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Facility management — Overview of available technologies

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Contents

Page

Foreword v

Introduction vi

1 Scope 1

2 Normative references 1

3 Terms and definitions 1

4 Scope of FM technology 1
- 4.1 FM technology 1
- 4.2 Impact of application on FM business goals 2
- 4.3 Golden thread initiative 2
- 4.4 Asset and FM applications 2
- 4.5 Interfacing 2
- 4.6 Optimization systems 3
- 4.7 FM technology drivers 3

5 Key concepts: Domains in FM technology 4
- 5.1 Ontologies 4
- 5.2 Conceptual landscape 5
- 5.3 Foundation domain pillars 5
- 5.4 Operating environment 6
- 5.5 Horizontal versus hierarchical structures 6
- 5.6 Grids and networks — FM technology periodic table 8
  - 5.6.1 General 8
  - 5.6.2 Networks (MbN, 1.1; LAN, 1.2; WAN, 1.3) 8
  - 5.6.3 Utilities (UTL, 1.4) 9
- 5.7 Transactions, security and storage 9
  - 5.7.1 General 9
  - 5.7.2 Biometrics (Biom, 2.1) 10
  - 5.7.3 Cyber security (CS, 2.2) 10
  - 5.7.4 Blockchain (BC, 2.3) 11
  - 5.7.5 Backup 11
  - 5.7.6 SMART contracts (SmC, 2.6) 11
- 5.8 Automation, monitoring and delivery 12
  - 5.8.1 Robotics (RBT, 3.1) 12
  - 5.8.2 Wearables (Wbl, 3.3) 12
  - 5.8.3 SMART assets and digital experience monitoring (SmA, 3.4; DEM, 3.5) 12
- 5.9 Digital workplace 13
  - 5.9.1 General 13
  - 5.9.2 Virtual reality and assistants (AR, 4.1; VR, 4.2; VA, 4.3) 13
  - 5.9.3 SMART workspaces (SW, 4.4) 13
  - 5.9.4 Operational applications (OA, 4.5) 13
- 5.10 Computer and data insights 14
  - 5.10.1 General 14
  - 5.10.2 Computer vision and learning types (CV, 5.1; ML, 5.2; CC, 5.3; DL, 5.5) 14
  - 5.10.3 Natural language processing (NLP, 5.4) 14
  - 5.10.4 Deep learning and neural networks (DL, 5.5; NN, 5.6) 15
- 5.11 Information models and frameworks 16
  - 5.11.1 General 16
  - 5.11.2 Building information modelling and location referencing (BIM, 6.1; GIS, 6.2) 16
  - 5.11.3 Whole life management (WL, 6.5) 16
  - 5.11.4 Health and safety, and well-being (HS, 6.6; Well, 6.7) 17
- 5.12 Data-generating systems for re-commissioning and restoration 17

6 Business case benefits from technological applications in FM 18
- 6.1 FM technological strategy 18

6.2 Response to organizational needs 18
6.4 Choice of technology 20
6.5 Creation of the business case and proof of return on investment 22
6.6 Agile project management 22
6.6.1 General 22
6.6.2 Examples of agile methodologies 22
6.7 Programmatic risk of being an early adopter 23
6.7.1 General 23
6.7.2 Risk management 24
6.7.3 Progress pace and judgement errors 24
6.7.4 Risk mitigation 24
6.8 FM technology maturity 25
6.8.1 Gap analysis 25
6.8.2 Assessment of business needs 25
6.8.3 Demand functionality 27
6.8.5 Additional considerations 28
6.9 Harnessing of opportunities available through technology 28
6.9.1 Point of intersection with FM practice 28
6.9.2 Intersection by stakeholders — Supporting change 29
6.9.3 Intersection by function 32

Annex A Example of an ecosystem landscape 35

Bibliography 36

Foreword

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Introduction

This document provides facility managers, their teams and stakeholders an overview of available facility management (FM) technologies. Only by understanding technology's diverse, evolving potential can the facility manager community make best use of its scope, efficiencies and benefits to support its everyday operations.

The long-term benefits of FM technology are not only commercial or budgetary, relating to hard or soft services, safety or environmental objectives, or achieving process change; they will contribute to achieving the United Nation's Sustainable Development Goals (SDGs). As a component of the ISO 41000 series, integrated technology also offers significant potential value by providing input to their core business strategy roadmap. It will allow facility managers to fully understand and deploy the power of technology as a business productivity enabler, to improve on their capabilities and system capacities. Those that take advantage and embrace technology will be better able to shape the vision of an enhanced, digitalised FM experience.

Globally, the FM industry continues to adapt by advancing thought leadership and creating innovative, operational digital frameworks. Applied effectively, frameworks that are designed to foster international best practices will enhance the productivity of the FM workforce and enable each FM sector keep pace with digital advancements and transformation campaigns.

Further education on achievable goals is needed, as well as a shared common vocabulary and a collective understanding. Digital FM (DFM) is the interface between FM and technology. It presents an ideal opportunity for transformation, enhancing workforce skillsets, improving asset owners' awareness and service delivery performance capabilities, by further automating the built environment and connecting all stakeholders.

FM has become a globally recognized discipline, in which challenges are faced, be they technology-related, involving safety or environmental protection, or even from pandemics or budget constraints. It is important to note that facility management is a people-centric sector. As devices become more tech-capable, these resources need to be able to work in buildings that are categorized as SMART (specific, measurable, achievable, realistic and time-related). From the PC to the internet, SMART phones to energy management, the public has high expectations from technology and its everyday use. Well-managed facilities and carefully applied technology enable facility occupants to work effectively and safely, in a constantly changing digital environment. Facility managers need to be an integral part of this digital transformation.

Adoption of the Internet of Things (IoT), together with Building Information Modelling (BIM), the use of 5G telecoms, new software products and applications for 3D to 7D management of the life cycle of buildings (including their design, construction, operations and maintenance), is not a single change management programme. This document gives insight into the means by which technology can be more understood and better incorporated, a key part of a business strategy.

Facility management — Overview of available technologies

1 Scope

This document provides an overview of the available facility management (FM) technologies. This document is applicable to facility managers, their teams and their stakeholders. It aligns specifically with ISO/TR 41013, the ISO 19650 series and the ISO 41000 series as part of an integrated framework to achieve FM best practice.

This document outlines various long-term benefits and enhanced value that can be derived progressively by the operators, occupants and owners of facilities, worldwide, via the effective application of technology. This document includes, defines and categorises systems, equipment, methodologies and software applications that are available.

This framework defines how facility managers can understand and integrate digital practice and technologies in the built environment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 41011:2017, *Facility management — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 41011 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Scope of FM technology

4.1 FM technology

A digital ecosystem is a distributed, adaptive, open socio-technical system with properties of self-organization, scalability and sustainability inspired from natural ecosystems. Digital ecosystem models are informed by knowledge of natural ecosystems, especially for aspects related to competition and collaboration among diverse entities.

There has been a significant increase in the introduction of innovative technologies used within the built environment. These technologies are often a key enabler to achieve better outcomes that were previously unimaginable due to legacy work practices and other human factor constraints. As the cost of storage per Mb of data has diminished progressively, the volume of data needing to be stored securely has increased, almost exponentially.

Technology is becoming an intrinsic part of this industry through realized opportunities, competitive differentiators and in response to market demands for cost efficiencies. Technological equipment and operating applications, like SMART devices and building management system (BMS) sensors, continues to decrease in price, and the positive impact of these advanced technologies has expanded exponentially.

One such example is the real-time engagement with facility owners, building occupants and service providers, to enhance the user experience via SMART-phone applications and cloud-based data storage. Other potential benefits to users include improved safety and security, better wayfinding and communications, enhanced service response and key performance indicators (KPIs). Additionally, communications and information flow are streamlined through technologies such as digital signage, touchless kiosks, geofencing and push notifications. Although this document focuses on such technologies, it is not meant to be an information, communication and technology ITC-centric document. It is designed to bridge technical knowledge and process gaps with FM operations.

4.2 Impact of application on FM business goals

Technology touches almost every aspect of an FM practice. Increased access to information and data empowers better planning of many FM activities. Sensors and other devices can provide real-time feedback for improved decision-making, helping to speed up responses. Foot traffic, congestion and people-movements can be analysed in real-time with increasing levels of automation.

Universal foundational elements include preferences for finding and using evidence in FM, the acquisition of data, and drawing evidence from data: This is the external validation process. The internal validity of data, also foundational, is comparable to quality assurance (QA). The data collated and stored is of known and consistent origin, validated in form and value, complete (or with known omissions), and uncorrupted (hopefully). From this verifiable position, data are usually selected by the FM exponent in context, from a variety of sources.

The impact of technology on FM provides a foundation for numerous additional benefits, including more target-based resource efficiency, optimizing the life and usability of assets streamlined facility operations, and improving the quality and reliability of outcomes. The use of technology can assist in mitigating risks.

4.3 Golden thread initiative

In 2017 in West London, the Grenfell Tower fire spread rapidly upwards through the entire building due to its flammable exterior cladding. Reference [9] suggested the implementation of a “golden thread of information”. This golden thread, in its association with the built environment, provides “the information that allows you to understand a building and the steps needed to keep both the building and people safe, now and in the future”[10].

The term has grown in its potential application to the built environment into one which applies not just to building safety but to whole life value and user experience. There are several international activities already underway looking to further extend this concept into existing information models and digital environments.

4.4 Asset and FM applications

Applications and systems that provide functionality to cover all asset management (AM) and FM life cycle processes and related data include those providing functionality such as incident logging, work order management, asset management, corrective and preventive maintenance, material, contract, vendor, project and financial management.

4.5 Interfacing

Back-office systems such as computer maintenance management systems (CMMS) and computer aided facility management (CAFM) rely on and maintain valuable historical data required to generate any report or KPI understanding. Some are promoted as being a complete software solution for all instances and activities. However, there are three types of interfaces that are usually considered when formulating an FM technology strategy and action plan: input, output and visualization (see Table 1).

Table 1 — Types of interfaces for consideration when planning

Interface type	Description
Input related interfaces	Input related interfaces allow systems to online or batch receive information for further processing. Such interfaces include BMS system, IoT devices, mobile devices / applications collecting information from the field.
Output related interfaces	Output related interfaces provide silos of FM and AM information to BI and artificial intelligence (AI) related tools for further analysis and decision-making. Output related interfaces are also required to synchronize CMMS/CAFM systems with back office financial and human resources systems such as enterprise resource planning (ERP) systems.
Visualization interfaces	Visualization interfaces are required to project FM and AM data to computer aided design and mapping systems such as GIS, 2D architectural designs, energy sustainability management systems and BIM models.

4.6 Optimization systems

These are the digital systems that allow transformation of raw data and transactions into FM and AM knowledge. Examples of these systems include AI, BI, prediction analysis, capital planning, and energy management systems, amongst others.

4.7 FM technology drivers

For a facility manager to achieve the optimal outcome from using technology, there is a need for clarity, communication and collaboration with technology providers in facility management consulting services. It is challenging for a facility manager to have an in-depth working knowledge of every aspect of the facilities they manage. It is therefore of critical importance to know the right questions to ask when evaluating or selecting a technological solution to ensure it will achieve its intended outcome. The compelling reasons for adopting such technology is the increase in likelihood of adoption when facility managers can identify and communicate relevant drivers (see Table 2).

Table 2 — Selection of technology-based drivers of change

Technology-based driver of change	Description
Health and safety	From wellbeing to building safety, technologies afford new ways to bring enhanced insight and support across the function's life cycle.
Commercial pressures	COVID-based, adversely-impacted commercial activities have meant, for many developers, building owners and business operators, a three-year reduction in revenues, additions to operating costs and lowering of profits that need to be redressed. This can be achieved by various means including raising productivity per resource, savings in utility cost outlay and enhanced competitiveness through business process efficiencies. Implementing technology can offer opportunities for each solution.
Data capture	Data capture is not a technology, per se, but an ongoing process which can be applied throughout various technologies.
Digital transition	Increasing digital integration from design, engineering and construction (DEC) through FM operations and maintenance (O&M).
Commercial competitiveness	By implementing new processes, systems, infrastructure, protocols and raising training standards, organizations can demonstrate recognizable international qualifications (e.g. the ISO 41001 series), building sustainability status (e.g. LEED platinum) and resource-based certifications and qualifications (e.g. certified FM qualifications).
Risk register	From a collated list of business continuity planning (BCP) criteria and disaster recovery planning (DRP) topics, identify what are the key issues that can impact an organization's ability to deal with potential built environment-related crises and identifiable risks.

Table 2 *(continued)*

Technology-based driver of change	Description
Technology value	User stories and customer journeys are critical to assess the value of new technologies.
Corporate social responsibility (CSR)	Many companies, by their articles of association, have a duty of care for the wellbeing of their employees and sections of the wider community. These responsibilities extend far beyond the workplace and boards are responding increasingly to the social and welfare needs of the less privileged. Recycling surplus ICT equipment to local schools is one proactive example.
Grids and networks	Practical or theoretical means of environmental sustainability and ways of limiting carbon emissions can help stimulate interest in and use of SMART grids.
Global sustainability campaigns	Global sustainability campaigns provide growing international requirements to reduce carbon footprints and improve water utilization.

Table 3 lists some foundational questions for a facility manager considering a technology solution and the creation of a FM digital technology strategy (see 6.1). They are typically used to form the basis of a checklist.

Table 3 — Potential foundational questions

Reference	Foundational question
T3-Q1	What strategic outcomes and business requirements are the demand organization seeking, such as enhanced health outcomes, higher productivity, improved user satisfaction, raised space utilization efficiency, greater sustainability, workspace flexibility?
T3-Q2	How will any technology deployments perform and scale in the future?
T3-Q3	What qualitative and quantitative technology gap analysis has been performed and what are the key results?
T3-Q4	Are there technologies that can be retrofitted?
T3-Q5	Is the digital network infrastructure capacity suitable to support planned FM technologies and to address future anticipated demand?
T3-Q6	Will the network infrastructure capacity be sufficient to address future anticipated demand?
T3-Q7	What cyber security measures are required?
T3-Q8	What corporate, local, national and international communication protocols and naming conventions are used?
T3-Q9	How will return on investment (ROI) be calculated: financial versus unit of productivity versus user satisfaction?
T3-Q10	What special skills or maintenance will be required to enable ongoing use of the technology?
T3-Q11	What type of FM sustainable impacts are expected from technological breakthroughs?
T3-Q12	What ethical principles and values of the organization are to be considered?

5 Key concepts: Domains in FM technology

5.1 Ontologies

An ontology is the philosophical study of a being in general, or what applies neutrally to everything that is real. How does this apply to technology in FM? Ontologies seek to classify and explain entities, specifically their relationships and conditions.

In FM and Technology, this concept is applied to the different naming and classification categories, so that existing things (assets) can be assigned to orders (categories) and groupings (data sets), to better understand all of the information associated with FM asset data (especially from BIM) and how it relates with data sets, status conditions and system data field definition criteria.

Those ontologies applicable within the scope of this document can include international foundation classes (IFCs), construction operations building information exchange (COBIE), even operational naming, classifications and definitions. Each one offers differing features, benefits and interoperability issues around the common purposes of data-mapping and asset-labelling.

5.2 Conceptual landscape

The intersection between FM and technology (known variously as FMTech, FM Ecosystem, FM Digital Twins, Digital FM or DFM) has presented the biggest opportunity for change in the industry, enhancing workforce awareness and capacity while automating and connecting the built environment.

With the reach and scope of facility management teams around the world, the operational requirements in both a direct context as well as alignment with each demand organisation can cover so many different parts that it is inevitable to end up with a system of systems delivering everything from environment control, space availability, asset performance and user experience.

DFM uses data and technological systems to automate, optimize and integrate with FM, as outlined in Table 4.

Table 4 — Digital FM data and technological systems examples

Digital FM data	Technological systems example
Sourcing and procurement	Dashboard data flows
Property and lease management	Asset database and life cycle costings
Relocation and space management	Auto-alert and reporting configurations
Handovers and commissioning	Reactive and preventive maintenance

Conceptually, digital FM comprises many related activities, but in principle, it can be broken down into these five classic main elements:

- what: technology ecology based on the as-is and to-be analysis to create strategy;
- where: place, space and asset definitions and methodologies;
- when: optimal start and delivery in the FM life cycle;
- why: performance outputs and key deliverables needed;
- who: the primary beneficiaries are those in the digital FM team.

These five elements are deployed to support the implementation of digital FM across various activities, dependent upon the maturity, capability and needs of each organization.

5.3 Foundation domain pillars

The digital FM model forms the foundational pillars (see Table 5) from a functional point of view. There are four such main pillars that build up this model, summarized here and included in the lower row of Figure A.1, the digital ecosystem “Periodic Table” infographic in Annex A. Not all technologies will fit every FM operation, either in respective need or in digital maturity. Therefore, taking short, medium and long term views that align to the ongoing FM strategy allows the FM operation to be built from a full list of potential enablers as given in Table 5.

Table 5 — Four foundation pillars

Pillar	Description
Demand end point	This pillar represents anything physically present and active such as place (including its 3D geolocation, label, name and address), space (defined by the floor section label, occupant or owner, building story or elevation, square metre size or cubic meter volume) or asset (details ranging from maker's name, purchase price, equipment model, construction materials and age, to net book value, associated original equipment manufacturer manuals, warranty and data loss prevention criteria, spare parts, standard operating procedures, and risk assessment models).
Edge	Where the physical world crosses seamlessly over to the digital world to monitor, communicate and deliver some type of autonomous action. Decentralized technology – be it a building sensor, a security camera or an access control system – is unlike traditional centralized systems, where data is sent to a main server or cloud for processing, edge computing processes data on-site or near the data source. This real-time processing capability can enhance responsiveness, reduces latency and can offer improved security.
FM information model	Where the full life cycle of facility management has been captured and structured to deliver an optimal whole life experience - leveraging the vast human knowledge data domain of the built environment. For example, CMMS systems can instruct elevators how to respond and even predict human movements and lift lobby queues.
Virtual environment	Represents the entire digital ecosystem in either its virtual or digital form on the Cloud or on-premise. Use of virtual reality (VR) is a simulated experience that can be, by design, similar to or completely different from the real world. Although VR applications can vary from graphic-intense, sensory-input entertainment video games, radical adoption has seen military training roles and medical interventions achieve successful results, with doctors and patients sited in different continents. The global uptake in the use of audio-visual internet-based video conferencing from 2020 to 2022 has yet to reach its zenith but the educational and commercial benefits have been immense, worldwide. Intuitive, creative memes, avatars, animated GIFs, and digital screen backgrounds are all available to an entire generation unphased by new features. Other distinct types of VR-style technology include augmented reality (AR) and mixed reality, sometimes referred to as extended reality (XR). VR headsets or high-resolution projectors can create ultra-realistic images, surround sounds and other sensory feedback that simulate a user's physical presence in a virtual environment. Pilots in the latest fifth-generation fighter jets are provided with such head-mounted displays. For FM resources, complex maintenance or repair procedures can be practiced in a VR domain beforehand, when sites are inaccessible or high-risk. With the latest digital XR accessories, specialized tools can provide sensitivity or touch and resistance to movement, via haptic technology.

5.4 Operating environment

With the four foundational pillars listed in Table 5, the operating environment (see Table 6) is intended to provide a resilient framework to inform, guide and integrate with all FM technologies of both today and tomorrow. The full "periodic table" model in Annex A illustrates how different technologies relate to one another and to the respective operational practice. This provides a foundational understanding of the entire FM ecosystem. Using this matrix, FM stakeholders plan and adopt an ongoing, digital transformation journey, that is aligned to support their facility and business needs.

5.5 Horizontal versus hierarchical structures

An organization's structure relates to its company or entity's hierarchy. It defines the concept of superiors and subordinates who collaborate to achieve specific goals. The organization's corporate culture and strategic objectives usually determine its structure and how it operates. Responsibilities are allocated according to the functions of the structure. Horizontal or flat structures operating with minimal management tiers are often found in small organizations. By delegating decision-making processes and awarding operating authority, productivity is enhanced, agility is commonplace and competence is expected.

Whatever the management structure or ontology in place to deploy FM-Tech via a framework process, international best practice is usually three-phased: as-is analysis, to-be planning, then implementation sequential process. The topics, activities and components of this ontology are therefore reviewed and categorized to support such a planning process. Each technology subject is represented by an “element”. In the example in Figure 1, "Blockchain" is abbreviated to "BC", represents Table 6, Column 2 (transactions, security and storage), and Element 3 from the transaction, security and storage group of the ecosystem landscape (reference code: BC, 2.3).

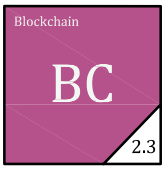

Figure 1 — Sample periodic table element

In Clause 5, components of the full “Periodic Table” model are defined and explained. The fully arranged elements of this diverse, constantly adapting environment are shown in a graphical format in Figure A.1. This illustrates how such technologies relate to one another and to which FM operational practice. This provides a foundational understanding of the entire, end-to-end horizontal ecosystem. Using this matrix, FM stakeholders plan and embrace an ongoing digital transformation journey aligned to support their own entity’s strategic needs. Table 6’s core structure is six rows, as shown below, each one defining the respective column as contained in the “Periodic Table”.

The components of the operating environment have been identified as given in Table 6.

Table 6 — Identified components of the operating environment

Periodic table column	Ecosystem landscape vertical column heading	Description of the component
1	Grids and networks	The digital FM model is empowered by a variety of elements which are not typically consumed directly; those elements are required to animate or bring to life the digital FM requirement: they are represented by a variety of means for connectivity to digital grids and networks. Some are established terms in use for several decades, some are relatively new in concept.
2	Transactions, security and storage	From every bit of stored data to digital transactions and connections to all the security surrounding all of these needs. Cloud-based data storage facilities are becoming more common yet effective cyber security protocols and protective measures are paramount. From this hierarchy, a set of concepts and categories in a given subject area or domain are defined that show their properties and the relations between them.
3	Automation, monitoring and delivery	Sensors drive autonomous activity where the Space, Place or Assets capture input and can control action output. The DFM captures digital states (using technology such as BIM photogrammetry or laser scanning) to capture reality and create base representations of buildings infrastructure and other assets. These can then be organized to align with human interpretation and ease of understanding: robotics are becoming more widely deployed, newly-adopted interfaces with the IoT are increasing in use.