubleshoot issues (Person D, p.13). This kind of support accelerates learning and increases the likelihood that the technology will be adopted enterprise-wide. Some providers offer formal training sessions, manuals, or even on-site support during rollouts. The participants indicated that such support is crucial: without it, the FM team might not fully understand the tool, leading to underuse. In one part of the discussion, a participant noted that many FM personnel weren't aware of certain features or even the existence of tools until someone externally introduced it to them (Person H, p.37). For instance, Person H mentioned he "didn't know [some new tech] until a friend who is very into technology showed me", and that awareness is often the hurdle (Person H, p.37). Here, a tech provider's role could be to ensure all users are informed about what the tool can do – essentially educating the client. If providers neglect the training aspect and just drop off the product, the digital strategy suffers because employees remain in the dark about capabilities (reinforcing the earlier challenge of low competence). On the other hand, some participants noted that vendors like CAFM/CMMS - 2 actively sought feedback and presumably trained users during the pilot (Person D, p.13), which helped their adoption. Another nuance is providers helping articulate the business case. One participant praised Statsbygg (a public agency, but in this context a provider of requirements and solutions) for being "forward-leaning" and good at specifying what they want and testing many systems (Person E, p.43). This suggests that when the provider side (or client side acting as tech advocate) clearly communicates the needs and demonstrates value, it pushes the whole industry forward. In summary, providers who take an active role in support and knowledge transfer significantly shape FM outcomes – they can empower facility managers with the know-how to use the tools effectively, thereby aligning the digital strategy with practical capability.

5.4.1.3 Influencing Standards and Integration

Technology providers also influence how well different systems work together, affecting an FM organization's ability to have an integrated strategy. If each provider creates a closed ecosystem, the FM team ends up juggling multiple platforms. Participants expressed frustration at having to use different programs that don't talk to each other because different vendors are involved (e.g. construction handover data might come via one system, maintenance management in another). One participant cut in to say that contractors often insist on their own systems, even delivering data on physical media, and the FM team had spent years pushing them to use the central system (Person D, p.7). In this case, contractors (as providers of building data) were slow to adopt the standards the FM organization wanted. The FM managers clearly desire providers to meet them halfway – for instance, by adopting a "common data environment" approach (Person H, p.5) or by offering integration capabilities. The question "Is the digital twin more open by 2050, and are there advantages to being more open?" was raised (Person B, p.39), indicating that openness (data sharing between systems/vendors) is a concern for the future. A provider's role here would be to enable openness – e.g. through APIs, data export features, or participating in industry data standards. Some participants recognized that no single provider will do everything, so the strategy is shaped by how easily the tech from different providers can be combined. If a vendor doesn't allow easy export of data, it might lock the FM organization in, and managers may avoid that product as a strategic choice. Conversely, a provider that collaborates (perhaps by forming partnerships with other tech companies or aligning to standards like COBie, BIM standards, etc.) can greatly enhance the FM digital ecosystem. In the workshop, although not deeply discussed, hints of this appear in concerns about "who owns the model and how to work across companies" (Person B, p.8). Technology providers who clarify ownership and facilitate cross-company data exchange effectively shape a more collaborative digital strategy, where FM, contractors, and other service providers can all contribute to and draw from a shared information pool. Thus, providers have the power to either silo information or help break silos, and facility managers are keenly aware that this impacts their strategy success.

5.4.1.4 Persuasion and Push vs. Pull

Finally, the workshop touched on whether FM departments drive their digital agenda or rely on providers to introduce ideas. One direct question asked if they collaborate with vendors or "get a product delivered and then it's [the vendors] who have to try to convince you to use it" (Person E, p.43). The implication is that sometimes a new system is procured (perhaps top-down or via IT departments) and the provider then has to push the FM staff to actually adopt it – not an ideal scenario. Participants generally felt that a pull approach (demand from FM side) works better than a push. For instance, Person H's organization didn't wait; "we seek out [new technology] because we're curious" (Person H, p.7), meaning they pulled providers into a dialogue about what's possible. In contrast, waiting for vendors to "knock on the door" with the next big thing might put FM in a passive role (Person H, p.5). However, the reality is a mix: vendors do bring new concepts around (AI offerings, new sensor tech), which can spark change if embraced. The group seemed to prefer being active players – forming partnerships as noted – rather than being sold to. This dynamic informs how strategies are shaped: a strategy purely dictated by vendor pitches might chase shiny new tools without fully considering fit, whereas a strategy that involves vendors as collaborators is more needs-driven. One participant noted that NTNU (as an FM organization) had room to explore and "expand horizons" but was limited by funds (Person G, p.42). Still, they emphasized improvement via interacting with provider products over time (like CAFM/CMMS - 2 improving from 2017 to 2020). So the role of

providers is also to continuously improve their products so that FM clients remain engaged and see progress, rather than getting disillusioned. In summary, technology providers shape FM digital strategies both by introducing new technological possibilities and by how they engage with the FM clients. The workshop insights underscore that a collaborative, user-focused provider can positively influence strategy (making it more ambitious and successful), while a disconnect between provider and user can stall adoption (even if the tech is delivered, it might sit unused without the proper engagement).

To directly answer SQ3: technology providers play a multifaceted role in shaping digital strategies for facility management. They are not just vendors but can be crucial allies in development and implementation, as seen in pilot collaborations that refine the tools to FM needs (Person D, p.13). Providers influence what technologies are available and viable – user-friendly solutions like CAFM/CMMS - 2 gained traction because the provider's approach aligned with user needs (Person H, p.13) (Person H, p.13). They also impact how integrated or isolated the FM digital environment is, depending on whether they support open data and cooperation across platforms (Person H, p.4) (Person H, p.4). Ultimately, the workshop evidence suggests that when FM professionals and tech providers work closely (sharing feedback, ideas, and training), the digital strategy becomes more coherent and effective. In contrast, a weak relationship with providers might leave facility managers with tools that are underutilized or ill-suited, requiring the FM team to either adapt on their own or possibly abandon the technology. Thus, a key part of improving digital adoption in FM (tying back to the main RQ) is improving how FM organizations collaborate with tech providers – essentially bridging the gap together rather than in isolation.

5.5 Strategies to Bridge the Gap Between Technology Potential and Adoption (SQ4)

Given the challenges and risks identified, and the understanding of how technology providers can assist, the workshop participants discussed strategies to bridge the gap between the potential of digital technologies and their actual adoption in practice. This "gap" was a recurrent theme – participants frequently noted that the technology's capabilities are far ahead of what is currently being used in their organizations. As one person put it, "the possibilities are there, but we can't seem to move up [to using them]" (Person G, p.11). Bridging this gap means finding ways to overcome the hurdles (from SQ1) and leverage the support (from SQ3) to realize the benefits (from SQ2). The strategies that emerged are both organizational (processes, culture, management) and technical (tools, training) in nature. Below are the key strategies, each tied to the challenges they address and supported by participants' input:

5.5.1 Strengthen Leadership and Strategic Commitment

A clear takeaway was that digital transformation needs to be anchored in strategy and championed from the top. To bridge the gap, participants argued that upper management must actively drive the digital agenda. This involves setting a vision, allocating resources, and establishing policies that mandate or encourage digital practices. "It must come from above and not below… It must be a strategy they choose," urged one participant, stressing that leadership should decide on a digital trajectory and make it part of the organization's core objectives (Person G, p.42). In practical terms, this could mean including digital KPIs in the FM department's goals, or a formal "digital transformation roadmap" approved by

executives. Another participant described the need for a "competence strategy to lift the entire company's digital competence", which should be "really facilitated" by management through funding training and possibly hiring additional support during the transition (Person G, p.42) (Person D, p.44). This indicates that leadership should not only set expectations but also provide the means (budget, time) to achieve them. The workshop dialogue suggested that when leadership lights the "spark" at the top, it's much easier for initiatives to flow downwards (Person H, p.7) – whereas trying to push new tech from the ground up is an uphill battle. One strategy example was management explicitly allocating a portion of the budget and work hours to digital projects and skill development, treating it as an investment in future efficiency. Additionally, leadership can help by breaking silos and encouraging collaboration (both internally and with external tech partners), since they have the authority to convene different departments (IT, FM, finance) to work together on digitalization. The reasoning is that without strong strategic alignment, any adoption will be piecemeal and fragile; with leadership backing, it becomes an organizational priority where everyone is expected to contribute. As evidence of necessity, participants noted that in their experience, whenever there was a lack of managerial focus, "we just carry on as before" (Person G, p.42). Therefore, a top-down push is seen as a critical strategy to bridge the gap between knowing that technology can help and actually using it at scale.

5.5.2 Invest in Training and Competence Development

Nearly all participants agreed that upskilling people is the pivotal strategy to improve adoption. Bridging the gap means turning the "bottleneck" (lack of competence) into a strength. Concretely, this involves organizing comprehensive training programs, continuous learning opportunities, and possibly certification requirements for using new tools. One participant likened it to safety training for a new power tool: just as a worker must be trained and sign off that they can use a new saw, we should do the same for digital tools (Person G, p.7) (Person D, p.7). In other words, formalize the training – ensure every relevant staff member goes through a course on the FM software or analytics platform and is validated in its use. Another suggested tactic was making digital competence an explicit job requirement or at least an expectation: "They can set the requirement that you must know this, otherwise you can't work here" – a somewhat extreme statement (Person G, p.41) (Person G, p.41), but it underlines the idea of holding staff accountable for learning the tools, not leaving it optional. More broadly, participants talked about fostering a culture of continuous learning and improvement. That means not just one-off training when a system is introduced, but ongoing upskilling as technology evolves (for instance, periodic workshops on new features, encouraging attendance at industry seminars on digital FM, etc.). Some mentioned bringing in young tech-savvy people and also enabling the older staff to learn from them, effectively knowledge transfer within the team. One strategy is to create digital champions or super-users: identify a few enthusiasts or skilled individuals and have them mentor others. We saw hints of this, like one person mentioning a colleague who was very curious and always adopts tech early, who then shared that knowledge with peers (Person H, p.37). Formalizing that – e.g. a mentorship or "each one teach one" program – could multiply competence internally. The reasoning behind the training strategy is straightforward: if lack of knowledge is stopping people from using the system, then giving them knowledge opens the door. Participants believe that with proper training, even complex systems like IWMS/CAFM - 1 can be mastered enough to deliver value, closing the usage gap. They also noted that training pays off in efficiency later: "Had we used a bit of time on training the operations staff, we would have had great profit from it," one noted, reflecting on missed opportunities (Person G, p.7) (Person G, p.7). In sum,

systematic competence development addresses multiple challenges at once (fear, lack of skill, inconsistency) and was seen as non-negotiable for bridging the gap.

5.5.3 Enhance User Engagement and Change Management

To complement formal training, the strategy of actively engaging users in the change process was highlighted. This involves communication, involvement, and demonstrating value to win hearts and minds. Participants suggested that involving end-users in pilot projects and feedback loops can make a big difference. The CAFM/CMMS - 2 pilot is a case in point: FM staff were directly involved in testing and shaping the tool (Person D, p.13), which not only improved the product but also gave the staff a sense of ownership and confidence. Expanding this approach, one strategy is to run small pilot implementations of a new technology in a subset of buildings or with a volunteer team, gather lessons, and then use those early adopters as ambassadors when scaling up. This creates internal success stories that can persuade more skeptical colleagues. Another aspect is clear communication of "what's in it for me" to the users. One participant noted you have to tell technicians that using the digital tool "is part of your job" and show them how it actually makes their job easier (Person G, p.12). Emphasizing quick wins is a strategy: for example, show a maintenance worker that by logging issues in the app, they can eliminate redundant paperwork or easily retrieve history later, saving them time. When users see personal or immediate benefits, they are more likely to adopt the change. The workshop also underscored the importance of addressing resistance empathetically – for instance, acknowledging concerns about new office layouts or work patterns and using data to have an open dialogue. One strategy used was to counter arguments with evidence: "that room is used only 60% of the time, so we have to allow more use" (Person F, p.27) – by transparently sharing sensor data, FM managers were able to make a case for change that is harder to dispute as mere opinion. This kind of data-driven persuasion can gradually change mindsets, as people realize decisions are based on facts, not whims. Additionally, leadership's visible support (as mentioned earlier) is part of change management – if the CEO or director is openly championing the new system and even using dashboards themselves, it signals to everyone that this is the new normal. In summary, bridging the gap requires not just technical fixes but winning over the human side. Strategies like pilots, champions, transparent communication, and evidence-based justification all serve to turn potential resisters into participants in the digital transformation journey, thereby increasing adoption rates.

5.5.4 Phased Implementation and Prioritization

Another strategy is to tackle digital transformation in manageable phases, focusing on high-impact areas first to build momentum. Participants recognized that trying to do everything at once is impractical, given resource constraints and learning curves. Instead, they suggested prioritizing certain technologies or use-cases where the payoff is clear and the organization is ready, and then expanding. For example, one group found success by starting with moving documentation to the cloud (a relatively simple step) back in 2017 (Person H, p.7). Once people got used to cloud storage, they could build on that foundation with more advanced tools. Others mentioned focusing on sensor data for space usage because it directly tied to cost savings in space management – a "low-hanging fruit" where benefits can justify the effort (Person F, p.28) (Person F, p.28). By achieving wins in such targeted projects, they gained organizational trust to attempt more ambitious projects like AI for maintenance or full BIM integration. A phased approach could also mean iterative improvement of a system: deploy a basic version, let users acclimate, then gradually

introduce more features. One participant described how CAFM/CMMS - 2 wasn't useful in 2017, but by 2020 it became the best system (Person D, p.29) – during that time, presumably the tool and the users both matured. FM teams can mirror this by not pushing every feature at once. Strategically, this reduces risk because if a phase doesn't deliver expected value, one can adjust course without having invested in an entire overhaul. It also prevents staff overwhelm. The data suggests facility managers are thinking in these terms: they talk about not aiming too far ahead (e.g. one said "2030-ish" for certain tech adoption, as aiming beyond might be futile since things change so fast (Person H, p.7)). Essentially, set realistic near-term goals (the next 5-7 years) and re-evaluate as technology and the organization evolve. This agile mindset is a strategy in itself – remain flexible and ready to pivot as lessons are learned. It bridges the gap by ensuring that the adoption curve matches the organization's capacity to absorb change. Rather than a big bang implementation that might fail, a phased strategy builds a staircase to the full potential, one step at a time.

5.5.5 Leverage Technology Providers and External Expertise

Building on SQ3 insights, a key bridging strategy is to actively use the expertise and support of technology providers (and other external resources like consultants or industry networks). Participants advocated for collaborative engagement with providers – not just buying a product, but involving the provider in training, customization, and continuous improvement. The CAFM/CMMS - 2 pilot again serves as a model: by having bi-weekly touchpoints with the vendor, the FM team accelerated their learning and ensured the product fit their needs (Person D, p.13). Scaling this idea, organizations can set up partnerships or innovation labs with trusted vendors or even startups to pilot new solutions in a controlled way. Another external resource is peer networks. One question was raised: "Do we think there will be more collaboration in the future?", referring to collaboration among facility owners or FM departments across organizations (Person E, p.43). The participants noted that networks like the "Eiendomsnettverket" (Property Network) already exist, where FM professionals share experiences. By tapping into such networks, strategies that worked elsewhere can be learned and adopted. For instance, if one company successfully implemented a common data environment with their contractors, they can share how they achieved buy-in. Participants did mention collaboration is "difficult… maybe because no one has time to think about it"(Person D, p.8), but they also felt it's necessary and should be pursued at a strategic level. Thus, a strategy to bridge the gap is allocating time for knowledge exchange with peers and inviting technology providers to joint forums, so that solutions can be co-developed industry-wide. Additionally, hiring external consultants for specific expertise (like data integration or change management) is a tactic some would consider, as hinted by a comment that sometimes they have to buy the service because internal staff are too busy (Person D, p.7). While not the first preference, bringing in external experts temporarily can kick-start an initiative (for example, consultants could set up a BIM system and train the team, leaving them to operate it going forward). The overall reasoning is that FM departments shouldn't try to bridge the digital gap in isolation – they can accelerate by learning from others and utilizing all available support. Technology providers, when treated as partners, often have a stake in the successful adoption of their product, so they are usually willing to assist. By embracing that assistance and cross-pollinating ideas through industry collaboration, facility managers can overcome challenges more efficiently than by internal trial and error alone.

5.5.6 Improving System Integration and Data Practices

On the more technical side, a strategy to bridge the gap is to fix the data fragmentation issue. Participants suggested working towards a "single source of truth" for facility data. For example, making a concerted effort to implement a centralized FM database or platform that all stakeholders (maintenance, projects, contractors) are required to use can ensure everyone is working with the same information. Person H gave an example of striving for a common data environment and trying to get "everyone on the team" by collecting documentation in one place (Person H, p.5). Bridging the gap here means removing the practical barrier of scattered information – when data is centralized and up-to-date, using digital tools becomes far more effective (people trust the system and can rely on it). The strategy might involve standardizing processes: e.g., mandate that all project drawings and manuals are uploaded to the central FM system upon project completion (no more binders or personal stashes). Some participants have already instituted policies like refusing to accept handover data on old media (Person G, p.4), effectively forcing digital submission. This kind of enforcement is sometimes needed to bridge the last mile of adoption. Additionally, investing in integration tools or middleware can bridge disparate systems – for instance, linking the building automation system with the maintenance management system so that sensor alerts automatically generate work orders. A participant alluded to existing technology that could be leveraged in new ways (like using building management (SD) system data for occupancy) and wondered why a provider can't just help use that data for monitoring. Ultimately, improving data practices (accuracy, ownership, accessibility) builds confidence in digital tools, which encourages usage. As one person noted, "if it's all collected in one place... it's much easier for everyone", whereas if data is in disarray, people give up on the tech (Person H, p.4). So, cleaning up data environments is an enabling strategy that the participants felt was necessary to truly capitalize on digital capabilities.

5.5.7 Balancing New and Old – Hybrid Strategy

Finally, an interesting strategic point was acknowledging and planning for a hybrid situation where both cutting-edge technology and traditional methods co-exist. Given that many facilities have decades-old equipment and will continue to for the foreseeable future, participants advised a pragmatic approach: don't ignore the "old school" aspects even as you push forward digitally. One participant explicitly said in 30 years they will still have very old buildings to manage, and "that will require two different competences" – modern tech skills and traditional maintenance skills (Person F, p.44). (Person F, p.44). The strategy here is to integrate digital tools in a way that complements, rather than entirely replaces, existing practices where those are still effective. For example, you might use a digital twin for a new smart building but continue to use simpler checklists for a 100-year-old building that isn't instrumented – and manage both within your FM portfolio strategy. Over time, the old building might get retrofitted with sensors, but until then, the strategy is to apply the right level of technology to each context. This was implicitly suggested to avoid overextending tech where it doesn't fit and to ensure staff maintain the skills for legacy systems too. It's about bridging 2050 and today, as one participant humorously wished they could see an exercise in 2050 to reflect on what revolution happened (Person I, p.28). (Person I, p.28). Their cautious prediction was that things won't change as dramatically as tech enthusiasts predict, so a strategy is to be prepared for incremental change and a mix of old and new. Concretely, this might mean continuing to budget for conventional maintenance even as you invest in digital or keeping some paper backups while trust in digital builds. While everyone expects digital to grow, the participants don't want to be

caught with a gap in basic services because they pushed too fast. In essence, a "bridging" strategy is itself a gradual blend – bridging implies connecting two sides, and here the sides are the traditional FM world and the future digital FM world. Strategies that overlay digital enhancements on a strong foundation of FM domain knowledge (rather than trying to disrupt everything at once) were viewed as more sustainable.

Strategies to bridge the gap between digital potential and adoption in facility management			
Strategy	**Core Focus**	**Challenge Addressed**	**Example Actions**
1. Strategic Leadership Commitment	Organizational Alignment	Lack of direction, weak prioritization	Digital KPIs, roadmaps, budget for digitalization, executive support
2. Training & Competence Development	Human Capacity Building	Low digital skills, resistance due to uncertainty	Formal training programs, digital onboarding, super-user mentoring
3. User Engagement & Change Management	Cultural & Behavioural Change	Low buy-in, resistance to change	Pilot projects, feedback loops, "what's in it for me" communication, ambassadors
4. Phased Implementation	Tactical Deployment	Overwhelm, unrealistic goals	Start with high-impact/low-complexity areas, gradual rollout, quick wins
5. Collaboration with Tech Providers	External Support & Co-creation	Poor fit between tools and needs	Joint pilots, biweekly meetings, vendor-enabled training and customization
6. Data Integration & Governance	Technical Foundation	Fragmented systems, mistrust of data	Unified platforms, data mandates, automated data flows between tools
7. Hybrid Strategy (New + Old)	Pragmatism & Continuity	Mismatch between tech ambitions and existing reality	Apply tech where fit, maintain legacy knowledge, plan for long-term evolution

Table 3: Strategies to bridge the gap between digital potential and adoption in facility management

Bringing these strategies together, the workshop painted an actionable roadmap for closing the gap between technology's potential and its actual use in facility management. It starts with leadership setting the course and providing resources, follows through with equipping and motivating the people who will use the technology, and involves smart use of external help and phased technical integration. One participant summarized the ethos well: "the technology is there – it's about being willing to use it that way" (Person H, p.37). The strategies above are essentially about making the organization willing and able to use the technology to its full extent. By implementing these measures – strong leadership, skill development, user engagement, phased projects, partnerships, data integration, and a balanced approach – facility managers believe they can unlock much more of the value that digital transformation promises. This directly answers SQ4, as each strategy is geared toward taking the existing gap (between what could be done with digital tools and what is currently done) and systematically narrowing it, ensuring that by 2050 (or even 2030) the

FM industry isn't still "stuck on paper and USB sticks," but is operating closer to the cutting-edge possibilities available.

5.6 Summary

The qualitative analysis of the workshop transcript reveals a cohesive narrative about digital transformation in facility management. Facility managers recognize the immense potential of technologies like BIM, IoT sensors, and AI to revolutionize their work – offering efficiency, insight, and adaptability. They also face real-world challenges in harnessing that potential: organizational inertia, skill gaps, budget limits, and fragmented systems, to name a few. Participants see technology providers as both sources of innovation and essential collaborators who can tailor solutions to FM needs and support the change process. Crucially, the findings link back to the main research question by showing that facility managers perceive the future of digital transformation with cautious optimism: they are excited about benefits and fairly aware of risks, and they believe that with the right strategies – particularly those involving collaboration (with providers and across the industry) – they can significantly improve adoption and effectiveness of digital strategies in FM.

In relation to the sub-questions, the workshop insights can be summarized as follows: For SQ1, FM professionals have clear needs (more training, better data integration, leadership support) and encounter recurring challenges (resistance to change, lack of time/resources, complexity of tools) in adopting digital tech (Person H, p.7) (Person D, p.7). These explain why adoption has been slower than desired and highlight areas to address. For SQ2, they perceive substantial benefits (time savings, data-driven decisions, improved collaboration, cost and energy efficiency) which motivate their interest in digital transformation (Person F, p.27) (Person F, p.28), while also noting risks (upfront costs, data governance issues, privacy concerns, reliance pitfalls) that must be managed for success (Person G, p.42) (Person G, p.42). Regarding SQ3, technology providers play a pivotal role – when providers engage as partners (through pilot projects, responsive development, and training), they help shape and even accelerate the FM digital strategy (Person D, p.13), whereas a lack of engagement or overly closed solutions from providers can impede progress. FM teams value providers that focus on usability and continuous improvement, as these factors have directly influenced which tools they adopt (Person H, p.13). Finally, for SQ4, a multi-pronged strategy is advocated to bridge the gap between what technology can do and what is actually done. This includes top-down strategic initiatives, intensive upskilling, change management tactics, phased implementations, industry collaboration, and improving technical infrastructure like common data environments (Person H, p.4). All these strategies are justified by the challenges they solve: for instance, training addresses the competence bottleneck, and strategic leadership tackles the lack of direction and coordination.

Overall, the data tells a story of an industry in transition. Facility managers are not blindly adopting technology for its own sake; they are thoughtfully considering how each innovation fits into their context, and they are learning how to overcome the inertia of long-established practices. They envision a future where routine tasks are streamlined, buildings "talk" to them via sensors, and decisions are made on live data – but they also know that reaching that future requires dealing with human factors and collaborating across traditional boundaries. In essence, the workshop findings suggest that bridging the

gap between technology and practice in FM is as much about organizational change and people as it is about the tech itself. By addressing the identified needs and challenges with the strategies discussed, facility managers believe they can gradually unlock the full potential of digital transformation, leading to smarter, more proactive facility management that aligns with the fast-evolving digital landscape. The insights from this workshop provide practical guidance grounded in real experience, ensuring that the recommendations for digital transformation in FM are both ambitious and achievable.

6 Discussion

6.1 Challenges in Adopting Digital Technologies (SQ1)

The workshop findings revealed a range of fundamental challenges that facility managers face when adopting digital tools. These challenges, summarized in Table 1 of the results, include limited digital skills among staff, resistance to change in organizational culture, resource and budget constraints, fragmented data and system integration issues, suboptimal usability of FM software, and a lack of strategic alignment or leadership support for digital initiatives (Workshop Findings, Table 1). Taken together, these factors illustrate that the primary barriers are not the technologies per se, but the socio-technical context into which they must fit. In other words, even though advanced FM technologies (e.g. BIM, IoT platforms) are available, their impact is curtailed by human and organizational factors. This aligns with the socio-technical systems (STS) perspective, which holds that successful technology adoption requires concurrent adjustments in people, processes, and structures (Baxter and Sommerville, 2011). The data show a clear STS misalignment: for example, staff *skill gaps* and *unfamiliarity* with new systems mean that sophisticated tools like digital twins go underutilized because *"the biggest bottleneck is having competence among our people"* (Workshop Person H, p.7). Likewise, an ingrained culture of doing things "the way we've always done" leads to *resistance to change*, blunting the effect of new digital workflows. These observations underscore that technology acceptance in FM hinges on more than just the tool's capabilities – it critically depends on user readiness and organizational willingness to change.

From the lens of the Technology Acceptance Model (TAM), many of the identified challenges can be interpreted as factors that reduce perceived ease of use or perceived usefulness of the technology (Davis, 1989). For instance, complex and unintuitive software (poor *usability*) lowers *perceived ease of use*, making employees less inclined to embrace it. The workshop highlighted how a powerful FM system *"can be quite advanced and then the gap [to adoption] becomes larger"* – only when it is made more user-friendly does *"you narrow the gap"* to adoption (Person H, p.13). This resonates with TAM's premise that if a system is too hard to use, users will not accept it regardless of its potential utility. Similarly, *limited digital skills and training gaps* directly impede users' ability to find a system easy or worthwhile to use. In TAM terms, even if individuals perceive a new tool as useful in principle, a lack of competence can prevent that perception from translating into actual use. The findings therefore support TAM's emphasis on ease-of-use: facility managers perceive that without improving user competencies and simplifying the tools, adoption will remain low. At the same time, some challenges lie outside TAM's immediate scope. TAM focuses on individual users' attitudes, yet organizational factors like leadership support and strategic mandates emerged as crucial in the workshop. Participants stressed that *"it has to be decided by leadership… If not, we just carry on as before"* (Person G, p.42), pointing to the need for top-down direction. This reflects a limitation of TAM in isolation: it does not account for the influence of leadership and organizational culture on technology uptake. Here, broader frameworks like Innovation Diffusion Theory (IDT) complement the analysis by considering the social system and management context (Rogers, 2003). According to IDT, the diffusion of an innovation depends on factors such as the organization's readiness and the presence of champions. The workshop data align with this – a clear relative advantage of digitalization is recognized (e.g. long-term savings, efficiency), but adoption stalls without a supportive environment. In Rogers' terms, a lack of *compatibility* between

the innovation and the organization's practices (e.g. digital processes vs. a paper-based culture), as well as high *complexity* (perceived difficulty of use), will impede diffusion (Rogers, 2003). Indeed, the existence of data *silos* and integration problems indicates low compatibility of new systems with legacy systems and workflows, making the innovation harder to implement. As one manager lamented, contractors were *"still at the CD and USB stick level"* in data sharing (Person G, p.4), highlighting an incompatibility between modern FM data environments and old practices.

Another critical challenge is the gap between different stakeholders' knowledge and expectations, which can be viewed through the concept of epistemic boundaries. Recent research by Ghalandar et al. (2023), as well as Briding the gap research, emphasizes that digital transformation in FM is often hampered by gaps in understanding between groups – for example, between technology providers (developers) and FM practitioners, or between design/construction teams and operations. The workshop provided evidence of such gaps: FM professionals struggle to get complete and integrated information from construction contractors and external vendors, resulting in fragmented data and misunderstanding. This is essentially an epistemic boundary issue, where each party operates with its own knowledge systems and terminologies. One participant's struggle to have all project documentation in a *"common data environment"* illustrates how bridging this divide is difficult (Person G, p.4). From a theoretical standpoint, «industry digitalisation frameworks» or standards can function as *boundary objects* to bridge these knowledge boundaries (Ghalandar et al., 2023; Carlile, 2002). In practice, the lack of such shared frameworks in the current FM landscape is seen in the persistence of data silos and proprietary systems. The challenges identified – especially *data integration difficulties* and *lack of inter-organizational cooperation* – suggest that FM teams often operate without effective boundary objects to align disparate stakeholders. This partially explains the slow progress of digital innovation: even when individuals in FM are willing to use new tools, the broader network of actors (contractors, software vendors, IT departments) might not be aligned, impeding implementation.

In summary, SQ1 findings highlight that FM practitioners face a complex of human, cultural, and structural challenges in digitalization. These challenges underscore well-known tenets of adoption theory: *user ability and willingness* (TAM), *innovation–organization fit* (IDT's compatibility), and *socio-technical alignment* (STS). The empirical data diverge from purely technology-centric views by showing that the «bottleneck is mainly organizational» – as one participant put it, the technology itself is often "genial" or capable, but *people and processes* are the limiting factors. This necessitates a holistic approach to adoption, a point that becomes even clearer when considering the opportunities and strategies discussed next.

6.2 Perceived Opportunities and Benefits of Digitalisation (SQ2)

Despite the hurdles above, facility managers in the workshop clearly perceived significant opportunities and benefits from digitalisation in FM. As summarized in Table 2, participants identified a suite of anticipated advantages: improved efficiency and time savings in operations, enhanced data-driven decision-making, better collaboration and communication, long-term cost savings and sustainability gains, and an overall boost to

innovation and future readiness in their organizations (Workshop Findings, Table 2 – *Identified Benefits and Risks of Digitalisation*). These benefits align closely with core goals in FM and provide strong motivation to pursue digital tools. Notably, every benefit corresponds to a key value driver in facilities management: for example, operational efficiency (through automation of routine tasks and quicker access to information), informed decision-making (using sensor data and analytics for proactive maintenance and space management), and collaborative working (via shared digital platforms that connect stakeholders). One participant described how a digital twin platform let the team work *"easier and better in a shorter time"* by providing instant access to information (Person D, p.29), illustrating the efficiency and collaboration advantages. Others highlighted energy savings and optimized space use (e.g. consolidating underutilized areas) as long-term financial benefits, tying digitalisation to sustainability and cost-effectiveness. In short, the FM practitioners see digital technology as a means to transform their role from reactive maintenance to proactive, evidence-based management, which they believe will *"add value over the building lifecycle"* (Workshop Person F, p.44).

These perceived benefits strongly reinforce the relative advantage of digital innovations, which IDT identifies as a key factor in adoption (Rogers, 2003). The fact that managers can articulate clear advantages – faster workflows, data-informed decisions, etc. – means the *perceived usefulness* (in TAM terms) of these technologies is high. Indeed, TAM would predict a positive attitude toward adoption given such high perceived usefulness (Davis, 1989). The workshop evidence confirms that *usefulness* is not in doubt: participants repeatedly affirmed that digital tools are valuable and even necessary for the future of FM. This alignment between empirical perceptions and theory is encouraging; it suggests that the fundamental value proposition of digital FM is recognized by practitioners, which is a prerequisite for acceptance. For example, efficiency gains were a dominant theme (every participant could cite a scenario where technology saves time or effort), reflecting a strong perceived usefulness that should, according to TAM, drive willingness to use the systems. Likewise, improved decision-making via better data (e.g. using occupancy statistics to optimize space) corresponds to a clear *relative advantage* over traditional guesswork, which should accelerate diffusion in Rogers' model. In theory, such advantages can create a pull for the innovation – people *want* the benefits, so they are motivated to adopt the tools.

However, the discussion also tempered this optimism with a candid look at perceived risks and concerns that come alongside the benefits (Table 2, "Perceived Concerns"). Practitioners acknowledged several risks: high upfront costs and uncertain ROI, data reliability and ownership issues, privacy and surveillance worries, dependence on technology and reliability of systems, and change management challenges for the workforce. This balanced view – enthusiasm for benefits, but caution about risks – is critical in understanding FM practitioners' approach to adoption. In many cases, the risks are essentially the *flip side* of the benefits. For instance, while digital systems promise long-term cost savings, there is the *upfront cost* risk of investing in new technology without guarantee of payoff. One manager noted that even if digital tools yield *"huge savings in the long run,"* it's hard to get approval because *"in the short term it's a cost"* (Person G, p.6). This reflects a common scenario in innovation adoption where short-term barriers can overshadow long-term relative advantage. In diffusion theory terms, this is a challenge of *initial trialability and observability* – decision-makers want to see proven results or low-cost trials before fully committing, otherwise the perceived uncertainty stalls the decision (Rogers, 2003). The workshop participants explicitly mentioned this catch-22: procurement rules can prevent trying a system before buying, yet without trying, its value remains unproven (Person G, p.5). Such structural inhibitors contribute to the *lag* between technology potential and actual use.

Other risks highlight areas where theory and practice intersect less perfectly. Data reliability and ownership concerns speak to issues of trust and governance that are not explicitly covered in TAM or basic IDT factors. Participants worry *who will ensure data is*

correct and up to date, and *"who owns it… how can we work across companies with it?"* (Person B, p.8, 39). These concerns indicate that *compatibility* in Rogers' sense is not only technical but also organizational – the innovation must fit within legal, ethical, and procedural norms. If FM teams fear that a digital system will create data ambiguity or inter-company conflicts (e.g. over intellectual property of a BIM model), this incompatibility with their operating environment will slow adoption. Additionally, privacy and surveillance issues were raised, particularly when technologies could be perceived as monitoring individuals (Person D, p.15). This ties into *social acceptability*: even if a tool is useful to FM, it might face pushback from employees or regulators if it intrudes on privacy. In diffusion theory, this might be seen as a negative aspect of *observability* – people become aware of the innovation's presence in a contentious way – or a question of *value compatibility* (the innovation conflicts with societal values on privacy). For example, using phones to track staff location was immediately flagged as *"not well received"* (Person D, p.15), showing a clear social boundary that FM tech should not cross.

These risk perceptions show that user acceptance is contingent on more than just usefulness. TAM's original constructs (usefulness and ease of use) might not fully predict adoption in cases where trust, security, and ethics are front-of-mind. The workshop data align with extensions of TAM that include factors like perceived risk and privacy concerns (e.g. in some TAM research for sensitive technologies, security and privacy significantly affect acceptance (Alsyouf et al., 2023)). Here, FM practitioners are implicitly weighing *perceived usefulness* against *perceived risk*. The result is a cautious approach: they *"seek to maximize the upsides while mitigating the downsides."* This balanced mindset is consistent with a socio-technical view of adoption – recognizing that the technology's success depends on addressing human and organizational fears, not just on technical capability. It also reflects an understanding that the introduction of technology is a *change process*, implicating change management theories. Indeed, one risk explicitly noted was the challenge of change management and workforce adaptation. Even though job loss was not seen as an imminent threat (no participant believed digitalisation would replace FM staff wholesale), they did point out the risk of alienating certain employees or creating a skill divide (Person G, p.41). This underscores that change fatigue or employee pushback can derail implementation, regardless of the technology's merits. In theoretical terms, this speaks to the importance of *user involvement and social influence* – concepts found in models like UTAUT (Unified Theory of Acceptance and Use of Technology) which extend TAM by including social and facilitating conditions (Venkatesh et al., 2003). Our empirical findings support those broader models: for digital tools to be embraced, the social system (peers, bosses, company culture) must encourage it, and users must feel capable and supported.

In summary, SQ2 showed that facility managers have a nuanced view: digital transformation is seen as both highly advantageous and necessarily careful. There is strong alignment with theoretical expectations on the advantages side – efficiency, better decision-making, and collaboration are classic hallmarks of IT value and clearly constitute the *perceived usefulness/relative advantage* driving interest in adoption. At the same time, the concerns they voiced highlight areas where practical realities impose constraints not fully explained by basic adoption models. The divergence lies in the "yes, but…": Yes, the tools are useful and even needed, *but* will they pay off financially? *But* can we trust the data? *But* will people actually use them correctly? These are the questions practitioners raise, and they set the stage for the next parts of the discussion: the role of technology providers (who often are key to addressing issues like usability, training, and support) and the strategies that can bridge the gap between the technology's potential and the day-to-day practice in FM.

6.3 Role of Technology Providers in Digital FM (SQ3)

The workshop discussion made it evident that technology providers (vendors of FM software, digital twin platforms, IoT systems, etc.) play a pivotal role in how digital strategies are shaped and implemented in facility management. Participants described interactions with providers that ranged from highly collaborative partnerships to more distant, transactional relationships. Overall, the consensus was that when providers act as *partners* – engaging closely with FM teams to tailor and support the technology – the adoption and value of digital tools improve markedly. Conversely, if providers simply "drop off" a product or push sales without understanding FM needs, the burden falls on the FM organization to make the technology work, often leading to underutilization. In essence, technology providers can either bridge or widen the gap between technology potential and practice.

One major theme was co-innovation and partnership. Several participants shared positive experiences where providers worked hand-in-hand with their team. For example, one FM team piloting a new FM platform had *"regular meetings every 14 days"* with the vendor to test features and give feedback, which the provider then used to refine the product (Person D, p.13). This iterative, two-way exchange meant the software evolved in line with the users' needs, and the users, in turn, learned the system deeply. The participant noted *"it works really well"* when the provider is responsive and collaborative, suggesting that the technology became better aligned to their workflows and hence easier to adopt. This case echoes a core idea from socio-technical systems theory: involving end-users in the design and refinement of technology leads to a better fit between the tool and the social context (Baxter and Sommerville, 2011). It also maps to Rogers' (2003) diffusion principle of using change agents – individuals or entities (often external experts or vendors) who actively facilitate adoption by working with users. In this scenario, the provider acted as a change agent, helping the innovation diffuse by reducing complexity (through training and tweaks) and increasing compatibility (adapting the tool to the organization's processes).

Participants contrasted this ideal with less favorable interactions. In some cases, a new system might be procured top-down, and then the vendor has to *"try to convince you to use it"* after delivery (Person E, p.43). Such a *push approach* was seen as problematic: FM staff become passive recipients rather than active shapers of the solution. The group expressed a preference for a *pull approach*, where the demand comes from FM practitioners themselves, who *seek out* technology and engage vendors proactively (Person H, p.7). This ensures the chosen solutions are needs-driven. The theoretical implication here is that user engagement in the innovation-decision process is crucial; when FM organizations drive the process, they likely select technologies with higher perceived compatibility and usefulness for their context, rather than being sold on hype. It also highlights the importance of knowledge transfer: often FM professionals are not aware of the latest possibilities until vendors introduce them. But if that introduction is purely sales-oriented, it may not succeed – it must be coupled with education and genuine dialogue. This aligns with Innovation Diffusion Theory in that the communication channel matters: interpersonal, trust-based communication (like a collaborative pilot) is more effective in persuasion than one-way advertising or sales pitches (Rogers, 2003). Our findings thus suggest that technology providers should act less like traditional vendors and more like consultants or partners that guide FM teams through new technology – effectively taking on a facilitative role in the social system of the organization.

Another aspect raised was how providers influence the features, usability, and integration of technology, thereby indirectly steering digital strategy. Participants observed that the market offerings from providers often determine what gets adopted. For example, one noted that *user-friendly solutions win adoption*: CAFM/CMMS - 2 became widely used in their circle because the provider invested in development and usability, whereas a more complex legacy system (IWMS/CAFM - 1) saw slower uptake (Person H, p.13). This

example underscores a point that is also reflected in TAM: if a provider delivers a system high in *perceived ease of use*, it will likely enjoy more success. In practice, FM managers gravitate towards tools that their staff can actually use with minimal friction. So the onus is partly on providers to heed usability (which, in TAM terms, drives acceptance). Indeed, the participant's comment that the best system had "more developers than salespeople" (Person H, p.13) implies that a provider focused on product improvement (meeting user needs) was more valued than one focused on aggressive marketing. This is a practical insight but also a theoretical reminder: models like TAM assume a given technology's characteristics influence adoption; here we see those characteristics are not fixed – they are shaped by provider behavior post-launch. Providers who continuously improve functionality and compatibility (e.g. through software updates, listening to feedback) are effectively *increasing the innovation's relative advantage and reducing its complexity over time*, thus encouraging diffusion. On the other hand, providers that do not facilitate *integration* (by keeping systems closed or data locked-in) create frustration. The workshop echoed this in calls for open APIs and data standards. One participant questioned whether by 2050 the "digital twin will be more open" and noted advantages to being more open (Person B, p.39). This reflects an expectation that providers contribute to breaking down data silos – a theme from SQ1 – by enabling interoperability. Ghalandar et al. (2023) discuss such *boundary-spanning frameworks* as key to innovation: if providers adopt common standards (turning their technology into a *boundary object* that various stakeholders can use), it helps align different domains (e.g. construction, IT, FM) and spreads the technology more smoothly across epistemic boundaries. Our findings concur: FM practitioners want providers to help unify the ecosystem (e.g. support a common data environment approach, Person H, p.5) rather than each provider creating an isolated island of data. When providers collaborate (with each other and with clients) to ensure systems can "talk to each other," they effectively foster a larger network effect for adoption. Conversely, if each vendor pushes their proprietary system without regard to integration, facility managers may resist adopting new tools out of fear of creating more silos or being "locked in." This dynamic is well-recognized in IT adoption literature: interoperability and vendor lock-in concerns influence the *adoption decision* (compatibility and risk considerations).

Crucially, the workshop highlighted that providers also shape user readiness through training and support. Participants valued vendors who provided immediate help and iterative training during implementation. For instance, in the (digital twin company) pilot, the vendor answering questions "then and there" (Person D, p.13) accelerated learning and built user confidence.

In our case, some FM staff didn't even know certain digital tools existed until introduced by a knowledgeable friend or vendor (Person H, p.37). That suggests providers also need to raise awareness (tackling the *knowledge stage* of diffusion). Once aware, users then need the *ability* to use the system – again something a provider can impart via training. These observations align with theory that beyond the individual attitude (TAM) and innovation attributes (IDT), the presence of support greatly influences actual usage. If a technology is delivered without instruction, the *knowledge barrier* may stall adoption; if delivered with comprehensive support, the organization can more quickly progress to effective use. The empirical data align with socio-technical recommendations that technology introduction should be accompanied by social system changes (training, new roles like "super-users") which often require input from the technology experts (here, the vendors).

In terms of alignment or divergence with theoretical perspectives, the role of providers is a reminder that technology adoption is an interplay between supply and demand. Classic TAM and IDT treat the innovation somewhat as a given object whose characteristics drive adoption, and focus on the adopter's side. Our findings emphasize the supply side agency: providers can modify the innovation and the context. This is where boundary spanning comes in as an analytical lens. Ghalandar et al. (2023) argue that industry-wide

digitalisation frameworks (often initiated or supported by technology providers and industry bodies) serve to align understanding between different groups. In the workshop, the instances of successful provider partnerships are effectively ad-hoc versions of this – by closely working together, the FM team and the vendor created a shared understanding of how the technology fits the FM practice. That shared understanding is what bridges the epistemic gap between "what the tech can do" (known to the provider) and "what the FM team needs/does" (known to the practitioners). When this bridge is built, digital strategies become much more coherent and actionable. One could say that the theoretical implication here is that models of technology acceptance in FM should explicitly factor in the collaboration with providers as a variable. Our empirical evidence strongly supports a co-development model: the best outcomes arose when FM practitioners did not adopt technology in isolation, but rather in conjunction with provider involvement. This finding is consistent with broader literature on innovation which highlights co-creation and stakeholder engagement as success factors (Von Hippel, 2005; Schmitter et al., 2024 in AEC industry context). It also echoes Wu et al. (2014)'s observation that lack of mutual understanding between tech providers and users is a barrier – our participants essentially found ways around that by investing in mutual understanding.

In summary, to answer SQ3, technology providers in the FM domain serve not just as vendors but as critical enablers (or impediments) of digital transformation. Providers shape the trajectory of adoption by:

(1) Co-innovating with users, which enhances the technology's fit and user buy-in

(2) Determining the usability and capabilities of the tools (better-designed products like the ones "with more developers than salespeople" naturally integrate into strategies more than clunky tools do)

(3) Providing training and support, thereby building user competence and confidence

(4) Influencing data integration and standards, which can either alleviate or exacerbate the data silo issues

The workshop evidence aligns with the view that effective digital transformation is a joint effort – FM practitioners and technology firms must form a partnership. Where such partnerships exist, the gap between technology potential and practice narrows, as both sides work towards a common solution. Where they do not, even a promising technology may languish due to poor implementation and lack of understanding. This insight directly feeds into the strategies for bridging the adoption gap (SQ4), as many of those strategies involve leveraging provider relationships and improving internal-external collaboration.

6.4 Strategies to Bridge the Gap Between Technology Potential and Practice (SQ4)

Given the challenges (SQ1) and the dual perspectives of benefits vs. risks (SQ2), and recognizing the role of supportive providers (SQ3), the workshop participants converged on several strategies to bridge the gap between the high potential of digital technologies and the slower reality of their adoption in FM. This "gap" – often described by participants as the difference between what the technology *could* do and what is *actually* being done with it – was addressed through a variety of pragmatic solutions. Table 3 in the results chapter outlines these key strategies alongside the challenges they target, serving as a roadmap for digital transformation in practice. The strategies can be categorized into organizational initiatives, human capital development, process and implementation tactics, and collaborative efforts. Each is discussed below with reflections on how they align with or add to existing theory.

1. Strengthen Leadership and Strategic Commitment. A clear consensus was that bridging the gap starts at the top: organizations need strong leadership commitment to digital transformation. Participants argued that digital initiatives must be anchored in the FM strategy and championed by senior management. This means executives should set a vision (e.g. a *digital FM roadmap*), allocate dedicated resources, and create policies that encourage or mandate the use of digital tools. The reasoning is straightforward – without top-down prioritization, efforts remain ad-hoc and easily abandoned. In the workshop, instances were cited where lack of managerial focus led teams to *"carry on as before"* despite new systems being available (Person G, p.42). By contrast, if leaders "light the spark" and integrate digital goals into business objectives, it legitimizes the change and motivates everyone to participate. This strategy directly addresses challenges of *lack of strategic alignment and leadership support* identified under SQ1. It also resonates strongly with change management theory (Kotter, 1996) which places "establishing a sense of urgency" and "creating a guiding coalition" at the forefront of transformation. In diffusion terms, top management can serve as champions/opinion leaders whose advocacy influences the rest of the organization (Rogers, 2003). Theoretically, this highlights an area outside of TAM's individual focus: organizational adoption requires leadership intervention to create an environment where individual acceptance can scale up. The implication is that no matter how user-friendly a technology is, if leadership does not endorse its use or provide time and budget for it, widespread adoption is unlikely. The workshop's call for leadership-driven *"competence lifts"* (training programs) and explicit digital KPIs in performance plans underscores a strategic approach – making digital competence and usage an expected part of FM roles. This strategy aligns with STS thinking as well, ensuring the *organizational structure* and *culture* (the social system) are realigned to accommodate the technical change.

2. Invest in Training and Competence Development. Nearly all participants agreed that upskilling the workforce is vital. This strategy tackles the *human capital* side of the gap: turning the current skills deficit into a strength. In practice, it means implementing comprehensive training programs, continuous education, and knowledge-sharing initiatives around digital tools. Participants suggested formalizing digital training akin to mandatory safety training – ensuring every FM employee attains a baseline proficiency in key systems (Person G, p.7; Person D, p.7). Some even argued for making digital skills a hiring requirement or condition ("you must know this, otherwise you can't work here") to underscore its importance (Person G, p.41). The idea of establishing "digital champions" or super-users within the team also came up: identify tech-savvy individuals to mentor others and lead by example. This approach creates internal support networks and spreads expertise organically. By emphasizing training, the strategy addresses directly the *limited digital skills* challenge and also reduces *resistance to change* (since people often resist what they find confusing or intimidating). From a TAM perspective, this is about increasing

users' *perceived ease of use* by actually increasing their ability to use the systems, thereby improving their confidence and reducing anxiety. It also likely enhances *perceived usefulness* as users who understand a system better can appreciate its capabilities more. In Rogers' diffusion model, this corresponds to moving potential adopters through the knowledge stage to persuasion – education reduces uncertainty and builds a favorable attitude. There is theoretical and empirical support for this strategy: technology adoption research identifies user training as a critical success factor (Chen and Popovich, 2003). Our findings reinforce that view in the FM context. The nuance added here is that training should be ongoing and proactive. Digital tech evolves rapidly, so a one-time training is not enough; a culture of continuous learning is needed. This mirrors the concept of the "learning organization" in management theory, suggesting FM departments should continuously update competencies as new features or systems emerge. By doing so, they ensure the workforce keeps pace with technology – effectively shrinking the gap from the human side. In terms of STS, investing in people is half of the socio-technical equation; it brings the social system (skills, practices) in line with the technical system.

3. Enhance User Engagement and Change Management. Beyond formal training, participants highlighted the importance of *actively engaging end-users* in the change process. This strategy is about winning hearts and minds – not just improving skills, but also improving willingness. Tactically, it involves involving staff in pilot projects, gathering their feedback, and visibly incorporating their suggestions (as was done in the CAFM/CMMS - 2 pilot). By participating in pilots, users feel ownership of the new tool, and success stories from these early adopters can be showcased to the wider team. This leverages peer influence: technicians or managers are more likely to embrace a new system when colleagues they trust advocate for it with real examples. Participants also stressed communicating the "what's in it for me" to users (Person G, p.12). This means translating the high-level benefits of digitalisation into day-to-day improvements for staff – for example, showing a maintenance technician that logging issues in a digital app will *save them time* on paperwork or make information retrieval easier. By demonstrating quick wins and personal benefits, management can reduce psychological resistance. This approach reflects principles from change management and motivation theory – people need to see value for themselves and feel part of the change to truly adopt it. The workshop discussion on using data to counter skepticism is a good illustration: one manager used occupancy data to show that a room was underused 40% of the time, making a compelling factual case to support a space optimisation change (Person F, p.27). Transparent communication of such data can help overcome the *"we've always done it this way"* mindset by grounding decisions in evidence rather than authority. In theoretical terms, this strategy addresses the *social influence* aspect of adoption. By having leaders and early adopters champion the technology (social proof) and by normalizing the use of the tool as "part of the job," it creates a new social norm. It's effectively shaping the organizational culture to be more accepting of digital tools – a change in shared mindset that STS would view as adjusting the social subsystem. Importantly, engaged users become partners in the implementation, which again mirrors an STS recommendation: involve users in system design and implementation to ensure their needs and concerns are met (Baxter and Sommerville, 2011). Our findings concur – user engagement is not just nice-to-have, it directly mitigates resistance and increases *system usage*, thus bridging the gap from the ground up.

4. Phased Implementation and Prioritization. Another strategy is to avoid trying to "do it all at once." Participants advocated rolling out digital innovations in manageable phases, targeting areas with clear benefit first to build momentum. This incremental approach addresses practical constraints like limited budgets and change saturation. By prioritizing high-impact, low-complexity projects (the "low-hanging fruit"), FM teams can generate quick wins and learn lessons before scaling further. For example, one organization began simply by moving documentation to the cloud (Person H, p.7) – a relatively straightforward step that acclimated staff to digital workflows. After success there, they could tackle more complex tools like sensor integration or AI. This approach aligns with Rogers' notion of trialability: the ability to experiment with an innovation on a small scale reduces the risk

and allows observable results, which in turn aids adoption (Rogers, 2003). Each phased project acts as a trial that, if successful, can be used to persuade stakeholders of the next project (leveraging observability of results). Moreover, phasing addresses the *resource constraint* challenge by spreading investment and effort over time. It is also reminiscent of agile implementation methodologies, which advocate iterative development and deployment. By not overloading the organization with change, phased implementation respects the capacity of the social system to absorb new technology – a consideration strongly advised by STS and change management literature. The participants' insight that *overwhelm* and *"initiative fatigue"* are real risks (Person D, p.13; Person G, p.41) shows a keen understanding of human limits. The phased strategy mitigates this by ensuring each step is digestible. Theoretically, this strategy does not conflict with TAM or IDT; rather it provides a practical pathway to improve the key factors in those models over time. For instance, by phasing, you might first implement a tool in a context where its *relative advantage* is very obvious and *compatibility* is high, thus ensuring a positive outcome that makes later, more challenging implementations easier (because people have seen it work and perhaps the technology has improved by then too). It's notable that participants expect digital transformation to be a gradual evolution – one even doubted a "total revolution" by 2050 (Person D, p.29), implying change will be incremental. Embracing that reality is strategic: it means planning for steady progress rather than magical overnight change. This measured approach is likely to bridge the gap more sustainably than any big-bang overhaul that could fail due to shock or missteps.

5. Collaboration with Technology Providers and External Experts. Building on the insights from SQ3, a key set of strategies involve actively leveraging external partnerships. Rather than seeing technology providers as mere suppliers, FM practitioners suggested formalizing partnerships – for instance, establishing joint pilot programs (like the CAFM/CMMS - 2 case) or even innovation labs where vendors and FM staff co-create solutions. By bringing providers into the fold, organizations can ensure better training, customization, and continuous improvement support, effectively extending their internal team with external expertise. This strategy directly addresses the *"poor fit between tools and needs"* issue: close collaboration means the tool is adapted to needs, and needs might even adapt to new possibilities of the tool in a constructive cycle. Additionally, participants noted the value of peer networks and industry collaboration. They questioned whether there will be more collaboration among facility owners in the future (Person E, p.43), hinting at existing forums like the "Eiendomsnettverket" (Property Network) where FM professionals share experiences. Tapping into such networks is a strategy to accelerate learning – if one organization has found a solution to a common challenge (say, effective use of a digital twin for maintenance), others can adopt that insight rather than reinventing the wheel. This collective learning is essentially an *industry-level diffusion process*, where innovations spread not just within one organization but across many via interpersonal channels (Rogers, 2003). The workshop recognized that while day-to-day pressures make collaboration difficult ("no one has time to think about it," Person D, p.8), the effort to collaborate can pay off by pooling knowledge. In theoretical terms, this speaks to boundary spanning once more – bridging boundaries not only between FM and providers, but also between separate FM organizations. Ghalandar et al. (2023) suggest that future-oriented frameworks and cross-boundary collaboration help make innovations "contagious" across the FM community. The idea of jointly developing standards or sharing best practices is exactly such a framework in action. By engaging with external experts (consultants, industry groups), FM teams can overcome internal limits. For example, if internal staff are too busy to set up a new system, hiring a consultant to do the initial configuration and training can jump-start the process (a tactic mentioned in passing by participants). The strategy here is recognizing that digital transformation is not a solo journey – seeking help and sharing experiences can bridge gaps faster. This aligns with open innovation concepts in theory, where organizations improve innovation outcomes by opening up to external ideas and expertise (Chesbrough, 2003). For FM, an often conservative field, this represents a shift to a more collaborative mindset, but the workshop findings show practitioners see value in it.

6. Improve System Integration and Data Practices. On the technical side, participants emphasized the importance of fixing data fragmentation. A strategy repeatedly mentioned was establishing a single source of truth for facility data – for example, mandating use of a centralized database or common data environment for all facility information. This means enforcing standards such that all contractors, projects, and departments contribute to and draw from the same digital repository (no more information hiding in email attachments or personal drives). Some organizations had already taken steps like *refusing to accept handover data on paper or USB – requiring digital uploads instead* (Person G, p.4). Such policy changes are strategic moves to eliminate *data silos*. Additionally, investing in integration middleware or interfaces between systems is part of this strategy: for instance, linking the building automation (BMS) system with the maintenance management system so that IoT sensor alerts automatically generate work orders. By integrating, the technology's usefulness multiplies (data flows seamlessly), and users don't have to manually bridge gaps between tools. This strategy addresses the *data silos and interoperability* challenge directly. In doing so, it also alleviates user frustration (which can cause disengagement). From a theoretical lens, improving integration increases the compatibility of the new technology with existing processes (Rogers, 2003). It makes the innovation feel like a natural extension of current work rather than a disruptive force that doesn't fit. It also can enhance *perceived usefulness*: if all data is in one place and reliable, the system is far more valuable to the user. Moreover, pursuing data governance and quality (assigning responsibility to keep data updated, as participants discussed) increases trust in the system, which is crucial for sustained use. This strategy has parallels with the concept of technical infrastructure readiness in IT adoption frameworks (Tornatzky and Fleischer's TOE framework, for example, highlights the need for adequate IT infrastructure). It also connects back to epistemic boundary spanning – by standardizing data and definitions across different contributors (e.g. builders, FM operators), it creates a shared language and reference that everyone can work with, essentially serving as a *boundary object* (Carlile, 2002; Ghalandar et al., 2023). Our findings indicate that when FM teams enforced or advocated for integration (even something as simple as teaching contractors to upload to a portal), over time it yielded benefits in usability of information. Thus, a practical implication is that FM leaders might need to be assertive in requiring digital data practices from all partners. While challenging, this is a strategic effort to *future-proof* the digital transformation – it ensures that as more technology comes in, it builds on a solid, connected data foundation rather than adding to chaos.

7. Embrace a Hybrid Approach (Balance New and Old). An insightful strategy that emerged is acknowledging the need for a hybrid operations strategy during the long transition to fully digital FM. Participants noted that many facilities still have very old assets and will continue to do so for decades. Thus, an FM organization must manage both cutting-edge smart buildings and century-old buildings simultaneously. The strategy is to apply technology where it makes sense, but not force it everywhere all at once. For example, use IoT sensors and digital twins in newer buildings that can support them, while continuing to use traditional methods (routine inspections, paper checklists or simpler digital tools) in older facilities until they can be upgraded. This hybrid approach ensures that the push for digitalisation does not compromise basic services in contexts where it is not (yet) feasible. It also prevents alienating staff who may be very capable with traditional methods needed for older infrastructure. In essence, it's a strategy of *gradual retrofit* and *context-appropriate technology*. This acknowledges a potential compatibility issue in adoption – not all parts of the organization are equally ready or suitable for the latest technology – and deals with it by segmenting the implementation. Theoretically, this aligns with the idea of reinvention in diffusion (allowing the innovation to be adapted to local conditions) and with change management advice to not ignore "legacy" processes that still work. It's also an instantiation of STS thinking: do not neglect the *work system requirements*. Some tasks might still be best done analog or with older tech until the environment changes. By planning for co-existence of old and new, FM organizations can avoid gaps in capability. Participants implicitly advocated this when they noted that by 2050 they expect significant progress but not a complete revolution, implying that strategies must be sustainable over

a long period of mixed technologies (Person I, p.28). This pragmatic approach diverges a bit from the more idealistic tone of some digital transformation narratives that assume a clean sweep of innovation. It is a reminder from practice that *incremental change and continuity* of service are paramount. The hybrid strategy ensures that digital transformation adds value steadily without undermining reliability. It bridges the gap by pulling the organization forward while keeping one foot on solid ground. For theoretical frameworks, this suggests that adoption is not binary (adopt vs. not adopt) but can be partial and staged across different operational areas – something that is increasingly recognized in literature through concepts like partial adoption or staged maturity models.

In summary, the strategies identified in SQ4 form a comprehensive plan to close the gap between technology's promise and its reality in FM. They span from top-level organizational change (leadership commitment) down to technical fixes (system integration), covering the socio-technical spectrum. This comprehensive approach is exactly what theory would prescribe for a complex innovation like digital transformation. Table 3 (Strategies to bridge the gap) in the results shows how each strategy maps to specific challenges, illustrating a tight coupling between understanding the problem and addressing it. Importantly, these strategies are interdependent: leadership support enables training programs; training and engagement produce feedback that can guide phased implementation; provider collaboration can support both training and integration, and so on. This holistic, *systemic approach* is a hallmark of the STS perspective – treating the organization and its technology and people as a unified system to be optimized in tandem. From a TAM/IDT standpoint, the strategies collectively improve the input conditions for adoption: increasing perceived usefulness (through leadership messaging of importance and through demonstrable wins), increasing ease of use (through training and better design via provider input), ensuring social acceptance (through change management and leadership example), and reducing risks (through phased investment and integration planning). They also incorporate boundary spanning by involving external parties and aligning cross-domain data, which goes beyond traditional adoption models and into emerging theory (Ghalandar et al., 2023) that emphasises shared frameworks and knowledge integration. In essence, the FM practitioners in the study are advocating a multi-level change program – not just deploying a tool, but reshaping their strategy, culture, skills, processes, and partnerships to truly realize the technology's potential. This is the critical bridge to ensure that by the time we reach the future (e.g. 2030 or 2050), FM is not "stuck on paper and USB sticks" but is leveraging digital tools as fully as the early visionaries hoped.

6.5 Theoretical Implications

This study's findings carry several implications for adoption theory and the analytical frameworks used (TAM, IDT, STS, and the concept of epistemic boundaries). First, the results affirm the relevance of TAM and IDT in the FM digitalisation context but also highlight their limitations when used alone. TAM's core constructs – perceived usefulness and ease of use – were clearly evidenced: FM practitioners do adopt and champion technologies when they see tangible usefulness (e.g. efficiency gains) and when the tools are user-friendly (or sufficient training is provided to handle complexity). Perceived usefulness was high among our participants, which is a positive indicator for acceptance. However, many barriers observed (leadership, culture, inter-organizational issues) are exogenous to TAM. This suggests that individual-level acceptance models need to be situated within a broader organizational context to fully explain outcomes in FM. The data diverged from what TAM alone would predict in scenarios where, despite high usefulness, adoption stalled due to organizational inertia or lack of support. This implies that complementary models or extensions may be necessary to apply in FM research. The theoretical implication is that future FM technology adoption studies should use TAM as

just one layer of analysis, embedded in a larger framework that accounts for organizational readiness and interdependencies.

Innovation Diffusion Theory (IDT) proved useful for interpreting macro factors – for example, compatibility issues (like data standards) and the importance of trialability (pilots) and observability (sharing success stories) came out strongly. The innovation attributes defined by Rogers (2003) were largely validated: participants discussed relative advantage (benefits), complexity (usability issues), and compatibility (fit with existing systems and values) extensively. They also indirectly pointed to the need for better communication channels (through training and peer networks) and the role of champions (through leadership). A theoretical insight here is that diffusion in FM might require more deliberate intervention than in some other domains because facilities management has historically been conservative and fragmented. The study suggests that traditional diffusion can be accelerated by consciously applying these principles (e.g. structuring projects to maximize trialability and early wins). Moreover, FM innovations often span organizational boundaries (construction to operations, multiple vendors), which means diffusion is not contained within one organization. This reinforces the importance of networks and inter-organizational diffusion, which Rogers' theory does consider (diffusion in social networks), but which might need extra emphasis in FM. For instance, an FM department trying a new technology might influence other departments or peer organizations if knowledge is shared – our findings support creating venues for that. The notion of epistemic boundaries (from Ghalandar et al., 2023) adds to IDT by explaining why diffusion can stall at organizational boundaries: knowledge doesn't transfer automatically across domains. Thus, a theoretical implication is that diffusion in the FM sector benefits from boundary objects and cross-domain communication – integrating Ghalandar's boundary-spanning view with Rogers' diffusion provides a more complete picture.

The findings strongly support a Socio-Technical Systems (STS) view as a guiding paradigm for digital transformation. Virtually all critical issues identified were socio-technical in nature – requiring changes in the social system (skills, culture, structure) to harness the technical system's capabilities. The success stories were those where both technology and the organization co-evolved (e.g. co-development with providers, training alongside implementation, process changes to match new tools). This underscores an important theoretical point: technology adoption in FM is not just an IT matter, but an organizational change matter. STS theory (e.g. Baxter and Sommerville, 2011) would predict that interventions must target both domains, and indeed the strategies workshop participants suggested do exactly that. This alignment lends weight to using STS frameworks in FM research and practice. For scholars, it suggests that evaluating a digital FM initiative solely on technical merits or user attitudes is incomplete – one must assess alignment between processes, people, and technology. Our study contributes empirical evidence that when such alignment is low (skills lacking, culture resistant), adoption flounders, but when alignment is deliberately improved (training, change management, process integration), adoption accelerates. It also highlights the need to consider organizational culture and leadership within STS. Ghalandar et al. (2023) specifically mention "technological culture" and inter-organizational collaboration as factors; our data concurs and gives concrete examples of culture (the "old guard" vs. new mindset conflict) and the necessity of collaboration (with IT, with vendors).

As discussed by Ghalandar et al. (2023), drawing on the well-established concept of epistemic knowledge boundaries is well illustrated by our findings and provides a valuable analytical lens that complements user-centered models like TAM. We saw that many challenges and strategies involve bridging gaps between different knowledge domains: e.g. architects/contractors and facility managers, or software developers and end-users. These gaps can hinder adoption even if individual acceptance is there (for example, an FM team might be willing to use a digital twin, but if the construction team doesn't provide the data or uses a different system, the initiative falters). By viewing the digitalisation framework itself as a *boundary object* (as Ghalandar et al. suggest), we can theorize that establishing shared tools, standards, or models (like a standardized BIM handover process) helps align these disparate groups. Our findings imply that treating something like a "digital twin roadmap" as a common reference for designers, builders, and FM could greatly ease adoption by ensuring everyone has a unified vision (a practical embodiment of a boundary object). Thus, a theoretical implication is that successful FM innovation requires boundary-spanning leadership – roles or processes that connect different expertise (IT, FM, construction, vendor). Traditional adoption models don't account for this well, so this is a meaningful extension for the FM context.

In summary, this research supports an integrated theoretical approach to understanding digitalisation in FM. TAM and IDT provide insight into individual and innovation factors, but must be expanded with STS (for organizational and social factors) and boundary-spanning concepts (for inter-organizational factors). The alignment between our empirical data and these combined lenses is strong: where TAM/IDT predict well (e.g. clear benefits, ease of use -> enthusiasm), we saw agreement; where they are silent (e.g. need for cross-company data exchange, leadership edicts), STS and boundary theory filled in, and our data underscore those elements. The divergence between theory and practice mainly appears if one uses a single theoretical lens in isolation. By using multiple lenses, the discussion found that theory and practice are actually in close dialogue – each challenge or success can be explained when the appropriate theoretical concept is applied. Therefore, we advocate for a multi-theory framework in both analysis and implementation of FM digitalisation, to ensure all relevant factors (human, technical, organizational, and knowledge boundaries) are accounted for.

6.6 Practical Implications for FM Practitioners, Technology Providers, and Leaders

The findings yield several practical implications for key stakeholder groups involved in FM digital transformation:

6.6.1 Facility managers

FM professionals driving digital initiatives should recognize that technology projects are as much about people as about tech. This means prioritizing training and change management in any digital rollout – e.g. allocate time and budget to train maintenance and operations staff on new systems, and designate *"digital champions"* within the team to support their peers. FM teams should also start small and build on successes: choosing an initial project with clear benefits (such as digitalizing work orders or energy monitoring in one facility) can demonstrate value and build momentum. Actively engaging in pilot projects with feedback loops will ensure the chosen solutions actually fit the FM workflows. Practitioners

are also advised to collaborate – both internally (with IT departments, sustainability teams, etc.) and externally (with peers in other organizations). For instance, joining industry networks or forums to share experiences can accelerate learning and help avoid common pitfalls. Perhaps most importantly, FM teams should communicate the wins upward and across departments: quantifying the time saved or cost avoided due to a digital tool helps convince management to continue investing. In essence, FM practitioners need to take on the role of change agents and educators, not waiting passively for technology to deliver results but actively shaping how it's implemented on the ground.

6.6.2 Technology Providers

Providers of FM technologies should approach their clients as long-term partners rather than one-off customers. The study shows that FM adoption improves dramatically with vendor support, so providers should invest in client success programs – for example, offering hands-on training sessions, responsive helpdesks, and regular check-ins to gather feedback and provide updates. User-centric design is crucial: vendors must focus on usability (simplified interfaces, intuitive workflows) knowing that FM users are domain experts but not IT experts. Incorporating client feedback into product development will make the tools more fit-for-purpose in FM settings (as seen with CAFM/CMMS - 2's improvements through co-development). Providers should also strive for interoperability: supporting open standards (like IFC for BIM data, open APIs for integrations) and data portability. This not only addresses a key client concern (avoiding data silos and lock-in) but could become a market differentiator as FM clients gravitate to solutions that integrate well with others. Another implication is for providers to help build the business case for their technology – providing templates or calculators that FM teams can use to estimate ROI, or case studies from similar clients to make benefits and best practices more observable. Finally, technology providers should be mindful of the *epistemic gap* – they might be experts in tech, but not in FM operations. Thus, hiring staff or consultants with FM domain knowledge, and learning the language of FM, will help in communicating value and understanding client needs. In sum, providers that act as trusted advisors and enable collaboration (rather than just selling a product) are more likely to see their solutions fully adopted and generating the intended value in practice.

6.6.3 Organizational Leaders and Decision-Makers (FM Directors, CEOs, Senior Management)

Leadership in organizations that include FM units plays a decisive role in digital transformation outcomes. Leaders should take an active stance by crafting a clear digital vision for FM and embedding it into the organization's strategy. Practically, this could mean setting specific goals (e.g. "within 3 years, all facility documentation will be managed in a digital platform" or "reduce energy consumption by 15% through smart building tech"), and then empowering the FM team to achieve them. Resource allocation is a key implication: management must be willing to invest upfront – in software, hardware, and importantly in people (training and possibly new hires) – to reap longer-term efficiencies. Cutting-edge tools often require new skills, so leaders should fund professional development and perhaps incentivize digital skill acquisition (for example, including it in performance evaluations or providing rewards for innovation). Leaders also need to champion the change: their visible support and enforcement can help overcome resistance. If a CEO or director actively uses the dashboards from a new FM system and speaks about data-driven decisions, it signals to all employees that the digital tools are priority and here

to stay. Additionally, leaders should encourage cross-department cooperation; for instance, ensuring IT and FM collaborate rather than operate in silos, possibly by establishing interdisciplinary teams for digital projects. The study also implies leaders should be patient yet persistent – supporting phased implementations and understanding that ROI may materialize over a longer horizon, while consistently pushing for progress and not allowing initiatives to stagnate in "pilot purgatory." Lastly, from a risk management perspective, leaders should update policies and guidelines to address digital risks (data governance, cybersecurity, privacy compliance) so that FM teams have a clear mandate and boundary within which to innovate. In short, leadership must orchestrate the environment for digital adoption: providing vision, resources, mandate, and support to ensure that technology potential is translated into operational reality.

By acting on these implications, each stakeholder group can contribute to a more successful digital transformation in facility management. The interplay is important: practitioners need to push needs and feedback upward and to vendors; vendors need to deliver and support; and leaders need to endorse and invest. When all three groups work in concert, the friction that currently hinders technology adoption can be greatly reduced.

6.7 Limitations

While the study provides valuable insights, there are limitations that must be acknowledged when interpreting the findings and their generalisability. First, the empirical base of the discussion is a set of workshop interviews with 15 facility management professionals Sampling limitations are inherent: the participants were individuals already engaged in developing digital FM, which could mean they are more forward-thinking or motivated about digitalisation than the average FM practitioner. This may introduce a *positive bias* – the group recognized benefits and discussed strategies extensively, which might not fully represent organizations that are less interested or experienced in digital transformation. In other words, the challenges and solutions identified are relevant, but the relative emphasis (e.g. strong optimism about future savings) could differ in a more conservative sample. Additionally, all workshops were conducted within a particular context (the "Bridging the Gap" project in Norway, involving organizations like NTNU, KLP, etc.). The findings may reflect context-specific factors: for instance, Norway's regulatory environment (with strong focus on data privacy via GDPR, etc.) could heighten privacy concerns; the presence of public agencies like Statsbygg might influence attitudes toward standardization and open data; or the maturity level of BIM in Scandinavian construction could shape the discussions. Therefore, caution is needed in generalising globally – different regions or sectors of FM might face additional challenges (or fewer, depending on tech infrastructure).

Another limitation is that the data are self-reported perceptions from workshops, which can introduce biases such as group dynamics or dominant voices. Participants might have influenced each other during discussion, potentially converging on common narratives (e.g. everyone nodding to the idea that leadership is crucial) – while this reflects consensus, it might also overshadow dissenting experiences. Also, because it was a facilitated workshop, some topics might have received more attention due to the moderator's prompts or the particular interests of the group. The study did not quantitatively measure outcomes; it relies on qualitative insight, which is rich for understanding "how" and "why" but cannot establish the frequency or magnitude of phenomena in the broader population of FM organizations.

Bias in interpretation is also a consideration. The discussion (and indeed the workshop analysis) was aligned to specific research questions (challenges, benefits, etc.), which could frame how data was coded and interpreted. There's a risk of confirmatory bias – looking for data that fits TAM, IDT, STS, etc. Additionally, being part of the larger "Bridging the Gap" project might have created an expectation among participants about focusing on certain issues. It's possible that topics like pure technical details or unrelated FM challenges were not discussed simply because the workshop had a thematic focus. Thus, the scope of findings is deliberately constrained to digitalisation matters; it does not cover, for example, external economic factors (like a recession forcing budget cuts) which could also impact digital adoption but were outside our immediate scope.

The study's time horizon is another limitation. It captures a snapshot of perceptions in 2024. Given the rapid evolution of technology, some concerns might diminish over time (for instance, as more FM staff become digitally native, skill gaps could reduce naturally, or as solutions mature, usability might improve). Conversely, new challenges might emerge (e.g. if AI use becomes widespread, perhaps ethical concerns intensify). Our discussions about 2050 are speculative and based on current views. Longitudinal research would be needed to see if the predicted trends (incremental change, hybrid approaches) hold true.

Finally, regarding generalisability, this research is most applicable to large or medium-sized FM organizations that have a degree of formal structure and are considering advanced digital tools. Smaller organizations or those in developing markets might face a different set of conditions (for example, they might lack access to cutting-edge providers, or the cost constraint could be absolute, not just initial). Therefore, while the principles (human-centric change, collaboration, etc.) likely apply broadly, the readiness to implement the identified strategies might vary widely.

In conclusion on limitations, the insights should be viewed as analytical generalisations rather than statistical ones – they illustrate how and why certain factors matter, under the assumption that similar conditions exist. Future research can build on this by testing these findings in other contexts or by quantifying the impact of these factors on adoption success. Despite these limitations, the coherence between our qualitative data and established theory gives confidence that the findings capture fundamental issues that many FM organizations will recognize, even if details differ by context.

7 Conclusion

Bringing the discussion together, this study set out to understand how facility managers perceive the future of digital transformation in FM and how collaboration with technology providers can improve the adoption and effectiveness of digital strategies. The empirical insights, interpreted through multiple theoretical lenses, provide a cohesive narrative in response to this aim. Facility managers in this study overwhelmingly perceive digitalisation as both necessary and beneficial for the future of FM – they see the potential for more efficient, proactive, and intelligent facility management through technologies like BIM, IoT, AI, and digital twin platforms. At the same time, they are keenly aware of the gap between this potential and their current reality. This gap is characterized by human and organizational factors: insufficient skills and training, cultural inertia, fragmented information flows, and uncertainties around costs and data responsibilities. In essence, practitioners do not lack vision or belief in technology – they lack the conducive conditions to fully realize it.

The discussion reveals that alignment (or misalignment) between empirical findings and theory largely centers on this point: classic technology adoption models explain individual acceptance of technology well, and indeed our participants echo those factors (they find tech useful and will use it if it's easy enough). But the divergence occurs at the organizational and inter-organizational level – areas that TAM and basic diffusion models do not elaborate. Here, socio-technical and boundary-spanning theories become crucial. Our findings align with those broader theories by demonstrating that digital transformation is a socio-technical endeavor requiring change in people, processes, and cross-boundary collaboration, not just provision of new tools. For example, the need for top management to mandate and support tech use confirms socio-technical and management theories that technology must be embedded in organizational strategy (and cannot succeed as a grassroots effort alone). Similarly, the importance of data standards and working with contractors and vendors confirms that spanning organizational boundaries (creating shared frameworks) is necessary so that all stakeholders can move forward together – a point advocated by Ghalandar et al. (2023).

Collaboration with technology providers emerged as a critical lever to improve adoption and effectiveness. By engaging providers as partners, FM teams can bridge knowledge gaps, ensure better tailored solutions, and get the support needed for smooth implementation. This finding ties directly to the second part of the research aim: it suggests that the oft-cited "gap" between technology potential and practice can be substantially narrowed if FM organizations and tech providers approach digital transformation collaboratively. Providers contribute technical expertise, innovation, and training, while FM contributes domain knowledge, context, and feedback – together co-producing a viable solution. The Macerich case (Hanford, 2017) and others cited in the literature review resonate here: IT and FM working hand in hand leads to greater success than FM trying to adopt off-the-shelf tech in isolation. Our participants' experiences reaffirm that notion in current practice.

Finally, the strategies outlined (leadership commitment, training, user engagement, phased rollout, provider collaboration, integration efforts, and a hybrid mindset) serve as the core interpretive contribution of this discussion. They translate the empirical insights into actionable guidance, and each strategy corresponds to both a set of empirical

observations and a theoretical justification. Taken together, these strategies form a comprehensive change program that FM organizations can consider as they navigate digital transformation. The theoretical lenses help justify why these strategies should work: for instance, leadership and training address the social/organizational side (STS), phased implementation leverages diffusion principles, and provider collaboration bridges epistemic boundaries. The practical implications further distill these strategies for different stakeholders, emphasizing that success requires coordinated action by practitioners, providers, and leaders.

In conclusion, the study finds that facility managers are cautious optimists about digital transformation. They foresee a future where FM is far more data-driven, efficient, and integrated – a future in which they "are definitely there" with advanced technologies by 2050 (as one participant imagined). Yet, they also recognize that reaching that future is not automatic: it demands overcoming today's challenges through deliberate effort. The alignment of our workshop findings with established theory gives credence to the idea that these challenges are not insurmountable; rather, they are well-understood issues of technology acceptance, diffusion, and socio-technical design. What is needed is a concerted push to apply this understanding in practice. By strengthening internal capabilities, fostering an open and collaborative culture, and building bridges with technology providers and across industry, the gap between technology's potential and its current use in FM can be systematically closed. In doing so, facility managers can transform their role – from stewards of buildings reacting to problems, to strategists leveraging digital tools to predict, optimize, and innovate in the built environment. This discussion, therefore, ties back to the main research aim by highlighting that the future of digital FM, as perceived by those on the front lines, is one of great promise unlocked through partnership and holistic change. The key to success will be ensuring that the human, organizational, and technical pieces of the puzzle evolve together, aligning practice with the full potential of digitalisation in facility management.

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