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New strategies for Building Information Modelling (BIM) with Facility Management (FM) integration and training in Public Administration

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Summary

The research addresses the integration of Building Information Modelling (BIM) and Facility Management (FM) within Public Administration, starting from a central critical issue: BIM has entered public policies and procurement procedures, while its translation into ordinary management practices remains fragile. The problem concerns the capacity of public organisations to transform models, data, and platforms into information that is usable, verifiable, updateable, and coherent with maintenance and management processes.

The work is situated within the Italian context and adopts the *Palazzo Unico della Regione Piemonte*, also known as the *Torre della Regione Piemonte*, as its case study: a public building that is complex in terms of scale, spatial articulation, building-services density, institutional functions, and quantity of information involved. The case makes it possible to test BIM–FM integration in a concrete condition, characterised by an as-built BIM model, an existing FM platform, and the relationship between models, documents, maintenance processes, people, and tools.

The central hypothesis is that **BIM–FM continuity** requires the alignment of three interdependent dimensions: **Models and Tools**, **Processes and Documents**, and **Training and People**.

The first pillar concerns the transformation of the as-built or as-is model into an information configuration oriented towards FM. The thesis develops the concept of the **Record Model** as the outcome of verification, simplification, selection, coding, and reorganisation of information, testing it on rooms, workstations, doors, movable furniture, and fan coil units. The model is assessed according to its capacity to make information searchable and integrated with management tools. The second pillar addresses flows, responsibilities, and public information demand. Information loss is interpreted as a governance issue, particularly evident in the transition between handover and the start of operation. The research proposes **two operational BIM–FM strategies**: fault-based maintenance, which transforms a report into a localised and traceable event, and planned maintenance, which connects assets, procedures, frequencies, work orders, and evidence. At the documentary level, the analysis of Italian ***Capitolato Informativo*** leads to the proposal of a protocol and a modular prototype aimed at making requirements, deliverables, checks, and data uses more controllable. The third pillar concerns competences and the internal capacity of Public Administration. Training is interpreted as the construction of operational and verifiable capacities: reading models, formulating requirements, checking deliverables, using platforms, and maintaining coherence between information and processes. The thesis defines and validates a **BIM–FM Training Framework** for Public Administration, structured into differentiated levels and based on needs, roles, and observable results. The opening of the **BIM Office** of *Regione Piemonte* represents the transition from training to capacity as a stable organisational safeguard.

The final part recomposes the three pillars through the perspective of **Drawing for FM 5.0**. Drawing and representation are interpreted as operational interfaces capable of connecting models, data, documents, platforms, actors, spaces, and processes. The main contribution of the thesis lies in the definition of an integrated methodological framework for making BIM–FM a governable capacity of Public Administration. The value of BIM for FM lies in making information legible, verifiable, and updateable within ordinary processes, transforming the model into an informational and organisational infrastructure for public asset management.

Acknowledgment

I believe that research cannot be limited to a theoretical exercise confined within the boundaries of academia. Research, especially when developed within a public university, should strive to produce a tangible impact: social, technical, institutional, and educational. It should contribute not only to the construction of knowledge, but also to the definition of tools, processes, opportunities for dialogue, and possibilities for growth for the people and contexts in which it is embedded. This work stems from this conviction: that knowledge acquires its full meaning when it is able to move beyond documents, models, and classrooms, and to engage with real problems, institutions, and people.

First and foremost, I would like to express my gratitude to Regione Piemonte for promoting and supporting this research project, making possible a doctoral path strongly rooted in a concrete public-sector context. The opportunity to engage with the Regione Piemonte Tower, with administrative processes, information models, digital platforms, and the operational needs of public asset management has been a fundamental element in the development of this work. I am particularly grateful to Dr. Lepri, Eng. Siletto, Renata, Alberta, all the members of the BIM Office, and all the regional directors and employees with whom I had the opportunity to interact over these years. Their availability, expertise, and trust enabled this research to confront the concrete complexity of Public Administration and the real challenges of the digital transformation of public heritage.

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I thank my family, my parents, my sisters, my brother-in-law, my nieces, my uncles and aunts, my cousins, and all the people who stood by me during these years, for the support, patience, and trust with which they accompanied this path. A special thanks goes to Rebecca, for the presence, dialogue, patience, and balance she was able to offer me even in the most complex moments of this journey.

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To those who were there.
To those who believed in me.
To those who taught me that even effort can become form and substance,
that even uncertainty can become method,
that even failure is a result,
and that there is always a way to rise again.
To those who reminded me that every path,
when crossed with love,
always leaves a trace.

To my family,
the loving root of every step I have taken:
to my mother, my father, my sisters, and my nieces.

To my guardian angels:
my grandparents and my uncle,
silent and luminous presences
who continue to walk beside me,
even from afar.

Take Me Home, Country Roads

"Vinca, dunque, la perseveranza, perché se la fatica è tanta,
il premio non sarà mediocre.
Tutte le cose preziose son poste nel difficile"

Giordano Bruno

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Chapter 1

Introduction

1.1 Managing public built assets and Facility Management in Public Administration

When a public building stops working, the impact rarely ends with the fault itself: what really breaks down is a service, a workflow, a shared routine. Schools, hospitals, administrative offices, and the supporting infrastructure around them are not just containers for activities–they are part of the material backbone of civic life. How well they are managed day to day directly affects usability, safety, comfort and – less visibly, but just as decisively – the trust that citizens and staff place in public institutions.

From this perspective, managing the public built estate cannot be treated as a secondary issue, something that sits "around the edges" of an organization's mission. On the contrary, it is a strategic responsibility: it concerns the continuity of essential services and the ability to deliver reliable performance over time, while balancing technical constraints, regulatory requirements, economic sustainability and social impacts. This approach aligns with the recent evolution of asset management, which increasingly emphasizes long-term thinking based on performance, risk, and value delivered across the asset life cycle. In this framework, the goal is not simply to keep a building "standing", but to keep it in service–manageable and predictable over time (ISO 55000:2024). This leads to a point that is often underestimated: decisions made during operations are, in practice, high-stakes decisions. Even seemingly routine choices – maintenance priorities, plant replacements, space management, safety measures – can trigger cascading effects on operational continuity, compliance, comfort, risk control, and public expenditure. The issue, then, is not only to "intervene", but to create the conditions for interventions to be traceable, justified, verifiable, and consistent with organizational obligations.

This is exactly where **Facility Management** (FM) becomes central. In the public sector, FM cannot be reduced to reactive, "on-call" maintenance or constant firefighting. It is better understood as an operating system for the organization: an integrated set of processes, information and roles that enables everyday management while supporting planning over the medium and long term. This view is reinforced by standards: ISO 41001 defines a dedicated management system for FM, aimed at ensuring effective and efficient service delivery and meeting applicable requirements and stakeholders' needs (ISO 41001:2018). In practical terms, this means governing activities such as ticketing and issue reporting, maintenance planning and record-keeping, asset inventories and registers (spaces, components, systems), contract and supplier management, performance control, and HSE/safety aspects–not as isolated tasks, but as coordinated functions built around reliable, up-to-date data. What makes public-sector management truly distinctive, however, is that **Public Administration** (PA) is not the private sector with a few extra constraints: it operates in a structurally different institutional environment. The stakes are not only internal efficiency or cost optimisation, but also accountability, transparency, decision traceability, and public responsibility. Recent literature on accountability highlights how "being accountable" is a defining feature of public organizations, shaping priorities, tools, and governance approaches (de Boer, 2023; Pérez-Durán, 2023). For this reason, public built-asset management cannot rely on informal practices or tacit knowledge held by a handful of individuals. It requires measurable processes, clear responsibilities, and verifiable information – so that continuity can be maintained even as people, departments, and organizational structures change.

This is the context in which **Drawing and Representation** naturally become a scientific key to the problem–not merely as a disciplinary label, but as an operational foundation. Managing a public asset largely means managing what is known about it, what is recorded, updated, and shared. In other words, management runs through representation. Yet these are not representations understood as purely descriptive outputs; they are information devices that make relationships, constraints, attributes, and responsibilities legible. From this perspective, **Building Information Modelling** (BIM) can be seen as an evolution of technical-graphic representation into an information-rich, computable form – designed for use and decision-making rather than document production for its own sake. The typical complexity of PA amplifies this need even further. Public real-estate portfolios are often heterogeneous (in age, performance, and function), spread across multiple sites, and governed through multi-actor arrangements involving technical offices and leadership, end users, oversight bodies, contractors and suppliers. Outsourcing is also common; it may be unavoidable, but it makes governance of responsibilities – especially around safety – particularly sensitive when contractors and subcontractors operate in workplaces. Recent studies on outsourced facility management show how safety management practices and criticalities in this context require specific organizational and operational attention. In such scenarios, the real challenge is not "doing maintenance": it is keeping processes, data and responsibilities stable over time and across changing actors, preventing management from slipping into fragmented, emergency-driven modes (Pilbeam, 2024).

In the Italian context, this direction is increasingly recognized at an institutional level as well. The Agenzia del Demanio's 2024 Sustainability Report explicitly links enhancement of public assets, value creation and digitalization, stressing the need for tools that support more effective, interoperable management oriented towards advanced maintenance (Agenzia del Demanio, 2024). At the same time, recent scientific literature converges on a key point: BIM–FM integration is promising, but far from "automatic". Difficulties emerge precisely when moving from model logic to everyday operations: data quality and structure, information requirements, interoperability, long-term updating, and the connection with the tools and workflows typical of the operational phase (Pinti et al., 2022; Patacas et al., 2020). In this sense, the bottleneck is not generating a BIM model, but making information usable in operations – queryable, updated, reliable, and tied to responsibilities and decisions. For these reasons, talking about public built-asset management today means talking about operational continuity and accountability. And, as a result, addressing BIM–FM integration in Public Administration is not a theoretical exercise or an unavoidable "technology step". It is a necessary problem: any innovation – BIM included – only makes sense if it strengthens operational capability, through processes that can actually be applied, data that can be maintained over time, and an organization able to turn representation into management infrastructure.

1.2 Digital innovation in PA: definitions, drivers and enabling conditions

In contemporary debates on Public Administration, “digital” and “transformation” are often used interchangeably, almost as if they were the same thing. In reality, one of the main weaknesses of public innovation pathways starts precisely here: the lack of a clear and shared conceptual hierarchy. Bringing order is not a terminological exercise, but a methodological choice, because it helps distinguish what is conversion, what is process improvement, and what is a structural change in an organization’s capabilities. From this perspective, the distinction between digitization, digitalization, and digital transformation is useful because it provides three progressive levels of maturity and makes it possible to ground the discussion in the specific nature of the public sector. A widely adopted formulation in the literature and in industry reports defines digitization as the creation of a digital representation of originally analogue content; digitalization as the improvement of processes enabled by digital data and technologies; and digital transformation as a deeper organizational change enabled by digital technologies, affecting operating models, roles, and skills (Sen Gupta, 2020; Mikalef & Parmiggiani, 2022; Plekhanov et al., 2023).

For PA, this distinction is not abstract: it describes three steps that are often confused or overlapped, with the risk of stopping at the first one and declaring “completed” what, in fact, has only just begun. In public-sector contexts, digitization primarily concerns the conversion of the organization’s basic information assets: archives, technical documents, building files, registers of components and systems, logbooks and maintenance sheets, inventories, certifications, and inspection reports. This is a necessary step, because without data in a digital format the system inevitably remains dependent on accidental information retrieval, people’s memory, and long reconstruction times. Yet digitization alone does not automatically generate efficiency or value: it can turn paper into files without changing how the administrative machine actually works. The shift happens when Public Administration moves into digitalization–when digital data becomes the foundation for making processes more consistent, traceable, and coordinated. Here, digital is not about “storing better”, but about working differently: clearer maintenance workflows, more structured management of requests and priorities, controlled automation, interoperability across functions and departments, integration between asset registries and contracts, and a more life-cycle-oriented approach to management. This is the level at which digital stops being a container and becomes an operational mechanism, reducing redundancy and ambiguity while improving decision quality. This is particularly relevant in contexts where– as discussed–operations are high-stakes and traceability of choices is part of public responsibility.

Digital transformation, in Public Administration, is the most demanding level: it implies a change in operating models and organizational capabilities that goes beyond “which tools do we use” and concerns how the organization produces and guarantees services over time. At this stage, digital transformation involves roles and responsibilities, performance metrics, decision-making practices, and widely distributed competencies: digital is no longer experienced as an add-on, but as the infrastructure that enables the organization to function. In line with the OECD approach, the goal is not simply to make a service available online, but to build an administration that is digital by design, where technology and data support the entire policy and service cycle (design, delivery, monitoring, improvement) (Organization for Economic Co-operation and Development, 2020). This is where digital stops being a matter of "compliance" and becomes a capability: the internal ability to govern processes and information independently of any single platform or project. This point is crucial because, in PA, digitalization often begins – for understandable reasons – as a response to external constraints: compliance requirements, procedural obligations, reporting, deadlines, calls for funding, and regulatory measures. But if it remains confined to this dimension, it tends to produce formal innovations: tools introduced without redesigning processes, repositories created without update rules, new software layered on top of old practices, generating even more fragmentation. European benchmarking on e-services also stresses enabling conditions such as interoperability and the maturity of digital "building blocks", highlighting that performance depends not only on the existence of online services, but on the infrastructural and organizational coherence that sustains them (European Commission, 2024; Capgemini et al., 2024).

In recent years, however, one condition has changed significantly: access to enabling technologies has increased. Not because complexity has disappeared, but because platforms and digital infrastructures have become more available, scalable, and "activatable" than in the past. Cloud services, shared environments, collaborative tools, and platform logics have lowered entry barriers that were previously structurally limiting–especially for organizations that cannot continuously invest in proprietary infrastructure. This is particularly true for managing data and documents across the life cycle: the shift towards cloud services and distributed architectures is becoming a strategic European axis, also to ensure interoperability and the sustainability of information ecosystems (European Commission, 2025; Manganelli & Schnurr, 2024).

In Italy, this direction is also explicitly formalized. The Strategia Cloud Italia and the cloud-first principle are framed as levers to make the digital infrastructure of Public Administration more reliable and secure, promoting operational continuity, service standards, and data governance – also through mechanisms such as service qualification, data classification, and strategic hubs (Agenzia per l'Italia Digitale, 2026a; Dipartimento per la trasformazione digitale, 2026). The 2024–2026 Piano Triennale per l'informatica nella PA further positions cloud, interoperability, and data management as structural pillars rather than isolated initiatives: digital transformation is described as a coordinated process requiring rules, infrastructure, and service design aligned with the European framework (Agenzia per l'Italia Digitale, 2026b). Yet greater accessibility does not mean "ease". And this is where the most defensible point of the introduction comes in: technology is not enough. The main risk–even in Public Administration–is to interpret innovation as the selection of a platform or a migration to a new tool, assuming that the transformative effect will emerge automatically. Research and international guidance on digital government consistently emphasise a recurring principle: success requires governance, leadership, alignment between strategy and implementation, and distributed responsibility across the public system. The OECD's E-Leaders Handbook, for example, directly stresses the need for coordination between strategic design and execution, agile management, and the responsible involvement of stakeholders (OECD, 2021). Consistently, a more recent OECD report on investments in public digitalization highlights that sustainable transformation depends on a "whole-of-government" strategic approach, capable of governing risks and steering public spending towards measurable outcomes (OECD, 2025).

In other words, what truly makes the difference is the integration between tools and ways of working. Digital fails when it remains a "tool" rather than becoming a "way of working". Public Administration may have accessible – and even funded – technologies, but if it does not clarify who decides, who updates, who validates data, and by which metrics, innovation remains fragile and reversible. This also brings out another structural issue: digital transformation in the public sector is largely a matter of human capital and organizational competencies. The OECD's framework on digital skills in the public sector focuses precisely on the need to build working environments, competencies, and a workforce capable of sustaining the maturity of digital government (OECD, 2021). And the most recent research on digital innovation strategies in Public Administration shows that there are different ways of creating value (adaptive, anticipatory, persistent, and so on), but all of them imply orchestration–not a simple technological procurement (Guenduez et al., 2025). This framework leads to an operational consequence that connects directly with your thesis: in Public Administration it is not enough to digitize documents; capabilities and processes must be transformed. Without clear management of roles, data, and responsibilities, technology does not generate stable value: it produces local outputs that often fade when the project ends or when turnover occurs. This is why BIM–FM integration cannot be framed as a "software project" or a technical migration: it is a capacity-building pathway that must include skills development, governance definition, and the alignment of processes and data with the public mission.

From this perspective, digital transformation in PA does not coincide with the introduction of more advanced tools, but with the ability to make information assets usable in operations – and therefore decisive for service continuity, administrative traceability, and the quality of decisions. This is precisely where the thesis positions its contribution: not "doing BIM", but enabling–through training and integration–a BIM that can genuinely support public Facility Management.

1.3 A realistic premise: BIM exists, but ordinary adoption remains difficult

Today it is hard to argue that Building Information Modelling is still "something new". In public policy and across the AECO supply chain, BIM has become a stable presence–also because, over the last few years, it has been supported by an increasingly solid reference framework made of standards and a gradual institutionalisation of information management processes throughout the asset life cycle (think of the ISO 19650 family and its guidance on roles, information flows, and security) (EN ISO 19650-1:2019; Cavallo et al., 2023). In the Italian context, moreover, the regulatory trajectory has made digital information management in public contracts progressively less "optional", pushing contracting authorities to develop tools, requirements, and capabilities that align with the evolution of public procurement (D.Lgs 16/2017; D.Lgs 34/23; Arcella, 2025).

This progressive consolidation is also reflected in the recent evolution of public tenders for architectural and engineering services (OICE, 2026). As shown in Figure 1, between 2017 and 2025 the total number of S.A.I. tenders decreased significantly, from 6,024 to 2,363, while BIM-related tenders increased from 83 to 638.

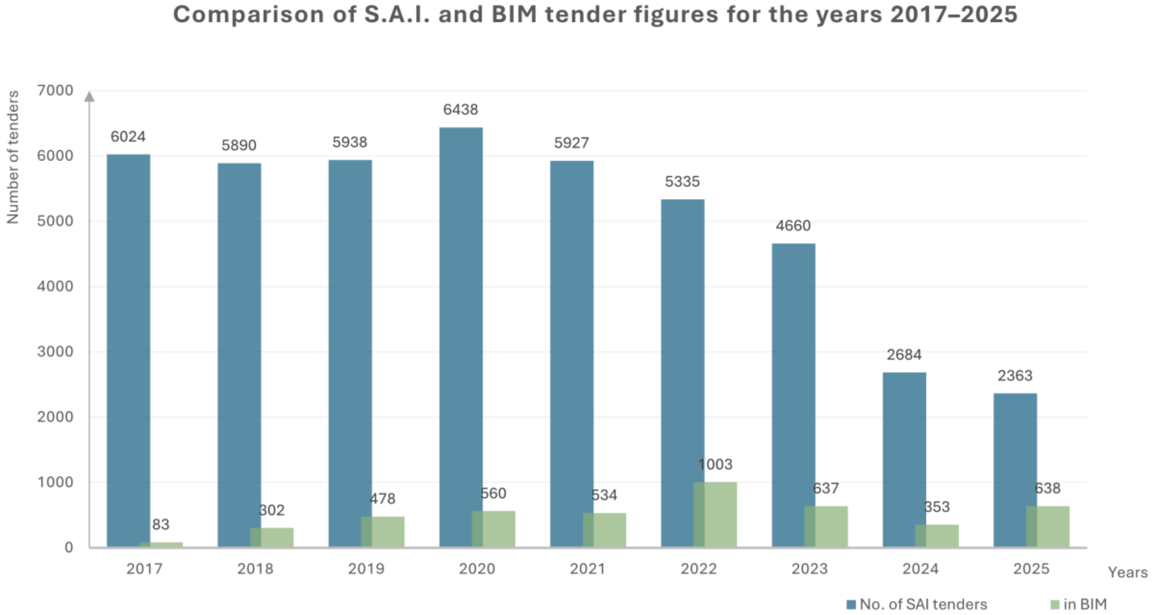


Figure 1 – Annual trend of S.A.I. tenders and BIM-related tenders in Italy, 2017–2025. [source: OICE Reports on Digital and BIM Tenders, I–IX; Author's elaboration]

The trend becomes even more significant when read in relative terms: their share of the total rose from 1% in 2017 to 27% in 2025 (Table 1).

Table 1 – Annual number, value and BIM incidence of S.A.I. tenders in Italy, 2017–2025. [source: OICE Reports on Digital and BIM Tenders, I–IX; Author's elaboration]

Years	Total S.A.I. tenders [No.]	BIM tenders [No.]	BIM incidence by number [%]	YoY change in BIM tenders [%]	Total S.A.I. tender value [€]	BIM tender value [€]	BIM incidence by value [%]	YoY change in BIM tender value [%]
2017	6024	83	1%	-	1 196 242 013.00 €	30 471 303.00 €	3%	-
2018	5890	302	5%	264%	1 250 230 624.00 €	291 526 814.00 €	23%	857%
2019	5938	478	8%	58%	1 501 921 653.00 €	296 317 150.00 €	20%	2%
2020	6438	560	9%	17%	2 412 723 430.00 €	711 615 642.00 €	29%	140%
2021	5927	534	9%	-5%	2 133 780 556.00 €	360 031 600.00 €	17%	-49%
2022	5335	1003	19%	88%	4 421 786 501.00 €	2 103 672 026.00 €	48%	484%
2023	4660	637	14%	-36%	3 834 445 725.00 €	1 249 084 754.00 €	33%	-41%
2024	2684	353	13%	-45%	1 690 512 500.00 €	596 180 962.00 €	35%	-52%
2025	2363	638	27%	81%	2 650 747 853.00 €	1 496 883 672.00 €	56%	151%

A similar pattern emerges in financial terms. As shown in Figure 2, the value of BIM tenders grew from €30,471,303.00 in 2017 to €1,496,883,672.00 in 2025, while their share of the total value of S.A.I. services increased from 3% to 56%.

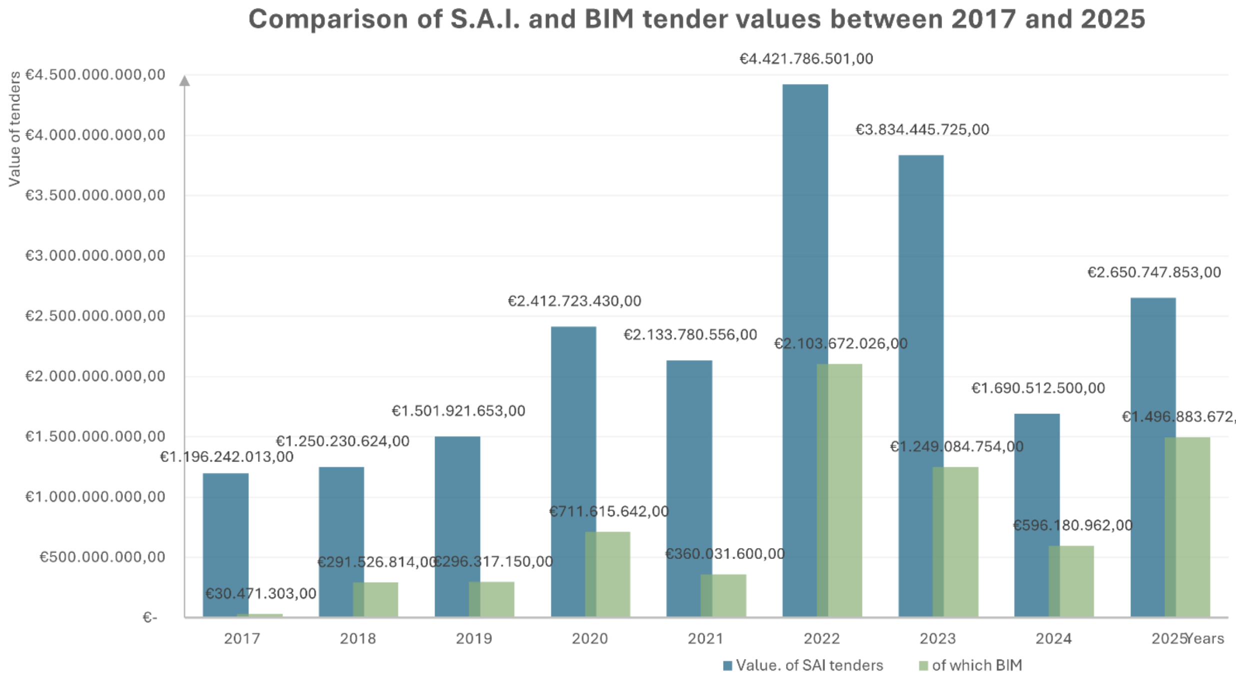


Figure 2 – Economic value of S.A.I. tenders and BIM-related tenders in Italy, 2017–2025. [source: OICE Reports on Digital and BIM Tenders, I–IX; Author's elaboration]

The overall trend is not linear, but marked by fluctuations: an initial phase of growth is followed by a slight decline in 2021, a sharp acceleration in 2022, a contraction in 2023-2024, and then a renewed increase in 2025, when BIM tenders rose by +80.7% in number and +151.1% in value compared with the previous year. Taken together, these figures show that BIM no longer occupies a marginal place in the public market for technical services; rather, it is becoming an increasingly relevant component, not only in numerical terms but, even more clearly, in economic ones.

And yet, precisely while BIM becomes more widely recognized – and in some cases explicitly required – a contradiction emerges, clearly highlighted by many recent studies: the challenge is no longer **whether** to adopt BIM, but **how** to make it ordinary-repeatable, sustainable, and manageable over time. In other words, the real gap is not between "***no BIM***" and "***BIM in place***", but between pilot adoption and operational routine.

Recent studies and reviews converge in identifying barriers that are rarely purely technical: initial and recurring costs, lack of skills, the time needed to learn and stabilise new processes, cultural resistance, and coordination issues across a fragmented value chain especially when roles and operational responsibilities change (Zucco et al., 2025; Mishra et al., 2024; Burgess et al., 2026; Lin et al., 2025).

At this stage, resistance to change should not be read as a rejection of the methodology itself, but as an understandable reaction to moving away from consolidated routines: much like Plato's allegory of the cave, stepping into greater "informational light" can initially be uncomfortable and requires support in order to become a sustainable practice. In the case of PA, this friction is amplified by the need to ensure service continuity and administrative traceability even while the transition is underway. This is a structural fragility: without incentives, clearly defined roles, and continuity in information management, BIM risks remaining an "***event***" rather than a "***method***".

This fragility becomes even more evident when looking at the public sector. Evidence on BIM implementation in public procurement shows that complexity is not only a matter of technology, but of the context itself: procedures, contracts, responsibilities, transparency and control requirements–often within organizations with limited resources and heterogeneous building portfolios (Pérez-García et al., 2024; EU BIM Task Group, 2024)

In other words, PA does not "implement BIM" in a vacuum, but within multi-actor supply chains and administrative constraints that make sustainable implementation a decisive issue: who governs the requirements, who validates information content, and who preserves data consistency as people, contracts, and suppliers change. This is where ordinary adoption tends to break down.

In many experiences (and often in the internal perception of organizations), BIM risks being reduced to three recurring snapshots: a model for tendering, a model for handover, and then–once the design or construction phase is over–a loss of continuity in operations. This is particularly critical because using BIM in management does not merely require a "nice" or "complete" model, but information that is targeted, verifiable, and maintainable - aligned with real Facility Management processes and with the organization's responsibilities.

A substantial portion of BIM–FM literature in the public domain highlights how the lack of integrated and standardized approaches leads to "bespoke" implementations that are difficult to replicate and maintain, often (improperly) shaped around private-sector logics (Pinti et al., 2022). Studies focusing on information requirements for operational use also show that, to be truly useful, data must be selected and structured around concrete needs (assets/equipment, maintenance history, risks, warranties, operational attributes), rather than accumulated as a generic "digital attachment" (Abideen et al., 2024; Otranto et al., 2025).

Within this realistic premise, the point is not to downplay BIM's potential (which remains enormous), but to recognize that making BIM ordinary is primarily an organizational and capability issue–not an automatic outcome of purchasing software or requiring a model in tender documentation. If an implementation strategy does not bring together requirements, roles, training, information quality control, and update processes, BIM introduction can become episodic: every contract almost starts from scratch, with a cognitive and operational cost that resembles a Sisyphean effort more than a stable transformation (Germanà, 2023).

For this reason, in a thesis focused on Public Administration**, the question is not whether BIM is mature, but whether the organization is in a position to make it routine**: sustainable within budget and procurement constraints, resilient to staff turnover, integrable with Facility Management, and–above all–capable of delivering continuous operational value, not only final deliverables. From this perspective, research cannot stop at describing BIM adoption; it must focus on what makes it maintainable: **implementation, integration**, and **organizational capacity**.

1.4 From BIM models to operational information: the bottleneck of BIM–FM integration

It is often in the shift from handover to operations that BIM's promises start to weaken. In many real-world cases, BIM works well as long as it remains "inside" the design and construction phases, where information modelling supports multidisciplinary coordination and document production. But once the asset moves into operation, the need changes radically: what matters is not "a richer model", but **actionable information**–data that an organization can actually use to run day-to-day Facility Management activities (maintenance plans, asset registers, ticketing, space management, contracts, inspections, and reporting).

The main friction point, therefore, is not modelling more, but making data reliable, maintainable, queryable, and traceable over time, with clear responsibility for who updates and validates it. Without this kind of **operational-grade quality**, FM workflows tend to fall back on heterogeneous tools (PDFs, Excel files, emails, individual know-how), and BIM's information value quickly dissipates. Recent studies on asset information delivery show that these difficulties are not simply "downstream" of design–they are structural, and they emerge when information needs for operations are not defined, contractualised, and made verifiable from the very beginning (Tsay et. Al., 2022; Godager et al., 2024).

This discontinuity is closely linked to a recurring mismatch: the BIM deliverable is often coherent with a **project-oriented** world, while FM operates in an **operation-oriented** one. ISO 19650-3:2020 makes it clear that the operational phase requires a distinct and continuous information management process–not simply a "final handover package" (ISO19650). From this perspective, the key issue becomes **information continuity** across phases (design → construction → handover → operations), and above all the ability to translate models into **Asset Information** governed through requirements: OIR/AIR, plus exchange rules and verification procedures.

Guidance linked to the ISO 19650 ecosystem consistently underlines one central point: without explicit information requirements calibrated to an organization's real processes, information does not "land" in operational use (Bolpagni & Hooper, 2021; Center for Digital Built Britain, 2020; UK BIM Framework, 2021). This is where the bottleneck sits: BIM–FM integration fails not because data is missing, but because data is not designed to be maintained–so it cannot sustain tickets, interventions, audits, and reporting across the full life cycle.

When organizations try to reduce this friction through technical solutions (BIM–CMMS/CAFM integrations, import/export automation, verification workflows), the literature reports promising results, but also delivers a very clear message: technology can improve quality and reduce manual re-entry only if it is embedded within a coherent design of processes, responsibilities, and standardization (Oliviera et al., 2024; Tsay et al., 2022)

Not by chance, several recent contributions stress the role of **openBIM approaches and standards** (e.g., IFC) in mitigating fragmentation and enabling more sustainable operational use of information–especially when systems must stay interoperable over time (and not just "at the moment of handover") (Chatsuwan et al., 2025; Otranto et al., 2025). This becomes even more relevant in the public sector, where integration unfolds across multi-actor supply chains and where the risk of the model "switching off" after tendering or commissioning is significantly higher. This is precisely where BIM–FM integration shows its true nature: it is not a software project, but a **socio-technical** challenge of organizational capability. The question is not "how much BIM", but what it is supposed to simplify: if adoption increases complexity, ambiguity, and dependence on a small number of specialists, operational routines will react–often legitimately–with rejection or workarounds. In many public administrations, this effect is amplified by administrative constraints, turnover, outsourcing, and the need to ensure service continuity while changing established ways of working.

Evidence on digital transformation in the built environment also highlights a structural point: there is a gap between more mature organizations and resource-constrained contexts (skills, budgets, time), which makes it harder to stabilise repeatable and maintainable implementations (Rinchen et al., 2024; EUBIM Task Group, 2024). This leads to a direct implication for this thesis: the real goal of BIM–FM integration in Public Administration is **operational capability**–the alignment of data, processes, and responsibilities that makes information genuinely usable in operations, and therefore useful, sustainable, and scalable over time.

1.5 The missing link: training and governance for BIM–FM integration in PA

In recent years, a number of conditions have made BIM–FM integration more feasible than it was in the past. The growing availability of cloud platforms, data-sharing environments, and scalable digital services has lowered the technical barrier to entry for many organizations, including public administrations. In the Italian context, this trajectory aligns with the institutional cloud-first approach, which frames migration and digital modernization as levers to improve the quality, efficiency, and reliability of public services, while strengthening data governance and security.

However, precisely because technology is now more accessible, a frequently underestimated point becomes more visible: technological enablement is not the same as the organizational capability to use it effectively. In Public Administration (and across the connected supply chain), uncertainty in adopting new practices often stems from very concrete factors: hardware and software costs, the need for qualified roles, resources required to manage the transition, and the risk of an initial drop in productivity–sometimes leading to the paradox of giving up before any real benefits can be observed. Added to this is the unevenness of digital maturity across the actors involved, which makes cooperation and the consistent application of standards more difficult, creating delays and organizational friction (Aprea, 2025; Racca, 2024).

Research on digital transformation consistently shows that digital technologies generate value only when they produce changes in processes, responsibilities, and everyday routines; otherwise, they remain an "add-on" that increases complexity without becoming established practice. In this sense, transformation is not an event (the introduction of a tool), but a pathway: technologies open up disruptions and opportunities, but the direction depends on strategic responses and on the organization's maturity (Verhoef et al., 2021; Vial et al., 2019).

This is particularly delicate in Public Administration, where the benefits of digital innovation must be reconciled with structural constraints: accountability, transparency, controls, heterogeneous stakeholders, and the need to maintain service continuity. Within this perspective, international "digital government" frameworks underline that a mature administration is not simply digitised, but data-driven, user-driven, and capable of operating as a platform–meaning it can orchestrate data, tools, and responsibilities across multi-actor chains and over time. The key issue, therefore, is the ability to govern information processes, not merely the availability of digital solutions (OECD, 2021)

When looking specifically at BIM–FM integration, this distinction becomes highly concrete. BIM workflows increasingly rely on the Common Data Environment (CDE – in italian called *Ambiente di Condividione Dati,* ACDat): a controlled space where information is collected, validated, updated, and exchanged within a managed process. In theory, this is exactly what Facility Management needs in order to move away from fragmented archives. In practice, however, the literature shows that adopting a CDE is not "automatic": its effectiveness depends on how roles, rules, and responsibilities are defined, and on the organization's ability to turn it into an everyday routine (rather than a repository used only at the end). Recent studies on CDEs confirm that the critical issues are not purely technical, but relate to governance, alignment with user needs, and real operational practices (Jaskula et al., 2024; Seyis & Özkan, 2024)

In other words, the digital infrastructure needed to connect BIM and operations is largely available today; the critical challenge is turning that infrastructure into a stable socio-technical system that can support business-as-usual–not only a pilot project. Evidence on barriers to BIM implementation (including in European "late-adopting" contexts) repeatedly points to factors such as skills gaps, resistance to change, stakeholder fragmentation, lack of feedback loops, and difficulties in standardising processes–elements that weaken the transition towards repeatable and sustainable use (Hammes et al. 2026, Lourenço et al., 2025; Zucco et al., 2025). In the public sector, this fragility can be amplified: if innovation remains concentrated in a few specialists or outsourced consultancy support, the administration may obtain a product (a model, a platform, a set of files), but it does not build internal capability. And when capability is not internal, information continuity breaks down: contracts change, suppliers change, people change–and very often, operational logics change as well. This is the point where BIM–FM integration reveals its true nature: it is not a one-off delivery, but an ongoing maintenance of information and responsibilities over time.

A further, non-negligible aspect is that this internal capability is not distributed evenly. Differences in resources between large and small authorities, the presence (or absence) of structured technical offices, the availability of digital skills and dedicated roles all create a potential implementation gap: some organizations can invest in stable structures and roles, while others remain trapped in episodic solutions. The European landscape confirms significant heterogeneity in BIM maturity across the public sector and in adoption conditions; the EU BIM Task Group survey (2024), for example, is particularly useful because it captures this variety of approaches and challenges from the perspective of public authorities (Seyis & Özkan, 2024).

To make BIM–FM integration routine in Public Administration, therefore, a level beyond technology is needed: governance. Operationally, governance means defining information ownership (who "owns" what), validation and update rules (who checks what, and when), responsibilities along workflows (who provides and who consumes the data), and minimum criteria for quality and traceability (what information qualifies as "operational-grade"). This work is less visible than modelling, but it is what prevents BIM from fading out after handover. At this point, it is worth making explicit – without anticipating the "State of the Art" – a specific issue for the Italian context: within the digitalization of public procurement, the availability of platforms does not automatically translate into "full digitalization".

Recent legal scholarship highlights that the first phase has often been dematerialization (translating procedures and documents into digital form), while the current challenge is the shift towards a fully digital, native cycle based on interoperable platforms that enable data integration, continuity of workflows, and – progressively–the use of artificial intelligence techniques. This transition requires cooperation, shared rules, and capability on the Contracting Authority (CA)side; in other words, it makes governance (data, platforms, responsibilities) even more central as a condition for effective digitalization (Aprea,2025; Racca & Ponzio, 2024).

Alongside governance, the other decisive element is training–understood in a strong sense: not as an introductory course, but as operational infrastructure. Public Administration does not simply need people who can *"use software"*; it needs people who can perform real tasks in real contexts: opening and closing tickets, updating asset registries, verifying interventions, querying data, managing handover processes, checking information compliance, producing reports and supporting accountability requirements. This kind of training must produce repeatable routines, and therefore needs to be designed as a pipeline, with onboarding, supported operational practice, and continuous updating.

In this respect, international guidance on digital skills in the public sector is clear: the challenge is not only “technical skills”, but widespread digital talent, the ability to work in collaborative environments, data management as a shared resource, and organizational conditions that allow competencies to be maintained over time. The OECD framework on digital skills for the public sector, for example, stresses the need to create context, roles, and pathways that make skills usable in day-to-day work, not only certified. Moreover, in line with the points you identified, effective training must be supported by internal information and communication efforts: making process changes explicit, involving both managerial and operational levels, clarifying expected benefits and practical impacts, and reducing hesitation and uncertainty during the transition. In this logic, training, operational coaching (e.g., workshops), and shared standards/methods become “connectors” and a common language outwardly as well (towards the supply chain), rather than an isolated compliance exercise (Aprea,2025; Racca & Ponzio, 2024).

This also links to a component that is worth stating here (while leaving its fuller discussion to the “People” chapter): BIM adoption and training are not neutral with respect to individuals. Entering new digital processes affects social and psychological dimensions: perceived workload increases, fear of mistakes, anxiety related to monitoring and control, self-efficacy, role redefinition, and identity-based resistance (***“this is not my job”***).

When transformation is perceived as a burden or as a loss of control, organizations defend themselves: they revert to PDFs, emails, private Excel sheets, and shortcuts. This is why training must also be pedagogical in the most practical sense: situated, progressive, task-oriented, and grounded in real examples–so that BIM becomes a tool that simplifies work, rather than an apparatus that makes it harder.

The conclusion, therefore, is straightforward: technology and standards are not enough. Even when robust tools exist (CDEs, cloud services, interoperability, platforms), BIM–FM integration in Public Administration fails if the socio-technical architecture that supports it is missing: stable governance and training as infrastructure. This is where digital transformation in the public sector takes on its specific profile: it does not coincide with simply “computerizing” activities, but with building management, decision-making, and responsibility capacities grounded in reliable information.

On these foundations, the direction of the thesis becomes both coherent and necessary: if the bottleneck of BIM–FM integration lies in operability and maintainability, then the key lever is not further technical sophistication, but the design of training strategies and governance models that make integration workable in everyday practice, sustainable over time, and replicable across organizations with different levels of resources. This provides the bridge to the next chapter, which formalizes the research framework without anticipating research questions and methodology here.

Chapter 2

Research Framework

2.1 Problem statement: why BIM–FM in Public Administration is still challenging

The ongoing digital transformation of the built environment has necessitated the development of innovative methodologies to manage increasingly complex architectural and infrastructural systems. Building Information Modelling (BIM) has emerged as a pivotal technology in this context, revolutionizing the design, construction, and management of buildings. However, despite its proven potential in optimizing the lifecycle of buildings, the integration of BIM within the FM domain – particularly in Public Administration – remains nascent. The integration of BIM and Facility Management is a process that involves the transfer of data and information from the construction phase of a building project to the operational phase. In public administrations, information management is often fragmented and disorganized, and this weakens data accessibility, communication among stakeholders, and decision-making processes during operations and maintenance. Moreover, the lack of standardized procedures and guidelines for BIM implementation in FM within public institutions limits the effective use of BIM-based models for ongoing facility maintenance and management, raising critical issues related to standardization, interoperability, and technological integration.

2.2 Motivation and research gap: barriers to BIM–FM adoption in the public sector

In recent years, BIM has gained significant traction in the construction industry, particularly in Europe, where several countries have implemented BIM mandates for public projects. Italy is one of the countries that have adopted BIM for public projects, yet adoption within the public sector – especially for FM purposes – has been relatively slow and fragmented. In this broader transition, the concept of Society 5.0 outlines a human-centered scenario in which technologies such as Internet of Thing (IoT), Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reaality (AR) are employed to improve living conditions. Within this vision, building Digital Twins (DT) can act as a bridge between the City-Building-Human system, supporting safety, well-being, and operational efficiency. Despite this context, scientific research and practical implementation of BIM methodologies for FM activities in public buildings are still in an *"embryonic state"* (Pinti et al., 2022), particularly due to the absence of reference standards. This gap motivates the need to investigate how effective frameworks can be developed so that BIM-based models and related digital processes can be fully leveraged in the operational phase.

2.3 Research aim and contributions: research questions, scope and boundaries of research

This research is driven by the recognition that BIM–FM integration can facilitate a more sustainable and effective management of public real estate, offering substantial improvements in data accessibility, communication, and decision-making processes. The objective of this research is the creation of new maintenance management strategies in order to improve the integration between BIM methodology and Facility Management activities and tools. The research aims to implement BIM for FM within public administration by critically analyzing the application of this methodology on complex existing buildings, such as the high-rise building of the Piedmont Region – "*Torre Regione Piemonte"* (TRP) or "Palazzo Unico Regionale" (PUR).

BIM–FM integration involves the creation of a digital model of the building that includes information needed by FM professionals to effectively manage the building, including equipment, facilities, building systems, and data on maintenance and operational requirements. What's more, the model can be updated throughout the building's lifecycle, ensuring that actors involved in FM always have access to the latest information.

According to Soliman et al. (2021), during the initial stages of surveying and building knowledge, it is essential to adopt strategies that incorporate a fusion of scanning technologies to obtain a precise and accurate BIM model – an aspect especially relevant for complex, large-scale buildings.

Within this context, the research questions to be addressed are:

Why is the Italian Public Administration still reticent in applying BIM methodology throughout the lifecycle of real estate?

What activities are useful to standardize the process to define a 3D BIM-based model for direct integration with FM tools?

How much does the lack of BIM–FM integration standards in public administration affect the practical application of the methodology?

This research pathway explores the application of BIM in the Italian public administration, with a specific focus on BIM–FM integration as a data and information handover challenge from project delivery to operations. The work critically analyses BIM implementation for FM on a complex existing public building, using the Torre *Regione Piemonte* / Palazzo Unico Regionale as a key case study, and concentrates on strategies to facilitate integration between BIM-based information and FM tools.

The research is situated in the Italian public-sector context and is developed in collaboration with **Regione Piemonte**, with the involvement of **CSI Piemonte** as the in-house provider of digital services. While the setting is predominantly Italian, EU/international references are considered where relevant to interoperability and information management. The empirical context is the **TRP site**, composed of **six physically interconnected buildings**. Activities are primarily conducted on the main high-rise building ("*Torre*") as the core demonstrator, while the approach is conceived as scalable to the whole site and transferable to similar public organizations managing public assets.

The scope addresses BIM–FM integration through **exemplificative yet scalable asset categories**: (i) architectural/space-related elements (e.g., rooms and doors), (ii) furniture and movable assets linked to public asset accounting, and (iii) selected MEP components, focusing on **mechanical HVAC** (e.g., fan-coil units) and **electrical** assets (e.g., luminaires and electrical towers). The research is positioned between as-built conditions and an FM-oriented **Record Model**, including both handover requirements and **update strategies during operation**. The FM processes explicitly addressed prioritise immediate operational value, particularly **space management**, **workplace management (PDL)**, and **BIM-based maintenance process definition**.

Concerning tools, the PA operates an existing FM platform (**Factotum**) and the study does not aim to replace it or benchmark alternatives; the focus is on integration procedures rather than software development. Interoperability is approached progressively from native environments toward IFC, aligned where applicable with ISO 19650 and especially UNI 11337, including classification guidance tailored to the PA. Out of scope are 4D/5D and cost control, construction-site management H&S, new proprietary software development, and live IoT/BMS integration; XR is treated as experimental and exploratory.

2.4 Methodological approach,

The research methodology is built on two complementary levels, stated from the outset in order to make the overall structure of the work clear. The first level describes the **operational workflow applied to the case study**: the definition of management objectives, the construction of a BIM-based information model oriented towards Facility Management, the integration with the tools actually used by the PA, and the development of strategies for FM 5.0 (Figure 3).

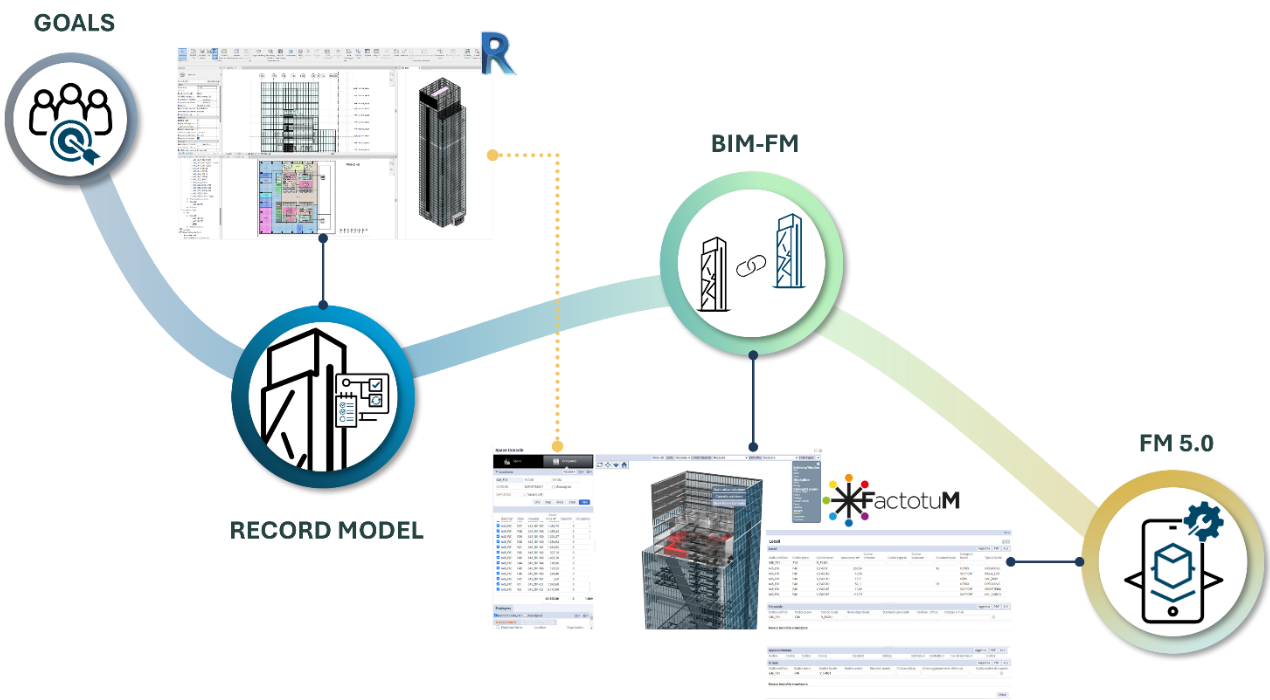


Figure 3 – Operational workflow of the research process. [Author's elaboration]

The second level sets out the methodological architecture of the thesis, organized around three interdependent pillars: Models and Tools, Processes and Documents, and Training and People. The distinction between these two levels allows the research to be read both as an applied experimentation on a real public building and as the construction of a methodological framework that can be transferred to other PA contexts.

BIM–FM continuity is understood as a methodological issue before being a matter of technological availability. The information produced around a complex public building gains managerial value when it can be selected, verified, organized, transferred, and used within ordinary work procedures. BIM is therefore adopted as a methodology for governing information throughout the asset life cycle, with particular attention to the Operations and Maintenance (O&M) phase, where data must support concrete activities: locating a space or an asset, interpreting a request, generating a work order, associating documentary evidence, updating registers, and maintaining coherence between model, platform, and process. Gao et al. (2019) highlight that the application of BIM to management and maintenance activities can improve the visualization, analysis, and accessibility of building information, helping to reduce coordination discontinuities between people, processes, and systems during operational phases.

The operational workflow of the research begins with the definition of management objectives. This phase clarifies which information is needed, for which activities, with which **levels of reliability**, through which tools, and under which responsibilities. Within the research path, this step is also connected to the functional workshop, understood as a moment of discussion among the actors involved in management. The workshop makes it possible to identify and organize operational priorities, recognize roles and responsibilities, begin defining the working group linked to the BIM Office, and focus on the first informational, organizational, and training-related flows. The definition of objectives therefore forms the starting point for building an information model genuinely oriented towards managerial use.

The next step concerns the **construction of a BIM-based model suitable for Facility Management**. The available as-built or as-is model is taken as an information base to be verified, selected, and reorganized. Its use for management requires a targeted transformation of its contents: geometries, parameters, coding systems, relationships between objects, and alphanumeric data must be brought back to the activities that the organization has to carry out over time. The FM-oriented model therefore emerges from a process of critical reduction, reliability checking, and information restructuring, aimed at making the elements relevant to inventory, maintenance, localization, space management, and data updating searchable and usable. This is where the issue of the **Record Model** becomes central. According to the definition proposed by the BIM Dictionary (2024), the Record Model can be understood as an accurate three-dimensional representation of a building, its assets, and its spaces, integrated with alphanumeric data useful for management, such as equipment information, maintenance schedules, and the condition of spaces or elements. Within this research, the Record Model is interpreted as an advanced information configuration of the as-is condition, built from the as-built base and progressively oriented towards Facility Management through simplification, reliability checking, updating, and the enhancement of geometric and alphanumeric data. Its specificity lies in the priority assigned to managerial use: information related to asset management becomes the criterion for deciding what to retain, what to verify, what to integrate, and what to make searchable.

The construction of the Record Model requires one to ***“begin with the end in mind”***, adopting from the outset the point of view of managerial use. Operational questions guide the selection of information: which objects require maintenance; what type of maintenance they require; which data must be associated with objects and spaces; who enters the information; who checks it; who updates it; and through which tools it is consulted. These questions transform modelling into a practice of information responsibility, because they connect each modelling choice to a management function, an actor, a procedure, and a form of control.

The third step of the operational workflow concerns the **integration between the model and Facility Management tools**. The research has an applied character and works on a real Public Administration case study; for this reason, the experimentation is carried out within the perimeter of the tools actually available to, and used by, the organization. In the case study, the reference management platform is *FactotuM*, an Archibus-family tool customized for *Regione Piemonte*. The relationship between the BIM-based model and the FM platform makes it possible to verify which information can be transferred, which requires normalization, which proves redundant or fragile, and which rules are needed to make the transition from model to management controllable.

Hosamo et al. (2022) relate effective asset management to the presence of a system capable of supporting the asset life cycle through tools, techniques, and processes oriented towards the analysis of performance, risks, and costs. Asset digitalization therefore represents an initial condition of the process; its managerial effectiveness depends on the ability to connect model, platform, procedures, responsibilities, and data updating. For this reason, the methodology includes interoperability tests between the BIM model and the FM platform. These tests make it possible to assess the quality of the modelling strategies adopted, the robustness of the transferred data, and their actual usability within maintenance and management processes.

The second methodological representation shows the cyclical structure of the research (Figure 4).

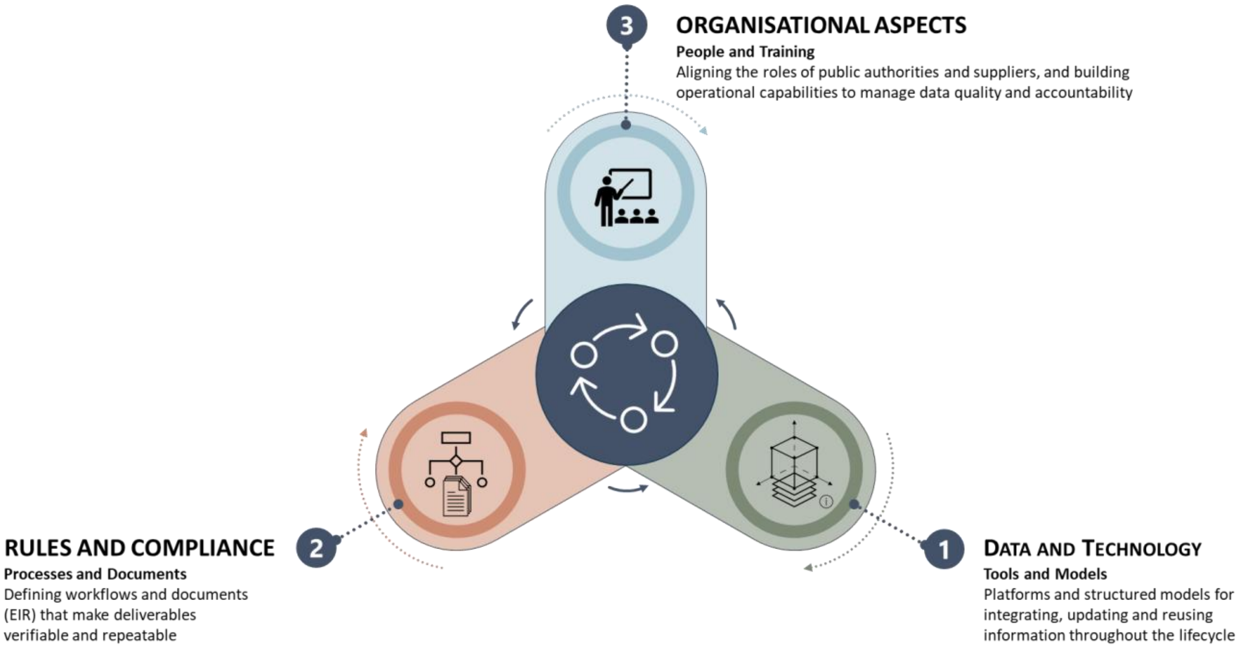


Figure 4 – Integrated methodological framework based on three interdependent pillars: Models and Tools, Processes and Documents, and Training and People. [Author’s elaboration]

The three pillars do not describe isolated phases, because each one acts upon the others and affects their effectiveness.

Models and Tools corresponds to the chapter *BIM–FM Integration from As-Built to Record Model* and concerns the construction of the management-oriented information model, the selection of useful data, the checking of their reliability, and the verification of integration with FM tools.

Processes and Documents corresponds to the chapter *Documents and Processes in the Public Building Life Cycle for FM* and concerns the definition of readable maintenance processes, controllable information flows, responsibilities, updating rules, and requirements expressed in the documents of the Contracting Authority, with particular attention to the *Capitolato Informativo*.

Training and People corresponds to the chapter *People: Training Strategies and BIM Office in PA* and concerns the competences required to read models, formulate requirements, check deliverables, use platforms, interpret data, and stabilize BIM–FM integration within the organization. The methodology of the thesis arises from the alignment of these three pillars. The construction of the model requires clear processes and requirements; processes require documents capable of translating management needs into verifiable deliverables; documents and tools require trained people who are able to use them, check them, and update them over time.

The **FM 5.0** perspective represents the outcome of this recomposition: a form of management in which digital technologies, information models, documents, processes, visualization, and competences are oriented towards supporting the human and decision-making activities of Public Administration.

2.5 Thesis roadmap

The structure of the thesis follows a progression that guides the reader from the definition of the research problem to the construction of the methodology, from the analysis of the theoretical and operational context to the applied verification on the case study, and finally to the discussion of results and future perspectives (Figure 5).

The organization of the chapters reflects the methodological logic based on the three pillars – Models and Tools, Processes and Documents, and Training and People – which are later recomposed within the proposal of *Drawing for FM 5.0*.

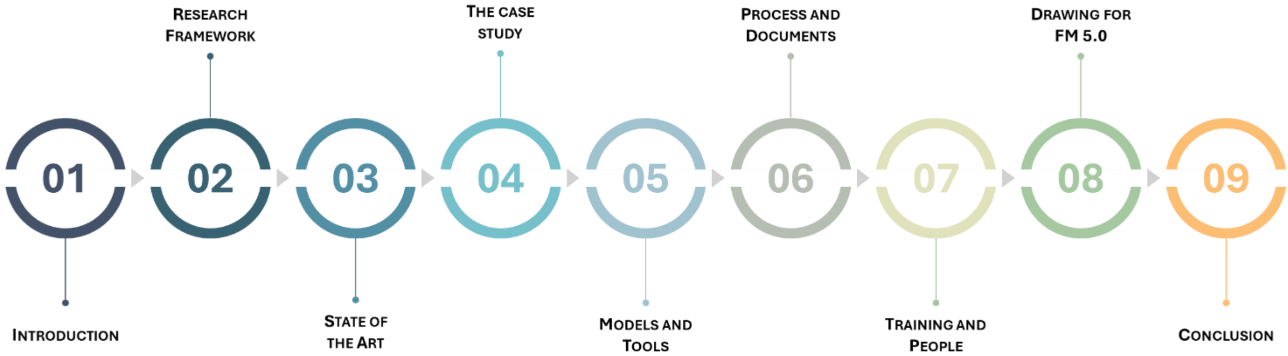


Figure 5 – Thesis roadmap and chapter structure. [Author's elaboration]

Following this structure, the individual sections guide the reader from the general problem of BIM–FM adoption in Public Administration to the operational testing of the proposed framework and its broader interpretative implications.

Chapter 1 *(Introduction)* introduces the issue of public asset management and situates the research within the fields of digitalization of construction processes, Facility Management, and the adoption of BIM in Public Administration. The chapter defines the general context in which the problem of information continuity between design, construction, and management is addressed.

Chapter 2 *(Research Framework)* clarifies the research problem, motivation, scientific and operational gap, objectives, research questions, field of application, and limitations of the work. The chapter also presents the **methodological approach** and the overall structure of the thesis, explaining how the different parts of the work are connected.

Chapter 3 (*State of the Art and conceptual background)* builds the theoretical and scientific framework of the research. The chapter brings together the main contributions related to BIM–FM, life-cycle information management, public-sector digitalization, Facility Management, and evolutionary trajectories connected to digital tools for building management.

Chapter 4 *(The Case Study: a real complex building)* introduces the case study of the ***Palazzo Unico della Regione Piemonte***, understood as a real and complex public building. The chapter describes the context, the main characteristics of the building, and the reasons why the case is suitable for testing a BIM–FM integration methodology in the public sector.

Chapter 5 *(BIM–FM Integration from As-Built to Record Model)* develops the **Models and Tools pillar**. The chapter addresses the transition from the as-built/as-is model to a model oriented towards Facility Management, highlighting the role of the Record Model as a selected, verified, and usable information base for integration with management tools.

Chapter 6 *(Documents and Processes in the Public Building Life Cycle for FM*) develops the **Processes and Documents pillar**. The chapter analyses the relationship between maintenance processes, information flows, roles, documents, and the requirements of the Contracting Authority, with particular attention to the *Capitolato Informativo* as the instrument through which public information demand can be formalised and made controllable.

Chapter 7 *(People: Training Strategies and BIM Office in PA)* develops the **Training and People pillar**. The chapter addresses the competences required to govern BIM–FM integration, proposes training strategies for Public Administration, and discusses the role of the BIM Office as an organizational structure capable of giving continuity to the competences developed.

Chapter 8 *(Drawing for FM 5.0: Human-Centered Visualization and FM in PA)*, recomposes the three pillars within a use-oriented perspective. The chapter interprets *Drawing for FM 5.0* as a space of convergence between models, processes, documents, training, and visualization, placing technology in support of people and the decision-making activities of Public Administration.

Chapter 9 *(Discussion and Conclusion)* closes the thesis by relating the results obtained to the initial research questions. The chapter discusses the scientific and operational contribution of the work, the limitations of the experimentation, and possible future trajectories for BIM–FM integration in PA.

Chapter 3

State of the Art and conceptual background

3.1 BIM-FM integration

The integration of BIM and Facility Management is emerging as a key element in the effective management of buildings and infrastructure, revolutionizing the way they are designed, built, and managed. Certainly, BIM methodology can **improve construction quality** by integrating technology, processes, and digital data (Fallon & Palmer, 2007). That synergy between design data and operational information is transforming the life cycle of buildings, enabling more efficient management, preventive maintenance, and data-driven decisions to ensure safer and more efficient environments.

The study addressed by Su et al. (2011) focused on how the Building Information Modeling approach can be used to create **3D models for building management and maintenance**. However, these applications have limitations. They can only track and manage the latest maintenance information, events, and problem descriptions in CAD-based 3D models. Unfortunately, there is no automatic system to monitor conditions or schedule maintenance quickly. In the same year, Lee and Akin (2011) tested marker-based Augmented Reality (AR) technology to accurately **identify the condition** of various components. In 2012, Shen et al. (2012) proposed a loosely coupled integration method to support decision-making in facility management and maintenance. They presented a framework to aid decision-making for building maintenance. However, the authors did not provide any detailed information on how to use this framework, nor did they present any specific case studies. In a similar way, an in-depth analysis of multiple case studies was conducted, and the creation of an **all-in-one system** that utilized case-based reasoning to acquire information and insights on building maintenance. (Motawa & Almarshaed, 2013).

Unfortunately, the integrated system was not capable of anticipating the malfunction of building components Motamedi et al. (2014), exploited the **visualization capability of the BIM model** to solve maintenance problems by developing a data model for identifying the causes of failures. However, this automated decision-making process using BIM was not considered in his study.

In their study, Cheng et al. (2017) conducted a comparison between marker-based and marker-less AR applications for indoor maintenance and decoration. Nonetheless, the application in question solely presents maintenance and operational data, while it lacks the capacity for maintenance planning. In the following year, they developed a framework that leverages BIM and FM systems to generate maintenance schedules automatically (Chen et al. 2018). This approach is useful for facility maintenance planning but not for predictive maintenance.

Therefore, it is well-known to all that BIM is a process that involves the creation of a digital representation of a building's physical and functional characteristics. This digital model serves as a database for all building-related information, which can be used across different stages of the building's lifecycle, from design to construction and operation.

As the study conducted by Durdyev et al (2021) states, BIM methodology enables various stakeholders, such as designers, engineers, constructors, and facility managers, to **collaborate more effectively** by sharing the same information. This results in better coordination, reduced errors, and faster decision-making.

Additionally, BIM can help identify and address potential issues early on, leading to cost savings and improved overall project outcomes. Studies have shown that utilizing BIM can result in maximized efficiency, improved information exchanges, and a reduction of costs (Vega Völk, 2017). Parn et al. (2017) conducted a comprehensive literature review on the **potential advantages** of integrating BIM into facility management practices. The use of BIM can also be leveraged during the O&M phase with the assistance of **various technologies** such as visual analytics (Motamedi et al., 2014), VR (Motamedi et al., 2017), or Radio-Frequency Identification (RFID) (Motamedi et al., 2016).

The utilization of **Building Information Modelling** during the operation and maintenance phase of facilities **remains restricted**, despite its proven advantages in the construction industry. In a recent study by Durdyev et al. (2021), various significant obstacles to the industry-wide adoption of BIM during the facility management phase were identified and prioritized. These barriers include contractual constraints that limit access to BIM data, interoperability issues that make it difficult to share information between different software and platforms, high upfront costs that discourage some organizations from adopting BIM, and more.

Addressing these barriers is of utmost importance to unleash the full potential of BIM in the operation and maintenance of facilities. According to the study conducted by Pishdad-Bozorgi et al., (2018), BIM has the potential to be used during the operation and maintenance phase to **incorporate both geometry and parameters** that can support the information technologies used by proprietor organizations. In addition, it can provide significant benefits; it optimizes management processes and can serve as an extensive database for detailed information relating to the constructed asset. BIM models have proven to be an incredibly useful tool for facilitating seamless information exchange between project management and asset management.

According to Vega Völk (2017), the use of BIM models significantly **reduces the time and effort** required for data transfer, restructuring, and management. Moreover, BIM models enable the **streamlining** of operation and maintenance activities by providing pertinent and up-to-date facility information, as pointed out by Vega Völk (2017).

Additionally, BIM data can be harnessed for space management, anticipating maintenance needs, and providing critical background information for renovation projects, as highlighted by Kensek (2015). The integration of tools such as Information Models, Virtual Prototyping and Facility Management (FM) signifies a pivotal transformation. This integration facilitates the optimization of multiscale and multidimensional management of real estate assets, thereby enhancing visualization and control (Fatta, 2020).

However, the effective management of complex systems necessitates a systemic methodological approach and a synergistic interplay between process innovations and enabling technologies (Lauria & Azzalin, 2020).

Such an approach is imperative to mitigate potential criticalities that could undermine the overall quality of management (Giallocosta, 2019).Among the most innovative technologies is the concept of the **Digital Twin** (Grieves, 2014), which serves as a conduit connecting the physical and virtual realms through the deployment of sensors. This connection not only improves the flow of data but also enhances the predictive management capabilities of buildings (Dejaco et al., 2022). The DT allows facility managers to monitor real-time performance metrics, enabling proactive maintenance strategies that anticipate issues before they escalate into significant challenges. Such predictive capabilities are essential in contemporary facility management, where operational efficiency and sustainability are paramount.

While the utilization of BIM has made considerable strides in the construction and management sectors, it is not without its challenges, particularly concerning data fragmentation. However, the adoption of OpenBIM standards and real-time integration techniques can effectively overcome these hurdles. OpenBIM promotes interoperability among diverse software platforms, ensuring that data can be seamlessly shared and accessed by all stakeholders involved in the facility management process. This not only enhances collaboration but also streamlines workflows, thereby reducing the likelihood of errors and miscommunication.

Furthermore, leveraging a modular approach in the implementation of these technologies should simplify the management of architectural complexity (Manni & Valzano, 2023). A modular system allows for the segmentation of various components and processes, thereby facilitating easier updates and modifications as needed. This adaptability is particularly valuable in an era characterized by rapid technological advancements and evolving building codes.

By embracing a systemic and integrated approach that incorporates cutting-edge technologies such as Digital Twin and OpenBIM, facility managers can not only optimize operational efficiency but also enhance the overall quality of building management practices. As the field continues to evolve, ongoing research and development will be crucial in addressing existing challenges and capitalizing on the vast potential these innovations offer for the future of facility management.

3.2 BIM, IoT, and Machine learning for Facility Management

Building Information Modeling (BIM) models, when synergistically combined with the Internet of Things (IoT), herald a new era in operation and maintenance: the era of predictive maintenance. This powerful integration provides a platform for real-time surveillance of building conditions, thereby enabling the forecasting of maintenance needs. Consequently, this allows for the initiation of preventive measures prior to the manifestation of potential complications.

Hao et al. (2010) developed a decision support system for **integrating** corrective, preventative, and condition-based maintenance, suggesting the integration of a condition monitoring system and BIM technology. Therefore, Hallberg & Tarandi (2011) demonstrated how open BIM can facilitate the **implementation of a predictive** lifecycle management system (LMS) for building structure maintenance and the adoption of dynamic long-term maintenance strategies. The paper highlights its specificity for building structures but does not mention the specific degradation models or approaches used for condition prediction. Another study, conducted by Wang e Wang (2017), proposed a **deep learning-based predictive maintenance strategy** but did not provide a demonstration of its practical application.

In the same year, a cloud-based, mobile agent predictive maintenance paradigm was explored to enable rapid collection, exchange, and use of information (Wang et al., 2017). This study found that the methodology used was useful in increasing the accuracy and reliability of fault diagnosis, remaining service life prediction, and maintenance scheduling. In addition, the authors suggested that storing and analyzing these data using effective predictive maintenance algorithms is an important challenge.

The application of machine learning techniques in Building Information Modeling (BIM) processes represents a significant advancement in building management and maintenance. This innovative approach enables more accurate and predictive analysis, thereby optimizing the efficiency of maintenance operations. Back in 2013 Silva et al, utilized multiple linear regression analysis and Artificial Neural Networks (ANN) to estimate façade coating durability and service life, revealing that statistical data-based studies are insufficient. Wang e Wang (2017) discussed the **impact of Artificial Intelligence** (AI) on predictive maintenance in advanced production systems. Deep learning is being integrated into predictive maintenance strategies, but it requires large data sets for effective use.

The success of predictive maintenance applications relies on selecting the right machine learning method. Carvalho et al. (2019) conducted a systematic literature review of the machine learning techniques used in predictive maintenance and found which ones are currently being explored. They also evaluated the **performance of the state-of-the-art** machine learning techniques in this field.

Moreover, der Mauer et al. (2019) found that predictive maintenance methods usually **require deep integration** with specific machines. They used specific neural networks to analyze sound sequences and found that their approach could help solve predictive maintenance tasks, but their implementation often faced technical, legal, and financial restrictions.

3.3 Digital Twin for Facility Management

The concepts of BIM and Digital Twin are frequently conflated, leading to confusion. Generally speaking, BIM's primary objective is to create a three-dimensional model of a physical object, while DT technology is intended to replicate and simulate that object's characteristics (Hosamo et al., 2022). It is essential to understand the differences between these two technologies, as they have distinct use cases and require different approaches.

The BIM model is the **fundamental data infrastructure** for the creation of a DT. Indeed, it when well-structured provides an accurate and detailed digital model of the building. In 2019, the CIRP Encyclopedia of Production Engineering (Stark & Dameraru, 2019) provided a detailed description of DT. As per this definition, a Digital Twin refers to a **virtual replica** of an active product, machine, object, service, or even an intangible asset. It may also denote a distinctive product-service system that comprises both a product and a related service.

This digital copy is constructed by utilizing models, information, and data that accurately capture the essential features, properties, conditions, and behaviors of the original object or system. The scope of the DT can extend across various life cycle stages of the real-world object or system (Grieves & Vickers, 2017; Grieves,2014).

The definition emphasizes the need for a DT to represent only one asset as a unique product. This is because the accumulation of information about the product's history is essential. The previous damage or repairs will significantly affect how the product responds to loads in the future. Ongoing research is currently exploring ways to integrate the DT concept with Artificial Intelligence, Machine Learning, and Big Data Analytics. The aim is to create dynamic models that can learn, adapt and update the status of the physical counterpart from multiple heterogeneous data sources (Lu et al., 2020).

According to the study addressed by Ali et al. (2010), the operation and maintenance (O&M) phase in facility lifecycle management is crucial as it is the longest and costliest period in a facility's lifecycle. This statement is also validated by the study conducted by Coupry et al. (2021). In accordance with what Al-Kasasbeh et al. (2020 and 2021) highlighted to achieve smart FM, it is necessary **to integrate and digitize asset management** from the design and construction phases to the O&M phases. Despite its importance, comprehensive asset management plans and data recording are **lacking** in the operation and maintenance (O&M) phase. An intelligent approach to facilities management is needed to ensure their functionality and security (Lu et al., 2020b).

Recent academic inquiry has increasingly concentrated on the integration of digital technologies within Facility Management (FM) across the entire lifecycle of built environments. Among these, **Building Information Modelling** (BIM) has emerged as a foundational methodology, adopted to enhance a variety of critical aspects of facility management, such as maintenance strategies, energy performance optimization, fire safety planning, indoor environmental monitoring, and ensuring occupant comfort (Liu et al., 2020). Nevertheless, the growing demand for real-time monitoring and the need for adaptive, intelligent feedback mechanisms have propelled BIM into its next evolutionary phase, manifesting in the concept of the DT.

The Digital Twin represents a significant advancement by enabling instantaneous, bidirectional integration between physical assets and their digital counterparts, thus facilitating intelligent decision-making through continuous interaction between cyber-physical systems (Haghighat Khajavi et al., 2019). The transition from BIM to DT reflects an evolutionary leap driven by the imperative for more dynamic and intelligent management systems.

Unlike the traditional static models offered by BIM, the DT paradigm allows for real-time data exchange, empowering facility managers to make more informed, data-driven decisions. This instantaneous feedback loop enhances not only operational efficiency but also predictive maintenance, energy management, and safety protocols.

The research of Deng et al. (2021) underscores the organic evolution of DT from BIM, detailing its development through four distinct phases, each representing progressive advancements in the sophistication of digital modeling technologies. This progression highlights the increasing complexity and integration of digital systems within the built environment, culminating in a fully operational DT that mirrors and interacts with its physical counterpart in real time, thereby offering unprecedented levels of control and optimization across the facility lifecycle.

The evolution of DT technology has been marked by a complex and multifaceted process that integrates a wide array of advanced technological tools, including sensors, simulations, and AI. This convergence has significantly enhanced the sophistication and dynamism of the system, presenting transformative possibilities for the fields of design, construction, and facility management. By leveraging these cutting-edge technologies, DT offers a paradigm shift in how built environments are conceptualized, executed, and managed. At its core, DT technology functions as a virtual replica of a physical asset, continuously using real-time data to monitor the asset's performance and behavior.

This real-time capability allows for proactive maintenance and diagnostics, enabling facility managers to identify potential issues before they escalate into costly or catastrophic failures (Florian et al., 2021). The constant analysis of performance data not only helps prevent operational breakdowns but also significantly reduces downtime and enhances the overall longevity and efficiency of assets (Samantas et al., 2021). This proactive approach is bolstered by advanced Internet of Things (IoT) technologies, which include smart sensors, laser scanning, photogrammetric tools, and various measuring devices.

These tools enable DTs to continuously collect and process real-time information about the facility's current status and operational conditions (Almatared et al., 2022). Furthermore, the incorporation of AI techniques, such as machine learning (ML) and deep learning (DL), allows DT systems to interpret and analyze vast amounts of data in real time. Through this process, DTs can monitor the health of a facility, learn from the surrounding environment, predict potential system failures, and provide immediate feedback or recommendations for corrective action. This real-time predictive capability is particularly groundbreaking, as it empowers facility managers to make informed, data-driven decisions that enhance operational efficiency and safety (Ozturk et al., 2021; Moinceanu et al., 2022). The precision and comprehensiveness of the information provided by DT technology significantly improve decision-making processes, ultimately fostering more efficient operations and ensuring the long-term sustainability of assets.

Therefore, Agnusdei et al. (2021) conducted a study to analyze the application fields of DT in supporting **safety management processes**. The review found that DTs have been developed and tested to support operators during normal and emergency conditions, enhance their safety control abilities, and ensure safety levels. Empirical evidence from the research conducted by Katona and Panfilov (2018) indicates that DT is an **essential component** of a smart facility management program. Indeed, according to their study, the utilization of digital twin-based predictive maintenance has become an advanced methodology for monitoring equipment and system performance in real-time. In addition, compared to tzraditional maintenance methods, this approach has been shown to be **more cost-effective** as it enables maintenance or replacement activities only when necessary, thus reducing the risk of unexpected downtime and ensuring optimal uptime.

A significant challenge that has surfaced across various studies is the difficulty facility managers encounter in obtaining detailed and actionable information about their assets through traditional two-dimensional (2D) drawings and conventional facility management systems. These antiquated methodologies frequently contribute to inefficiencies and errors in facility management and maintenance, ultimately leading to heightened operational costs and diminished productivity (Cheng et al., 2020).

The limitations inherent in 2D representations hinder the facility managers' ability to visualize complex systems, effectively stymying their capacity to make informed decisions and efficiently address maintenance issues. To rectify this predicament, Hopland et al. (2018) advocate for facility managers to seek modern solutions that provide more accurate and comprehensive data sets. These advanced methodologies should empower facility managers to streamline operations and enhance decision-making processes.

A compelling solution in this regard is the development of a DT, a sophisticated digital replica of the physical facility, which encapsulates reliable data pertinent to maintenance activities. By utilizing a DT, facility managers can access real-time information and detailed insights that are critical for effective facility management, thereby enhancing operational efficiency and reducing the likelihood of costly errors.

However, existing research on predictive maintenance has often fallen short in equipping facility managers with precise and practical methodologies to forecast the future condition of a building accurately. The traditional approaches to maintenance prediction lack the necessary integration of technologies that can holistically inform predictive analyses. Therefore, it is imperative to adopt a comprehensive approach that synergistically combines Building Information Modelling (BIM) with the Internet of Things (IoT) and advanced data processing techniques. This integrated framework can culminate in the creation of a DT specifically designed for predictive building maintenance (Hosamo et al., 2022). By harnessing the capabilities of BIM and IoT, a DT can not only simulate the current state of the facility but also predict future conditions based on historical and real-time data.

This proactive stance allows facility managers to anticipate maintenance needs before they manifest as significant issues, thereby optimizing resource allocation, minimizing downtime, and enhancing overall asset performance.

Consequently, the implementation of this integrated approach not only addresses the inherent limitations of traditional facility management practices but also paves the way for a more efficient, responsive, and informed operational paradigm in the realm of facility management. While that study contributed greatly to the knowledge about the applications of the DT within the AEC-FM industry, it still **has limitations**. As the authors themselves state, some search terms may have been left out and subjective evaluations were used to find relevant publications.

Therefore, the results may not accurately represent the literature. They defer to future research the development of a complete picture of the research from a global perspective. Certainly, implementing effective maintenance techniques can lead to a significant reduction in building maintenance costs while increasing the service life of building components (Lewis et al., 2011).

Building maintenance management currently employs two distinct approaches, namely reactive and proactive maintenance (Talamo et al., 2019). Both methods are critical in ensuring optimal building performance and **minimizing disruptions** caused by unexpected breakdowns. In conclusion, as Condinhoto et al. (2013) argue, integration between DT and Facility Management is difficult because the two systems operate using **different data formats**, making their integration a complex task. This claim is also endorsed by Lavy and Jawadekar (2018b).

Furthermore, the **lack of an effective information integration technique** between BIM and FM is a well-documented problem in the industry. This presents a challenge for organizations seeking to streamline operations and improve efficiency by leveraging both systems (Chen et al., 2018b).

3.4 BIM-FM in Public Organization

The integration of BIM and FM within public organizations is currently a focal point. The literature on these subject states that BIM has the potential to greatly benefit facility management, yet it remains an area that is underdeveloped (Pinti et al., 2022).

The authors show that while research has largely focused on the use of BIM for hard FM and capital expenditure (**Capex**) projects, knowledge on BIM implementation for soft FM and operational expenditure (**Opex**) projects is limited. Despite its potential to alleviate pressure and improve efficiency, the adoption of BIM in the public sector has been slow. Although some progress has been made in the private sector, the use of BIM-FM in public organizations is **still primarily limited** to pilot research implementations. Governments around the world have emphasized the **importance of modernizing** the facility management (FM) sector by embracing digital technologies (Wong et al., 2018).

According to the *SmartMarker Report* (2014), asset management and asset information have become two of the most critical areas for facility managers. It involves collecting asset data early in the building life cycle, analyzing it, and using it to support decisions during the operational phase (Araszkiewicz, 2017). In 2014, Völk argued that maximizing the efficiency of asset operation through the availability of asset data is a crucial aspect of **improving** the total cost of ownership for large and public buildings (Völk et al., 2014). This is particularly important, given the significant number and complexity of assets in these buildings compared to residential ones. By supporting lifecycle information management, BIM can unlock substantial economies of scale.

In public sector, the use of Building Information Modeling methodology has proven to be important especially in the early stages of a project (Teicholz, 2018). However, its implementation in facility management is still in the nascent stage, especially in terms of its potential advantages for organizations beyond specific projects. Additionally, the value proposition of BIM adoption for public organizations differs from that of private organizations due to the distinct management of public funds (Le et al., 2018).

Leygonie et al. (2022) conducted a careful analysis of the various standards and guidelines for owners who wanted to integrate FM with BIM models. This study found that standards and guidelines such as those provided by organizations like *AIQS & NIQS (2019)*, *Georgia Tech University (2021)*, and the *University of South Florida (2018)*, has revealed that these guidelines often **lack comprehensive information** to ensure the ease of use, efficiency, interoperability, and maintainability of FM models.

Therefore, it is imperative that the guidelines to be provided to facility owners and managers include specific recommendations for the appropriate use of BIM models in FM systems. These recommendations should include the types of data that should be included, the level of detail required, and the format for transmitting data to FM systems.

By providing detailed and comprehensive guidelines, it can be ensured that BIM models are optimized for FM and can be used efficiently throughout the life cycle of a facility. Angusdei et al. (2021), also revealed that the integration of DTs and safety issues represents the most recent emerging research field within the broader DT research field. The United States, Germany, and China were the top countries affiliated with authors of research on the intersection of DTs and safety, with the UK and Italy also being notable contributors.

As Cheng et al. (2015) show, the **lack of guidelines** and standards has contributed to the sluggish adoption rates of BIM-FM implementation. Additionally, public bodies at different levels have established BIM programs, set up BIM goals and implementation roadmaps, and published BIM standards, making them essential actors in leading and supporting the industry towards BIM implementation. As such, their leadership and support are critical to empowering the industry to successfully integrate BIM into their operations. All this is also confirmed by the study of Tan et al. (2018).

The research on BIM-FM implementation in the public sector, as per Pinti et al. (2022), has primarily emphasized the methodological process of integrating technologies. While some publications propose new technological solutions or platforms, the study does not have a prevalent technological orientation. Instead, it mainly focuses on the process aspect, which is described in detail within a methodological framework.

The current literature on the use of BIM systems in the Facility Management phase is limited, which may be attributed to the novelty of the subject matter and the preponderance of process propositions as opposed to challenges and their descriptions, as observed in practical applications of BIM-FM implementation. Publications on the topic tend to prioritize benefits and positive aspects, rather than the challenges encountered (Pinti et al. 2022).

The fundamental challenge of implementing BIM-FM can be summed up by the **lack of standards**, which results in obstacles to effective data and information exchange. Thus, there is a need to define a c**ommon approach** to managing BIM in FM, especially in public environments.

3.5 Synthesis: framework and operational context

Across the reviewed literature, BIM–FM integration emerges not as a simple technological upgrade, but as a socio-technical transition, in which value is generated only when information, processes, and responsibilities are aligned across the operations and maintenance (O&M) lifecycle. On the one hand, BIM–FM studies highlight recurring promises – improved information accessibility, better coordination, and decision support – yet they also report persistent limitations related to handover continuity, the difficulty of keeping models updated over time, and the gap between merely "visualizing data" and enabling truly operational maintenance planning, up to more advanced predictive scenarios. On the other hand, research on BIM–IoT/ML and DTs frames an evolution toward real-time and data-driven management, while also showing that interoperability, data quality, and governance are often preconditions, rather than automatic outcomes.

These issues become even more critical in public organizations, where adoption is shaped by procurement constraints, heterogeneous asset portfolios, pre-existing FM platforms, and the absence (or fragmentation) of operational standards and guidelines that are genuinely aligned with owners' and operators' needs. Building on this synthesis, the thesis adopts an operational lens that interprets BIM–FM integration through four closely interconnected dimensions, as summarized in Table 2.

Table 2 – Operational lens for analyzing BIM–FM integration in the public sector. [Author's elaboration]

Analytical dimension	Object of analysis	Operational focus (BIM–FM)	Implications for implementation in PA	Expected evidence/indicators
LIFECYCLE CONTINUITY	Transition from handover to operations and updating during O&M	Information handover; update rules and responsibilities toward a Record Model	Reduced information loss/obsolescence; clarity on roles and update timing	Traceability of responsibilities; existence of update rules; reduced inconsistencies between "as-is" and operational information; time/effort required for updates
INFORMATION STRUCTURE AND QUALITY	Information requirements, classifications, and granularity	Fit-for-purpose LOI/LOD; data consistency and traceability for FM tasks	Interoperability and reuse; reduced ambiguity and information fragmentation	Data completeness/ correctness per asset; consistency of coding and classification; reduction of missing/duplicate data; extractability (schedules/exports)
ORGANIZATIONAL READINESS	People, roles, competencies, and training	Ability to use the model in day-to-day processes (space/PDL/maintenance)	Sustainable adoption despite constraints and resistance; reduced internal "digital divide"	Pre/post results (questionnaires/tests); perceived usability; reduced time to retrieve information; operational autonomy; confidence in use
ENABLING PROCEDURES AND DOCUMENTS	Documentation and standards for procurement /operations	Guidelines and requirements (CI/EIR) for FM deliverables and integration with tools	Procurement as an enabler; minimum standardization for continuity and controllability	Availability of templates and minimum requirements; deliverable verifiability; reduced contractual ambiguity; replicability of the process in new tenders

Chapter 4

The case study: a real complex building

4.1 The Palazzo Unico della Regione

The Palazzo Unico della *Regione Piemonte* (PURP), also referred to throughout this thesis as the *"Torre della Regione"* (TRP), constitutes the main case study owing to its institutional, urban, and architectural significance. The building is located in the southern sector of Turin (Figure 6), within the Lingotto district, in a transitional area between the railway corridor, the consolidated urban fabric, and the system of open spaces extending along the River Po.

Its location therefore places it within a context that is neither episodic nor self-contained, but rather within a part of the city where long-term processes, morphological discontinuities, and successive functional reconfigurations overlap in a particularly evident way. From this perspective, the Palazzo Unico cannot be read as an isolated architectural object; rather, it must be understood as part of a broader process of urban transformation that shapes its form, role, and meaning within the city. Strategically situated in the *Ex Fiat AVIO* area, the *Palazzo Unico* spans a substantial 70,000 square meters, reflecting its role in a wider urban regeneration project aimed at revitalizing a historically industrial zone. The building complex integrates seamlessly into the urban fabric, contributing to the transformation of the surrounding area and promoting sustainable development.

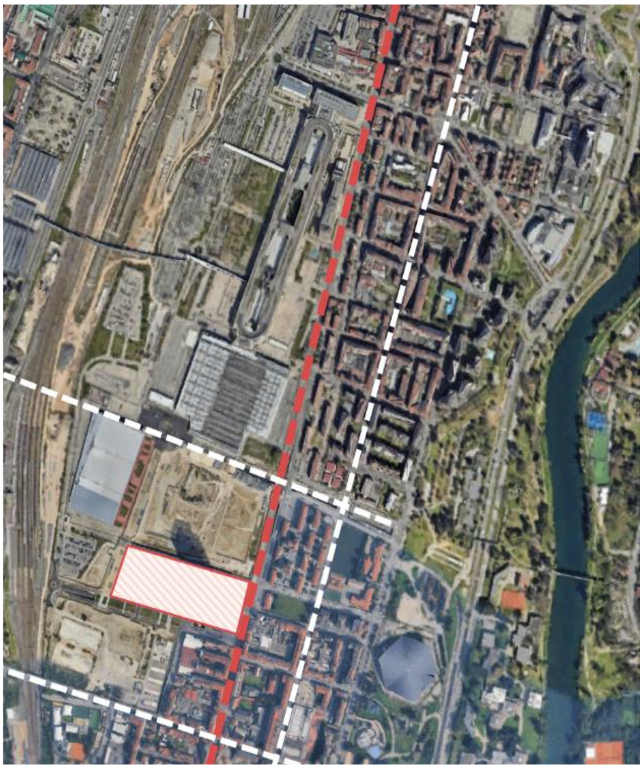


Figure 6 – Territorial framework with case study highlighting. [Author's elaboration]

The site's regeneration aligns with the broader goals of urban redevelopment, aimed at improving both the functionality and aesthetic value of the region.

The centrality of the case study does not stem solely from the scale of the intervention or from the visibility of the building within the urban landscape, but also from the broader framework within which the present research is situated. The doctoral work from which this dissertation originates is embedded in a line of inquiry developed around BIM, Facility Management, and training, within the context of a fellowship funded by *CSI Piemonte* on behalf of *Regione Piemonte*. Within this framework, the TRP project represented from the outset the primary point of reference, not as an abstract illustrative case, but as a concrete operational field through which to examine issues of information organization, built asset management, and process articulation. The relevance of the case therefore also lies in the fact that it constitutes the point of convergence between a real institutional demand and the research objectives of the study. For this very reason, the events and dynamics of the case study acquire their full significance only when read within the broader urban history of Lingotto, a district that cannot be interpreted as a mere modern urban expansion, but rather as the outcome of a long process of transformation: from a settlement outside the consolidated city, structured around historic farmsteads and rural routes, to an industrial district, and finally to a system of new urban and metropolitan centralities. The *"Torre della Regione"* must therefore be understood in relation to this stratified context, of which it represents a recent yet highly significant phase. It is precisely through its relationship with this long urban trajectory that the case study assumes its specific value, not only as a major work of contemporary architecture, but also as an episode inserted into a much broader historical and territorial sequence.

For this very reason, the developments associated with the case study acquire their full depth only when interpreted within the broader urban history of Lingotto, a district that cannot be understood as a mere modern expansion, but rather as the outcome of a long process of transformation. From its earliest origins, the area took shape as a suburban settlement lying outside the consolidated city, organized around historic farmsteads and developed along ancient rural routes connecting Turin, *Moncalieri*, and *Stupinigi*. In this initial phase (Figure 7), the fabric was still dispersed, low in density, and lacking a fully defined urban regularity, although *Via Nizza* had already emerged as one of its earliest structuring axes. This original matrix gives *Lingotto* a historical depth that long predates its twentieth-century industrial image.

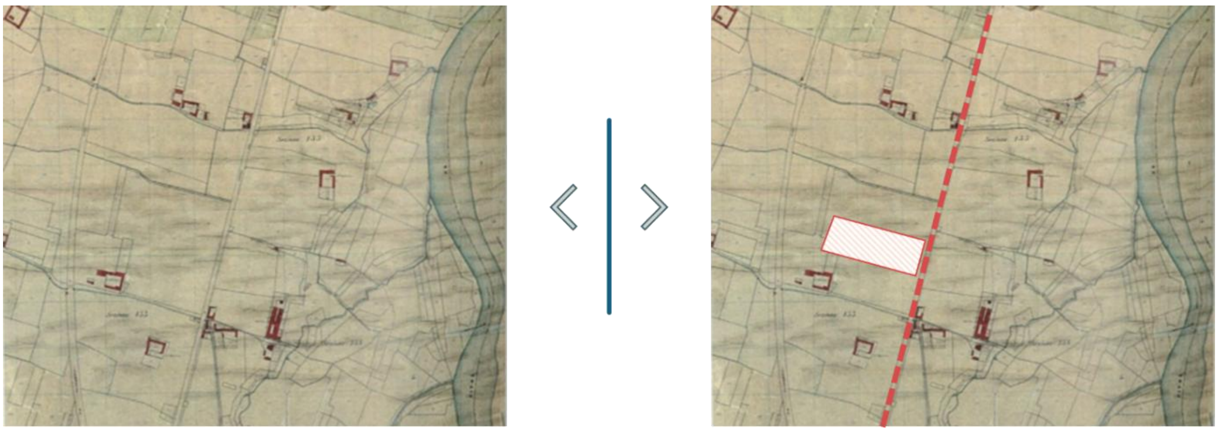


Figure 7 – Extract from the Map of the Municipality of Turin, Catasto Rabbini (1866), with interpretative overlay highlighting the Via Nizza axis and the location of the case study. [source: "Map of the Municipality of Turin, Catasto Rabbini", 1866, Archivio di Stato di Torino; Authors' elaboration]

A decisive turning point occurred in the early twentieth century, when the district was progressively absorbed into the city's strategies of urban expansion and, above all, when the establishment of the *FIAT Lingotto* complex produced a radical historical and morphological discontinuity.

The location of the factory along *Via Nizza* (Figure 8), adjacent to the Turin–Genoa railway line, did not merely respond to a productive rationale; it also triggered a new system of relationships capable of redefining the spatial hierarchies, infrastructures, functions, and settlement patterns of the entire district.

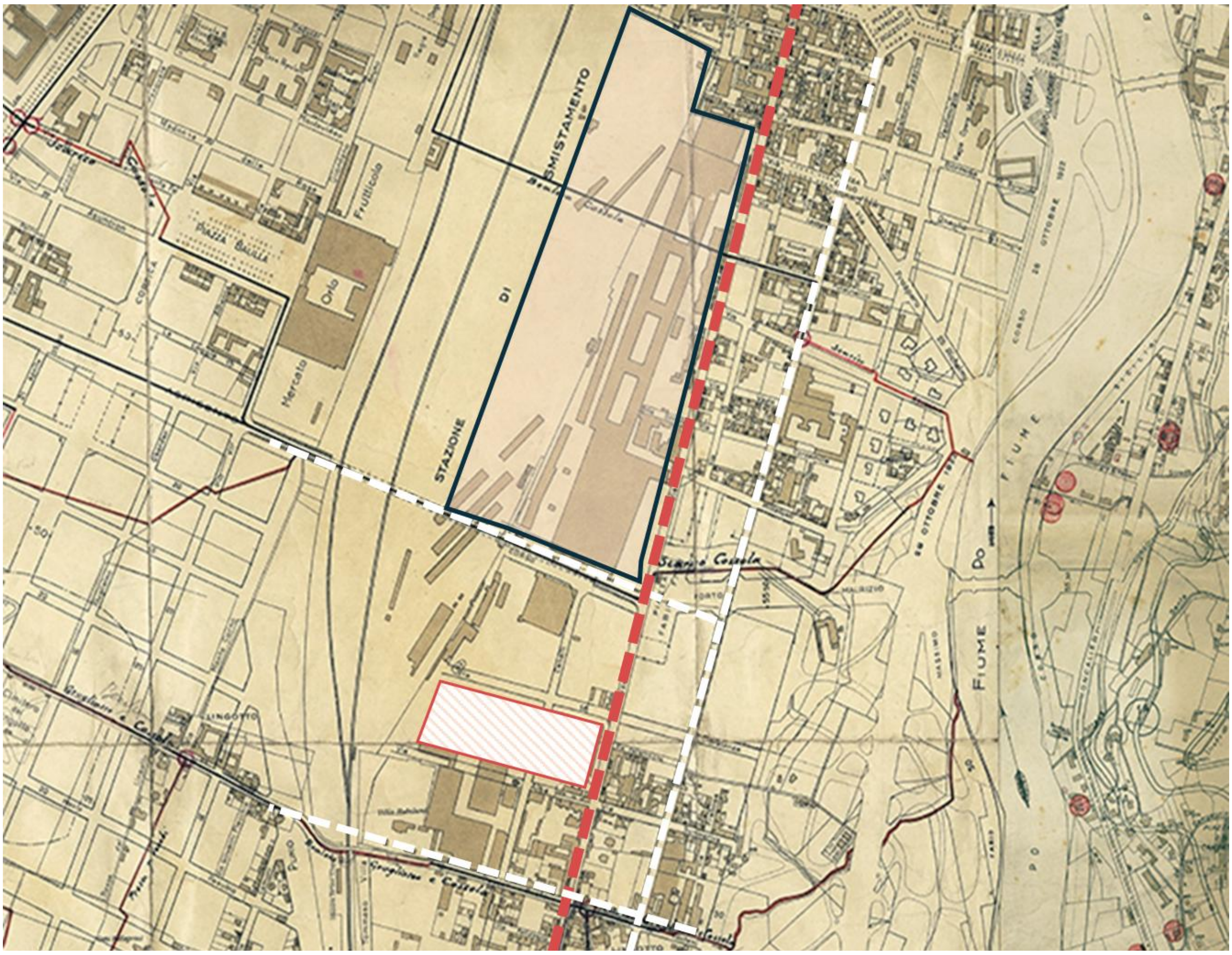


Figure 8 – Extract from the Map of Turin indicating the two Regulatory and Expansion Plans, updated to June 1935 (third variant of the 1908 plan), with highlights of the Via Nizza axis, the case study area, and the former FIAT factory area, now the Lingotto building. [source: Servizio Tecnico Municipale dei Lavori Pubblici, ASCT; Author's elaboration]

From a rural and marginal borough, *Lingotto* thus became an area deeply marked by industrialisation, with new workers' housing, new infrastructures, and a gradual shift in the city's center of gravity towards the major productive presence of *FIAT*. Even today, however, some traces of the original suburban structure survive in the urban landscape, particularly along *Via Passo Buole*, *Via Ellero,* and in certain stretches of *Via Nizza*, although they are now embedded within a profoundly transformed context.

The transformations that shaped the district throughout the twentieth century, however, cannot be reduced to industrialisation alone. The bombings of the Second World War, post-war reconstruction, public housing developments, collective facilities, and, later, the major interventions associated with Italia ’61, the redevelopment of the former Lingotto complex, and the urban changes connected with the 2006 Winter Olympics gradually replaced the earlier suburban and industrial identity with a mosaic of functions, architectural languages, and distinct centers of gravity. From this perspective, the contemporary district appears as a hybrid system in which housing, hospital services, university facilities, commercial activities, industrial remnants, underused spaces, and new metropolitan polarities coexist. Its present identity is therefore neither unitary nor linear, but stratified and partly fragmented, marked by the coexistence of permanence, replacement, and discontinuity.

It is within this condition that the “*Torre della Regione*” acquires its urban significance. The complex is in fact part of a constellation of landmarks (Figure 9) and polarities that structure the contemporary image of *Lingotto*: the Lingotto complex with *Lingotto Fiere*, the *Italia ’61* system with the *Palazzo del Lavoro* and the *Palavela*, the Torino 2006 system with the *Oval* and the *Olympic Arch*, as well as more recent poles such as the *Museo dell’Automobile*, Eataly, and the extension of the metro line to Piazza Bengasi. Within this framework, the *Regione Piemonte* skyscraper emerges as a new institutional landmark at a supra-local scale, capable of reshaping not only the perceptual profile of the southern sector of Turin, but also its symbolic and functional geography.

Figure 9 – Graphic restitution of the perceptual analysis of the Lingotto district, highlighting the main landmarks. [Author’s elaboration]

From a morphological and functional point of view, moreover, the case study does not consist of a single compact volume, but rather of an articulated complex (Figure 10), composed of the office tower, the service center, the basement court, the underground parking areas, and the connecting promenade.

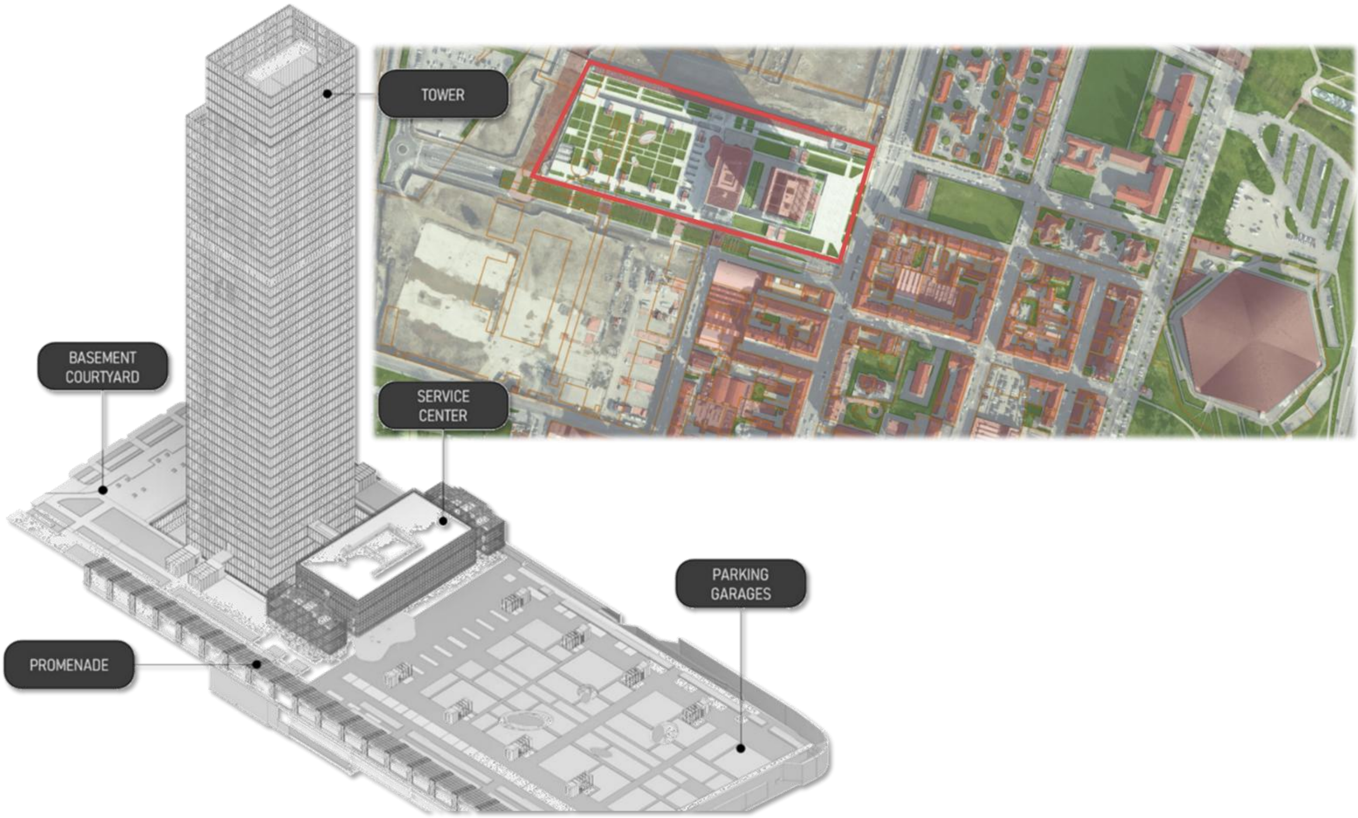


Figure 10 – Close -up site plan of the complex and building subdivision of the Palazzo Unico della Regione Piemonte site. [Author's elaboration]

This articulation is not merely a descriptive feature, but one of the elements that makes the case especially relevant for the purposes of this research: although distinct in configuration, role, and performance, the different building components belong to a single settlement and operational system, in which spaces, access points, technical infrastructures, and functions are organized through complex reciprocal relationships.

4.2 Why can it be considered a complex building?

Defining the Palazzo Unico della *Regione Piemonte* as a complex building does not simply mean acknowledging its large scale or physical size. In this case, complexity does not coincide merely with the extent of the building or with the sheer presence of numerous technical components; rather, it emerges from the interplay between spatial configuration, functional articulation, systems density, continuity of use, organizational structure, and informational framework. The PURP thus presents itself as an organism whose different parts cannot be understood in isolation, since the overall behaviour of the system depends on the relationships they establish with one another and with the surrounding urban context. Its complexity must therefore be interpreted not as a single technical condition, but as the outcome of several overlapping and interdependent dimensions.

Table 3 provides a synthetic overview of these dimensions, identifying the principal domains in which the complexity of the case study becomes manifest. The table is intended to anticipate the discussion that follows, while the subsequent paragraphs examine each dimension in greater detail.

Table 3 – Dimensions of complexity characterizing the Palazzo Unico della *Regione Piemonte* case study. [Author's elaboration]

Dimension	Main characteristics	Why it generates complexity
ARCHITECTURAL AND SPACIAL	Articulated complex composed of multiple buildings, spaces, levels, and connections.	Complexity arises from the internal differentiation of the built system and from the need to hold distinct parts together within a single operational whole.
BUILDING SYSTEMS AND TECHNOLOGICAL	High density of technical systems and coexistence of multiple interdependent disciplines.	Complexity derives from the need to coordinate overlapping, interconnected, and potentially interfering systems.
ORGANIZATIONAL AND USE-RELATED	Major public headquarters characterized by intensive and differentiated patterns of occupation and use.	Complexity lies in the need to accommodate simultaneous operational, institutional, and managerial requirements.
INSTITUTIONAL AND ADMINISTRATIVE	Building serving a hierarchical and articulated public administration with differentiated roles, competences, and responsibilities.	Complexity depends on the need to align the spatial and operational structure of the building with a non-homogeneous institutional apparatus.
URBAN AND CONTEXTUAL	Located within Lingotto, a stratified and transformed urban context marked by infrastructures, landmarks, and multiple centralities.	Complexity is amplified by the building's relationship with an already heterogeneous and historically layered urban environment.
INFORMATIONAL	Large amount of data generated by the plurality of parts, disciplines, and systems.	Complexity emerges from the need to describe, organize, coordinate, and govern the building through an equally articulated information system.

A first dimension concerns the architectural and spatial nature of the complex. As already noted, the case study does not correspond to a single, simple building mass, but to an articulated ensemble composed of multiple buildings. This plurality of volumes is matched by a plurality of spaces, levels, connections, and regimes of use, making the building system internally differentiated already at the morphological level. The tower concentrates a strong vertical and organizational component, while the other parts of the complex perform supporting, access, distribution, and connective functions. Architectural complexity therefore lies not only in the presence of different elements, but in the fact that these elements participate in a single settlement and operational arrangement, within which the distinction between primary spaces, serving spaces, circulation paths, technical areas, and interface zones assumes structural relevance.

Superimposed upon this articulation is a second dimension, related to building systems and technology. A building of this scale and role cannot be understood as a mere container of administrative functions, but rather as a system characterized by a high density of devices, networks, and mutually interdependent technical subsystems. In the case of the TRP, the distinction between architectural, structural, mechanical, hydraulic, electrical, and fire protection disciplines is not merely an organizational convention, but reflects the genuinely multidisciplinary nature of the building. The need to break the model down by buildings, levels, disciplines, sub-disciplines, and groups of floors clearly shows that the technological complexity of the complex could not be contained within a single, undifferentiated representation, but required instead a logic of decomposition and coordination capable of keeping different, overlapping, and often interfering systems under control.

A third dimension, equally decisive, concerns organization and use. The PURP is neither an episodic nor a mono-functional building, but a major public headquarters intended to concentrate administrative activities that were previously distributed across several locations in the city. This entails not only a considerable intensity of use, but also the presence of a plurality of practices, actors, temporalities, and modes of spatial occupation.

In a building of this kind, access flows, security requirements, the distribution of functions, continuity of activities, and the relationship between representative environments, workspaces, services, and technical support areas generate a form of complexity that cannot be reduced to the geometry of the built form alone. Rather, it emerges from the fact that space must simultaneously support different operational, institutional, and managerial needs while maintaining coherence, accessibility, and functionality.

To this is added a specifically institutional and administrative dimension of complexity, linked to the nature of the body housed within the building. The Palazzo Unico does not host a homogeneous structure, but a hierarchical administrative apparatus in which decision-making levels, operational competences, technical responsibilities, and support functions are differentiated and must also find correspondence at the spatial and managerial levels.

Within the specific framework of the present research, this complexity also becomes visible through the administrative actors directly involved, particularly those related to asset management, workplace safety, and the governance of the building itself. From this perspective, the complexity of the case depends not only on the built asset as such, but also on the need to align the building system with an articulated institutional structure in which functions, competences, and operational responsibilities do not coincide linearly, but must be held together within a coherent framework.

This condition is further embedded within an urban context that amplifies the complexity of the case even more. As discussed in the previous section, Lingotto is the result of a long sequence of transformations that led it from a rural settlement to an industrial district, and then to a system of new metropolitan polarities, producing a contemporary condition that is hybrid, stratified, and partly fragmented. Within this framework, the *Torre della Regione* is not only a complex building in itself, but also an object that enters into relation with a context already marked by strong infrastructures, heterogeneous landmarks, differentiated centers of gravity, and morphological discontinuities. Its presence as a new institutional landmark must therefore be read within an urban geography in which industrial remnants, public facilities, cultural poles, mobility networks, and new metropolitan projections coexist.

The final dimension, and perhaps the most important for the purposes of the present research, is informational complexity. A building such as the PURP is not difficult only to construct or to use, but also to describe, organize, coordinate, and represent. The plurality of parts, disciplines, and systems generates a quantity of information that cannot be effectively managed either through fragmented documentation or through a merely geometric representation. The need to introduce logics of federation, decomposition, coding, parameterization, and coordination arises precisely from this condition. In other words, the complexity of the building system inevitably translates into complexity in its corresponding information system. It is precisely this passage—from the real building system to the information system that attempts to represent and govern it—that constitutes the central hinge of this chapter.

From this perspective, the Palazzo Unico della *Regione Piemonte* may fully be regarded as a complex building system, not only because of its scale or its functional articulation, but because several levels of complexity converge and overlap within it: architectural, technological, organizational, institutional, urban, and informational. It is precisely this convergence that makes the case particularly significant for the present research. If in the previous section the complex was framed as a real and historically situated object, here the reasons emerge more clearly as to why it requires instruments of description and organization commensurate with its nature. From this awareness follows the next step: understanding how such complexity was translated into the existing model adopted as the as-built basis of the case study.

4.3 The as-built BIM model: coordination structure and modelling choices

In current Public Administration practice, the availability of a BIM model of an existing building still cannot be regarded as an ordinary condition. In many cases, knowledge-based and managerial activities must still contend with heterogeneous documentation, two-dimensional drawings, partial databases, or unstructured information systems. The case of the *Torre della Regione*, by contrast, belongs to a rather specific situation.

Between 2012 and 2019, *Regione Piemonte* progressively developed a BIM as-built modelling base through a collaboration with the Politecnico di Torino, in particular with the DISEG Department and the DrawingtotheFuture Lab, coordinated by Professor Anna Osello, which supported the digitalization of the project alongside the development of the building itself. Within this framework, the present thesis does not begin from a "blank page," but from a concrete informational pre-existence: a set of BIM models already produced, which must nevertheless be understood, interpreted, and critically assessed in relation to the specific objective of the research, namely their actual usefulness from a BIM–FM perspective.

The existing model of the *Torre della Regione* (Figure 11) therefore constitutes the informational starting point through which the complexity of the case study could be described, organized, and progressively opened to interrogation. Rather than being conceived as a mere geometric restitution of the built asset or as an autonomous representation detached from the actual conditions of the work, it should be understood as a parametric basis developed at an advanced stage of the design and construction process. At that stage, good practice requires a model that can be associated with an *as-built* condition, namely a representation of the building's actual state sufficiently reliable to support its subsequent phases of use and management. From this perspective, the starting point is a parametric model of the work as realised, while the quantity and level of development of the graphic information and associated data may vary considerably according to the purposes of the modelling process. The available model should therefore be regarded as an *as-built* basis for the building, although not yet as a fully homogeneous, exhaustive, and definitively validated representation.

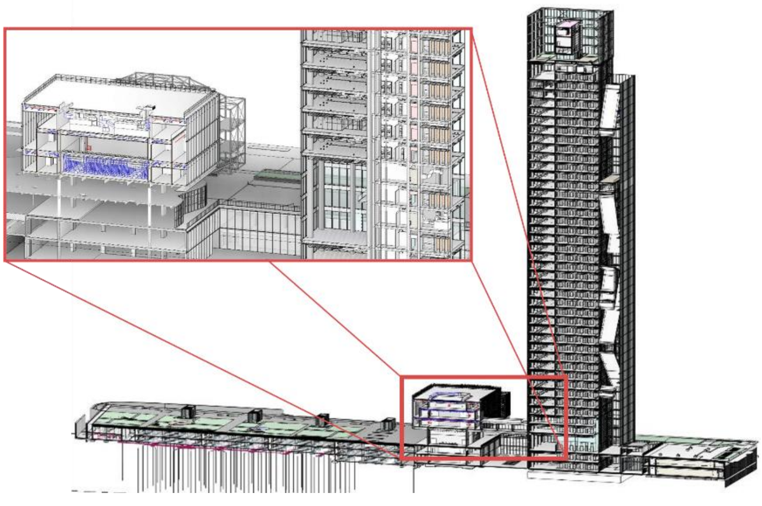
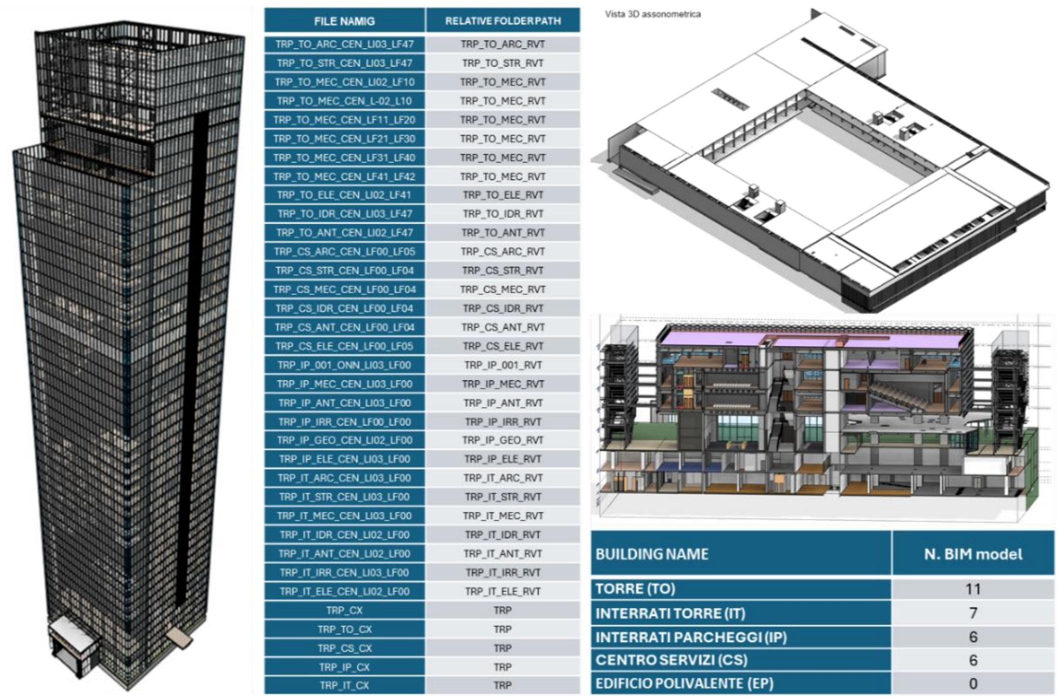


Figure 11 – Cross-sectional detail of TRP BIM model. [Author's elaboration].

This informational base refers to a building complex articulated into five main components: the office tower, the service center, the basement court, the underground parking areas, and the connecting pedestrian promenade. Within this system, the tower is the most prominent and recognizable element: an office building with an almost square plan, approximately **45 meters** on each side, rising over **42 floors**, with **2** basement levels and 3 technical levels, characterized by a double-glazed skin, inclined transverse fins, and a roof garden. These features, together with the scale and functional density of the complex, help explain why its translation into a model could not be addressed as a single compact construction, but required instead an informational articulation consistent with the physical, spatial, and technological complexity of the building. From an operational point of view, this basis was developed in Revit, within a process that involved the progressive updating of the disciplinary and coordination files up to Revit 2019, in order to optimize their use and management in relation to the available hardware, software support, and file compatibility. This aspect, though apparently technical, is in fact methodologically significant, because it shows that the construction of the model was not conceived as an abstract exercise in representation, but as a process concretely shaped by requirements of stability, interoperability, and operational feasibility.

The organizational logic adopted was that of the federated model. The BIM project for the new single headquarters is described as being broken down by buildings, levels, disciplines, and sub-disciplines, according to a strategy based on shared coordinates and model federation (Figure 12). The BIM files were organized into two major groups: single-discipline or integrated models, which were directly subject to modelling activity, and multidisciplinary, building-services, or multisite coordination models, intended for consultation and for the integrated extraction of data. At the end of the activity, there were 30 single-discipline or integrated BIM models; to these were added 4 building-services coordination models, 4 multidisciplinary coordination models, and 1 multisite coordination model, for a total of **39 BIM models** organized according to a naming system consistent with the project guidelines.



FILE NAMIG	RELATIVE FOLDER PATH
TRP_TO_ARC_CEN_LI03_LF47	TRP_TO_ARC_RVT
TRP_TO_STR_CEN_LI03_LF47	TRP_TO_STR_RVT
TRP_TO_MEC_CEN_LI02_LF10	TRP_TO_MEC_RVT
TRP_TO_MEC_CEN_L-02_L10	TRP_TO_MEC_RVT
TRP_TO_MEC_CEN_LF11_LF20	TRP_TO_MEC_RVT
TRP_TO_MEC_CEN_LF21_LF30	TRP_TO_MEC_RVT
TRP_TO_MEC_CEN_LF31_LF40	TRP_TO_MEC_RVT
TRP_TO_MEC_CEN_LF41_LF42	TRP_TO_MEC_RVT
TRP_TO_ELE_CEN_LI02_LF41	TRP_TO_ELE_RVT
TRP_TO_IDR_CEN_LI03_LF47	TRP_TO_IDR_RVT
TRP_TO_ANT_CEN_LI02_LF47	TRP_TO_ANT_RVT
TRP_CS_ARC_CEN_LF00_LF05	TRP_CS_ARC_RVT
TRP_CS_STR_CEN_LF00_LF04	TRP_CS_STR_RVT
TRP_CS_MEC_CEN_LF00_LF04	TRP_CS_MEC_RVT
TRP_CS_IDR_CEN_LF00_LF04	TRP_CS_IDR_RVT
TRP_CS_ANT_CEN_LF00_LF04	TRP_CS_ANT_RVT
TRP_CS_ELE_CEN_LF00_LF05	TRP_CS_ELE_RVT
TRP_IP_001_ONN_LI03_LF00	TRP_IP_001_RVT
TRP_IP_MEC_CEN_LI03_LF00	TRP_IP_MEC_RVT
TRP_IP_ANT_CEN_LI03_LF00	TRP_IP_ANT_RVT
TRP_IP_IRR_CEN_LF00_LF00	TRP_IP_IRR_RVT
TRP_IP_GEO_CEN_LI02_LF00	TRP_IP_GEO_RVT
TRP_IP_ELE_CEN_LI03_LF00	TRP_IP_ELE_RVT
TRP_IT_ARC_CEN_LI03_LF00	TRP_IT_ARC_RVT
TRP_IT_STR_CEN_LI03_LF00	TRP_IT_STR_RVT
TRP_IT_MEC_CEN_LI03_LF00	TRP_IT_MEC_RVT
TRP_IT_IDR_CEN_LI02_LF00	TRP_IT_IDR_RVT
TRP_IT_ANT_CEN_LI02_LF00	TRP_IT_ANT_RVT
TRP_IT_IRR_CEN_LI03_LF00	TRP_IT_IRR_RVT
TRP_IT_ELE_CEN_LI02_LF00	TRP_IT_ELE_RVT
TRP_CX	TRP
TRP_TO_CX	TRP
TRP_CS_CX	TRP
TRP_IP_CX	TRP
TRP_IT_CX	TRP

BUILDING NAME	N. BIM model
TORRE (TO)	11
INTERRATI TORRE (IT)	7
INTERRATI PARCHEGGI (IP)	6
CENTRO SERVIZI (CS)	6
EDIFICIO POLIVALENTE (EP)	0

Figure 12 – Overview of the BIM models for the TRP project, including the file structure. [Author's elaboration]

This arrangement emerges particularly clearly in the coordination diagram reported in Figure 13, in which a central COOR Model aggregates the main building and discipline models, while intermediate coordination nodes organize further specialist groupings, especially on the building-services side. The structure therefore does not follow a simple accumulation of files, but rather a genuinely hierarchical network: at its center lies the general coordination model, to which the main models relating to the different parts of the complex and the principal disciplines are connected; these, in turn – especially in the case of the tower and the mechanical systems – are further articulated into sub-models divided by portions of the building and by groups of levels. From this perspective, coordination is not merely a technical matter, but a strategy for governing modelling complexity, necessary in order to hold together a building organism characterized by a high density of spatial and disciplinary relationships.

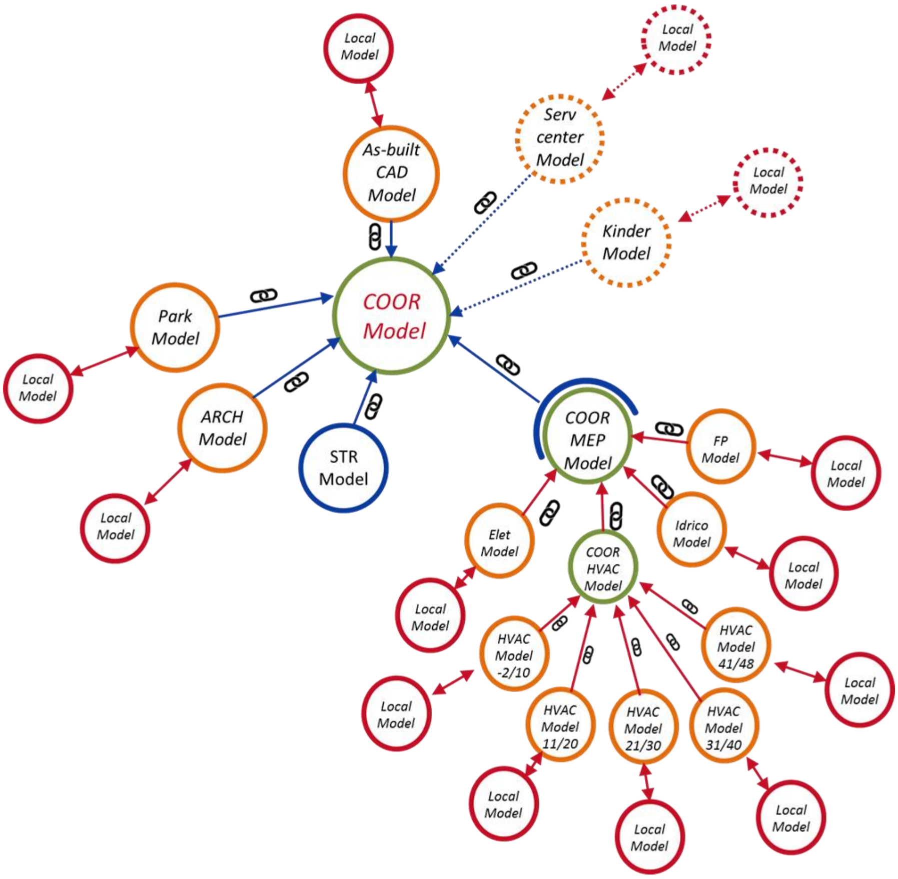


Figure 13 – TRP As-Built BIM Model Coordination Scheme. [drawingTOthefuture LAB's elaboration]

The decomposition of the model directly reflects the complex structure of the case study. The structure of the informational containers clearly distinguishes at least four major partitions – Tower, Tower Basements, Parking Basements, and Service Center – to which must be added the reference to the Nursery, although the latter was not modelled due to the lack of available documentation. Within these, the subdivision then proceeds by disciplines and, in some cases, by sub-disciplines or groups of levels. The summary table in the report shows that there were 11 models relating to the Tower, 7 to the Tower Basements, 6 to the Parking Basements, and 6 to the Service Center, while no models were available for the Nursery. More than a simple inventory, this articulation reveals a principle: the complexity of the built asset was addressed through its controlled decomposition into manageable informational units.

In the case of the tower, for example, there were architectural, structural, plumbing, electrical, fire protection, and several mechanical models, distinguished between smoke extraction and air conditioning. It is significant that the HVAC models in particular were articulated by floor range – LI02-LF10, LF11-LF20, LF21-LF30, LF31-LF40, and LF41-LF42 – alongside a separate smoke extraction model extending across the whole tower. This choice should not be read as a merely descriptive option, but as a direct response to a precise technical constraint: the report explicitly states that the structure of the models was reorganized in order to avoid excessively heavy files, and that the maximum permitted file size was set at **250 MB.**

The segmentation of the mechanical systems by groups of levels therefore also responded to the need to keep the files within manageable thresholds, while ensuring continuity of modelling and the possibility of coordination. The file sizes confirm this choice: the tower HVAC models (Figure 14) were approximately 236 MB, 235 MB, 246 MB, and 247 MB, thus approaching the maximum threshold allowed.

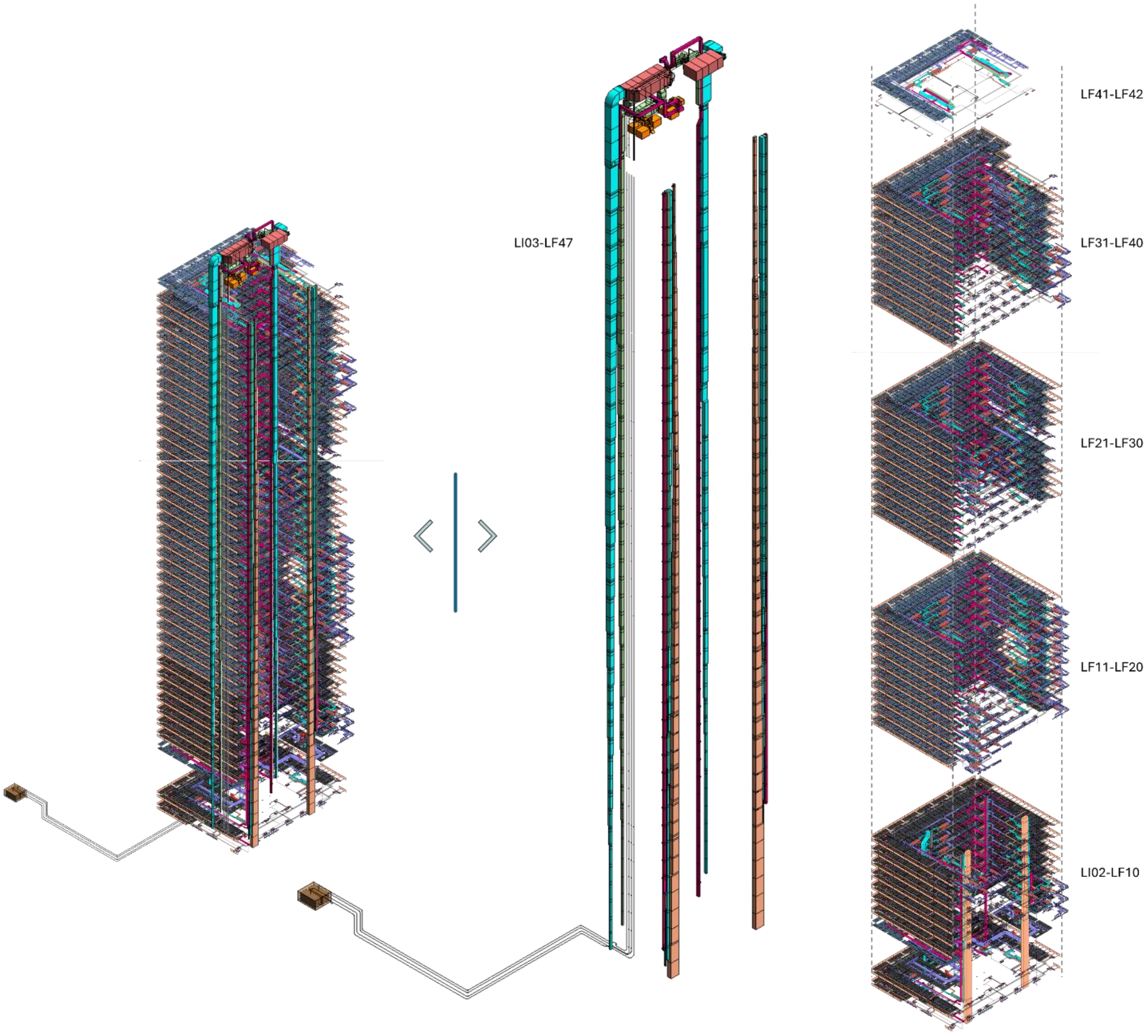


Figure 14 – MEC models of the TRP project. [Author's elaboration]

The modelling choices likewise confirm that the existing model was not intended as a simple three-dimensional replica, but as an organized informational structure. The report notes that Revit's standard project parameters were not sufficient to characterize the model elements and that, for this reason, shared parameters were introduced in order to describe their informational features more effectively and improve their organization. The standard sheet prepared to document the state of the models also shows that the assessment concerned not only geometric completeness, but also CAD–BIM correspondence, coding, the presence and completion of shared parameters, and the quality of geometric and graphic-documentary aspects, in addition to a discipline-dependent variable axis: room creation for architectural models, hierarchical organization of load-bearing elements for structural models, and classification and hierarchy of systems for building-services models. This makes it possible to interpret the model as a construction in which geometry, nomenclature, parameters, schedules, and disciplinary organization all contribute together to defining a structured informational base.

The technical configuration of the model system itself was also calibrated according to operational manageability. The use of worksharing, central models, local copies, worksets, and linked files shows that the construction of the model did not pursue an abstract idea of completeness, but rather a balance between level of development, system performance, and the possibility of collaborative work. In this respect, it is significant that the report explicitly refers to a heterogeneous level of detail across disciplines, adopted to ensure a performant model that could also be used on medium-performance workstations. The file size data likewise confirm this approach: the tower architectural model reached approximately 192.2 MB, the structural model 78.4 MB, the electrical model 181.5 MB, while the smoke extraction model stood at 41.2 MB.

The existing model of the *Torre della Regione* should therefore be interpreted as a federated as-built basis, developed through a logic of disciplinary, building-based, and portion-based decomposition, and supported by a coordination and coding framework designed to make the complexity of the case study manageable. Its importance within this research lies not so much in the idea of any presumed absolute completeness, but in the fact that it constitutes the first systematic translation of the real building into an organized information system. It is precisely from this point that the central problem of the thesis begins: understanding to what extent this basis is actually useful in relation to the BIM–FM objective, and to what extent it must be verified, selected, and reorganized in order to become an informational support genuinely consistent with that purpose.

4.4 Limitations, incompleteness, and reliability of the existing model

If the existing model of the *Torre della Regione* constitutes an informational base of considerable importance for understanding the case study, it is equally necessary to recognize clearly its limitations, its areas of incompleteness, and its only partial degree of reliability. The documentation analyzed shows, in fact, that the model system—although grounded in a coherent federated structure and in an already advanced logic of information organization—still exhibited a condition of heterogeneity across disciplines, portions of the building, and levels of development. In other words, the value of the work carried out does not lie in having produced a definitive and perfectly consolidated representation of the complex, but rather in having constructed a significant as-built base, already rich in contents and relationships, though still marked by unresolved critical issues and margins for verification.

A first issue concerns precisely the non-uniformity of the models' level of development. The state-of-the-art sheets show that the various components of the system had not reached the same degree of completeness, either geometrically or informationally. In the case of the tower, for instance, the structural model is described as substantially complete, but excluding the foundations and the upper floors from the forty-third level upwards; similarly, the architectural model is reported as complete except for the upper stores from the forty-third floor onwards. Some building-services models, however, display different kinds of criticality: the smoke extraction model and the fire protection model for the tower require verification on the upper floors, generally from the forty-second level upwards; the electrical model reveals gaps and inconsistencies both on the upper levels and in relation to Level 10; the HVAC models, although organized by groups of floors and declared geometrically modelled, require systematic verification of duct dimensions and of their coordination with the other disciplines. The first limitation of the available model is therefore its disciplinary and spatial heterogeneity, which prevents it from being regarded as a fully homogeneous and uniformly reliable information system.

This heterogeneity is accompanied by more specifically geometric and coordination-related issues. Several sheets repeatedly highlight problems concerning openings, service shafts, the correct position and thickness of certain structural elements, as well as the need to update the relationship between building-services components and architectural elements. The architectural model of the tower, for example, requires the creation or verification of openings in relation to the building-services components, in addition to the adjustment of certain worksets and specific fire-rated walls; the structural model requires checks on openings, shafts, and the positioning of beams and slabs; the mechanical models of the tower call for verification of duct dimensions, flexible geometry, and diffuser placement, with a consequent updating of openings. The electrical model indicates clashes with ventilation systems and suspended ceilings, while the fire protection model requires checks on the positioning of extinguishers and hose reels and includes levels and views that are not correctly coded.

These issues show that, although the model was structured and already largely usable, it was not yet free from misalignments between disciplines and between representation and the constructed condition.

A further aspect concerns the quality and stability of the alphanumeric information. The report emphasizes that, in many cases, shared parameters had been introduced and were, for the most part, correctly populated, though not everywhere with the same degree of reliability. Some sheets note the presence of materials that had been entered but not coded, the need to rename certain types, the need to verify the correspondence of some parameters with the project guidelines, or the presence of additional parameters whose reliability had not yet been fully validated. In the electrical model of the tower, for example, it is specified that many extra parameters were present but not yet verified; in the fire protection model, levels and views are reported as not being correctly coded; in other cases, material coding remained incomplete. This aspect is particularly important because it shows that the limitation of the model was not merely geometric, but also concerned the informational consistency of the system and, therefore, its ability to support readings that were fully coherent, controllable, and transferable.

There is also a subtler, but decisive, level of limitation related to the modelling assumptions required to fill documentary gaps or inconsistencies between sources. Some of the basement sheets show clearly that, in the absence of univocal indications in the CAD drawings or attached documentation, certain elements had to be reconstructed on the basis of reasonable assumptions that were not, however, fully verifiable. The report mentions, for instance, fictitious system origins, hypothesized placements, inconsistencies between documentation and model, and uncertainties regarding levels, dimensions, or the distribution of technical equipment. Even if these examples concern, in part, areas beyond the tower alone, they confirm a general characteristic of the system: the existing model was the outcome of an advanced process of informational reconstruction, but one not always grounded in documentation that was complete, unambiguous, and coherent. The reliability of the model, therefore, cannot be understood in absolute terms, but rather as a graduated condition, dependent on the disciplines involved, the quality of the sources, and the degree of verification actually achieved.

This does not mean, however, that the existing model should be regarded as inadequate or insufficient. On the contrary, its value lies precisely in being a federated as-built base that is already extensive, articulated, and information-rich, capable of providing a first systematic translation of the real building into a coordinated environment. The presence of limitations, incompleteness, and still-open checks does not diminish its relevance; rather, it more accurately defines its status: not a finished model, but an advanced working base from which a subsequent process of selection, control, and reorganization can begin. In this sense, the heterogeneity of the system represents not only a critical issue, but also an indication of the work still required to transform a plurality of models and contents into a more coherent and purpose-oriented informational arrangement.

It is precisely within this gap – between the available as-built base and a fully reliable, use-oriented informational arrangement – that the transition to the following chapter is situated. The existing model of the *Torre della Regione* constitutes, in fact, an indispensable prerequisite, though not yet a sufficient one, for the construction of a Record Model. If the present chapter has shown how the complexity of the case study was translated into a federated and organized modelling structure, the next step will consist in understanding how this base can be subjected to a process of verification, selection, reorganization, and critical reduction so as to make it more consistent with a controlled and genuinely operational use. From this perspective, the limitations of the existing model do not mark the end of the process, but rather constitute its most important methodological premise.

Chapter 5

BIM-FM Integration from as-built to Record Model

5.1 As-built, as-is and Record Model: from definitions to FM usability

The previous chapter showed that the *Torre della Regione* is supported by a federated, articulated and information-rich BIM as-built base. At the same time, this base is characterized by heterogeneous levels of development, incompleteness and non-uniform degrees of reliability across disciplines, building portions and alphanumeric contents. The issue addressed in this chapter is therefore not the mere availability of a BIM model, but its effective transformation into an information structure that can be used for Facility Management.

This point is particularly relevant because many BIM models are developed primarily during the design and construction phases and incorporate technical, geometric and documentary information that is not necessarily pertinent to operation and maintenance. Moreover, in multidisciplinary processes, the quality and consistency of non-geometric data may be uneven, making stricter control of information contents, shared requirements and validation procedures necessary (Leygonie et al., 2022).

From this perspective, the limited standardization of the information parameters associated with model elements is also a critical issue, as it affects the possibility of verifying the relevance of data in relation to the lifecycle phase and of ensuring their reusability within shared quality assurance processes (Hjelseth, 2010).

In order to address the transition from the available model to a model that is actually usable for management, it is necessary to distinguish precisely between a number of information configurations that do not coincide with one another: the **As-built Model**, the **As-is Model** and the **Record Model**.

These configurations should not be understood as simple increasing levels of detail, but rather as different knowledge conditions, related to different moments and purposes within the building lifecycle. From a BIM–FM perspective, this distinction is essential because it makes it possible to clarify whether the model documents the asset as delivered, represents the current condition of the asset, or selects and organizes the information required for management.

In this direction, Zucco et al. (2024) identify a sequence of knowledge moments – Physical Twin, As-built Model, As-is Model and FM Model – through which the information model can progressively approach the logic of a Digital Twin prototype for maintenance (Figure 15). Within this sequence, the Record Model assumes a specific role, as it represents the configuration through which modelled information is made selective, controllable and oriented towards operational use.

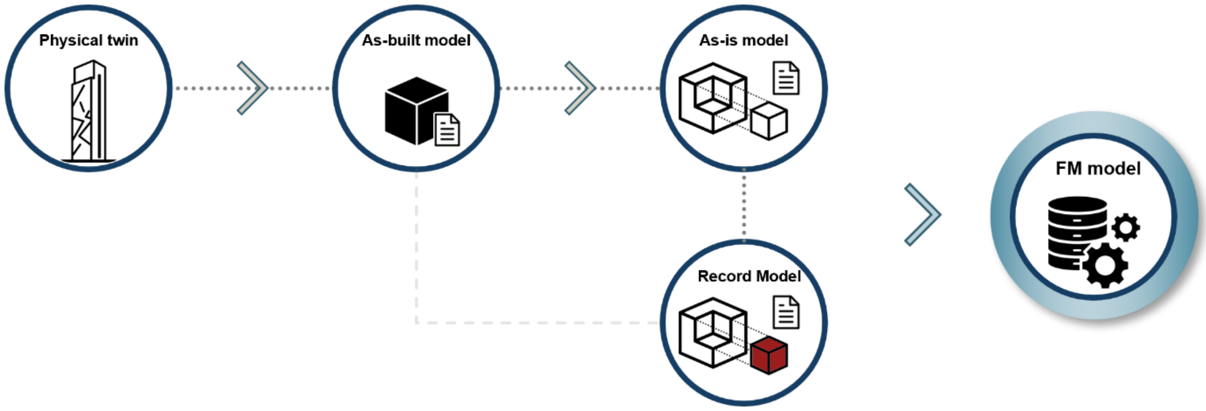


Figure 15 – Knowledge moments from the real building to the model for management, through successive information model configurations. [Author's elaboration]

5.1.1 As-built Model

According to the definition provided by the BIM Dictionary, a BIM as-built model is an accurate and complete digital representation of the physical and functional attributes of a building or other constructed asset, produced at the end of the construction process (BIM Dictionary, 2024a). From a methodological perspective, it can be interpreted as the information configuration of the asset at the moment of handover: not the model of the building as designed, but the model of the building as actually built, or as it should result after the completion of the construction process, inspections and commissioning. Its main function is therefore to document the completed works, representing the final geometry of elements, the position of components, the main physical and functional characteristics of systems and, where available, the technical information consolidated during construction.

The As-built Model, however, should not be reduced to a mere three-dimensional visualization of the asset. It may constitute a complex information container, bringing together geometric data, alphanumeric attributes, technical drawings, product specifications, external documentation and information derived from survey or verification activities. Technologies such as laser scanning can contribute to increasing the accuracy of this representation, especially when the model needs to be compared with the actual configuration of the built asset (Zucco et al., 2024). Its quality, however, does not depend only on geometric accuracy, but also on the coherence and standardization of the data associated with model objects. In the absence of shared information parameters, the model risks becoming difficult to query, poorly compatible with other digital environments and only weakly reusable in subsequent lifecycle phases (Hjelseth, 2010).

This issue is particularly evident in complex and multidisciplinary projects, where the coexistence of different disciplines, models, responsibilities and production methods can generate discontinuities in the quality of non-geometric data and in their actual reliability (Leygonie et al., 2022). For this reason, an as-built model, even when accurate and information-rich, cannot automatically be considered ready for Facility Management. It may contain a large amount of information useful for understanding the building, but not necessarily organized according to the needs of operation, maintenance or asset management. It may preserve data that are relevant to the design and construction phases but redundant for management; at the same time, it may not yet include essential operational attributes, such as unique asset codings, stable relationships with spaces, maintenance data, references to procedures or fields required by the FM platform.

In the case of the *Torre della Regione*, the as-built base described in the previous chapter therefore constitutes the information starting point of the research and can also be represented graphically through the federated model produced to support the documentation of the completed asset (Figure 16). However, this base is not assumed to be a model already fully usable for FM, but rather an initial configuration to be verified, compared and reorganized according to management uses.

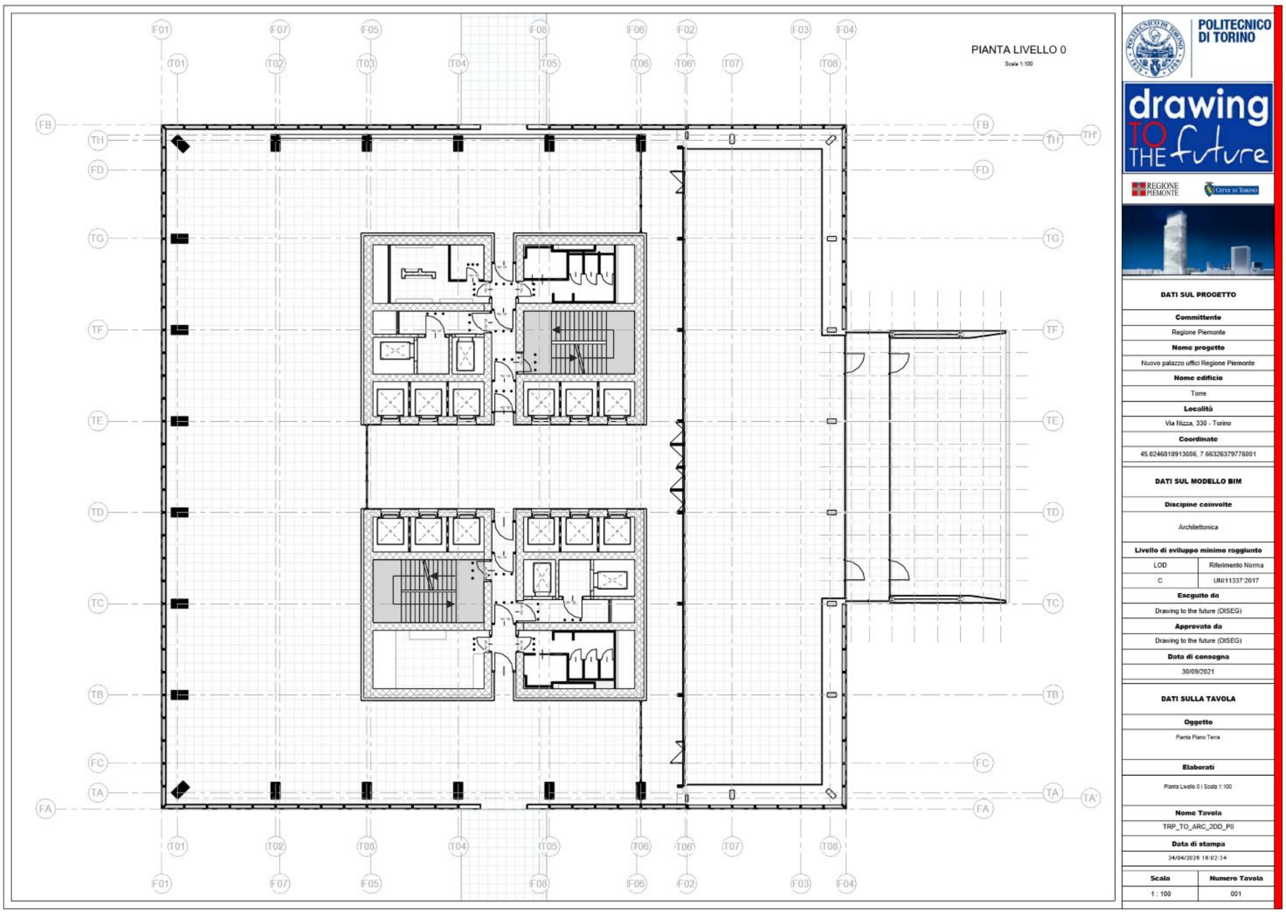


Figure 16 – Graphic output extracted from the as-built BIM model of the TRP project. [Author's elaboration]

5.1.2 As-is Model

The **As-is Model** describes the actual condition of a building at a specific moment during its operational phase. Unlike the **As-built Model**, which documents the asset at the end of the construction process, the As-is Model refers to the current state of the asset, including any transformations that may have occurred after handover, such as spatial modifications, component replacements, building services upgrades, maintenance interventions or changes in use conditions. It can therefore be understood as a temporally situated information configuration, intended to represent the building not as it was delivered, but as it actually exists at a precise moment in its lifecycle (Zucco et al., 2024). The development of an As-is Model consequently requires a process of knowledge acquisition and verification that is more directly connected to the real condition of the building. This process may begin with the review of available documentation – technical drawings, plans, reports, photographs, registers or previous information – but must be supplemented, when necessary, by survey, inspection and data acquisition activities. Techniques such as laser scanning, photogrammetry, topographic surveys, photographic documentation and, in some cases, sensor-derived data can contribute to verifying or updating the correspondence between the physical building and the digital model. The aim is not only to produce an updated geometric representation, but also to associate modelled elements with information that is consistent with the actual state of the asset, such as materials, finishes, maintenance conditions, completed modifications, detected issues or further data useful for understanding its current condition (Zucco et al., 2024).

The relationship between the As-built Model and the As-is Model should not, however, be understood in rigid terms. If BIM-based management is initiated immediately after the completion of works, and if the as-built model has actually been verified against the completed asset, the two configurations may temporarily coincide.

At that moment, the delivered building and the existing building tend to overlap.This coincidence, however, remains valid only until the physical asset undergoes transformations that alter its actual configuration. The first significant maintenance event, the replacement of a component, the modification of a building system, the reconfiguration of a space or the update of a technical fitting may generate a gap between what the model documents and what the building has become.

From this point of view, the As-is Model plays an essential role because it makes it possible to realign the digital model with the physical reality of the asset. Nevertheless, even a model updated to the current condition does not automatically coincide with a model for Facility Management. It may describe the existing condition of the building accurately, but still not be selected, simplified or structured according to the operational needs of management.

It may contain a large amount of information useful for understanding the asset, while still lacking a coherent logic of coding, querying, connection with spaces, relationship with maintenance procedures or integration with management tools. In this sense, the As-is Model represents a knowledge base (Figure 17) necessary to understand the actual state of the building, but it does not in itself constitute a Record Model. The latter requires a further critical step, in which the representation of the current condition is selected and reorganized according to management use.

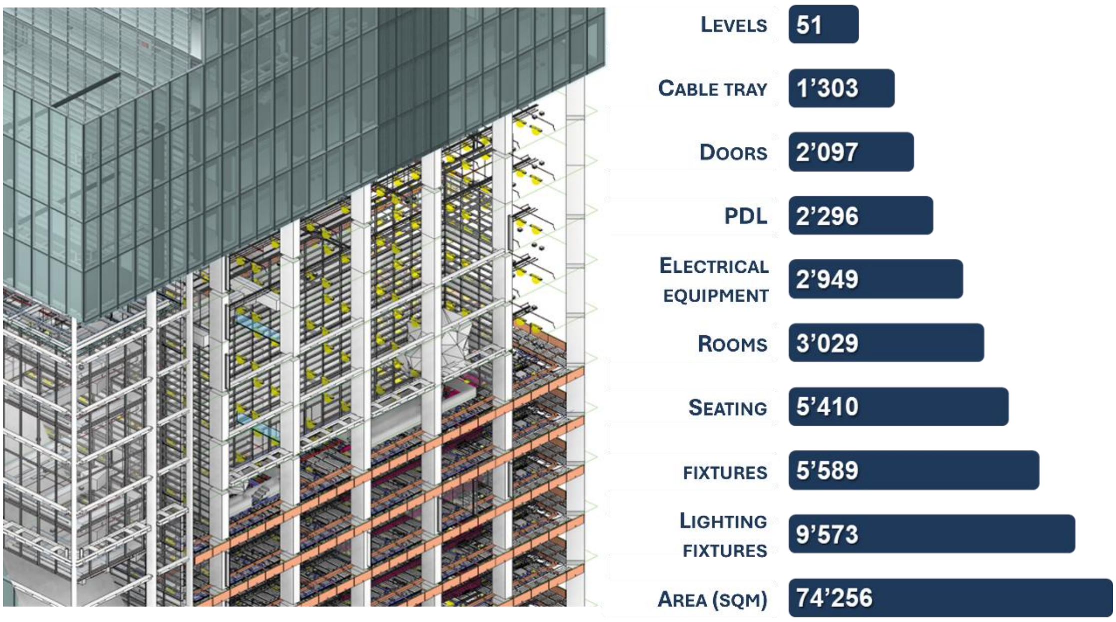


Figure 17 – Representation of the knowledge level and quantitative content of the BIM model for the TRP project [Author's elaboration].

5.1.3 Record Model

The **Record Model** represents the information configuration through which the BIM model is explicitly oriented towards the requirements of building management, maintenance and operational use. According to the BIM Dictionary, it consists in the use of BIM tools to generate an accurate representation of an existing structure, including its spaces, assets, physical conditions and surrounding context (BIM Dictionary, 2024a).

A particularly useful operational definition is also provided by the BIM Project Execution Planning Guide of Pennsylvania State University, where **Compile Record Model** is described not only as an information deliverable, but as a process aimed at collecting and organising information related to facility elements (Figure 18), surrounding conditions and assets, including at least the main architectural, structural and building services systems (CIC Research Group, 2021). This clarification is relevant because it allows the Record Model to be interpreted not as a simple final deliverable or static archive, but as the outcome of a procedure of information selection, verification and structuring.

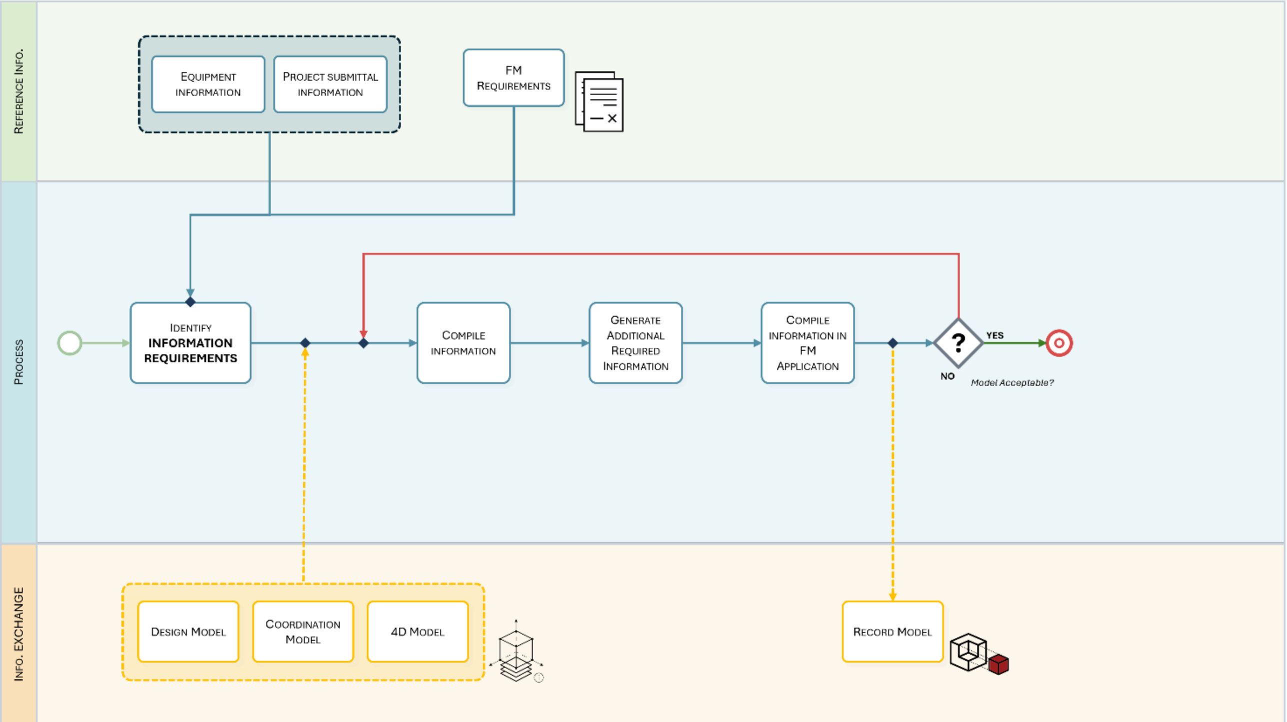


Figure 18 – Author's reinterpretation of the Record Model production process outlined in the Pennsylvania State University BIM Project Execution Planning Guide [Author's elaboration based on the Pennsylvania State University BIM Project Execution Planning Guide]

Compared with the As-built Model and the As-is Model, the specificity of the Record Model does not lie only in the type of content represented, but above all in the purpose for which that content is made available. The As-built Model documents the asset at the end of construction; the As-is Model describes the actual condition of the asset at a given moment; the Record Model, instead, selects and organizes the information that allows the building to be managed.

From this perspective, it belongs fully to the field of BIM for Facility Management, where the issue is not the simple transfer of the entire information asset accumulated during design and construction, but the identification of the information actually required for O&M. BIM–FM literature shows that the efficiency of information exchange between BIM models and FM systems depends on the ability to define, verify and collect information requirements specific to management systems, avoiding both the loss of relevant data and the accumulation of unusable information (Matarneh et al., 2020). From this point of view, the Record Model may be understood as an asset-oriented information structure.

Hossain and Ahmad Tarmizi propose the concept of an **Intelligent BIM Record Model** precisely in relation to the management of built assets, emphasising the need to capture relevant assets within BIM during the construction process and to connect the information required for O&M to a queryable database that can be integrated with the model (Hossain & Ahmad Tarmizi, 2018).

This approach makes it possible to move beyond a purely geometric interpretation of the model: for management purposes, it is not enough to know that an element has been modelled; it must also be identifiable, locatable, queryable and connected to the operational information required for maintenance, replacement, inspection and asset management. The transition to the Record Model therefore requires a change in information priorities.

In FM strategies, it is not always necessary to preserve the highest level of geometric complexity produced in the previous phases; it is often more relevant to ensure the stability, legibility and reliability of the alphanumeric data associated with model objects.

As shown in Figure 19, from this perspective, the **Level of Information** (LOI) tends to assume a prevailing role over the **Level of Geometry** (LOG), since the model's ability to support management depends largely on the quality of codes, parameters, relationships with spaces, technical information and maintenance data assigned to assets (Ugliotti, 2017).

The Record Model therefore does not result from an indiscriminate increase in information content, but from a critical reduction: structures, spaces and components relevant to FM are maintained, verified and organized, while information that is unnecessary or not pertinent to management uses may be simplified, excluded or assigned to other documentary environments.

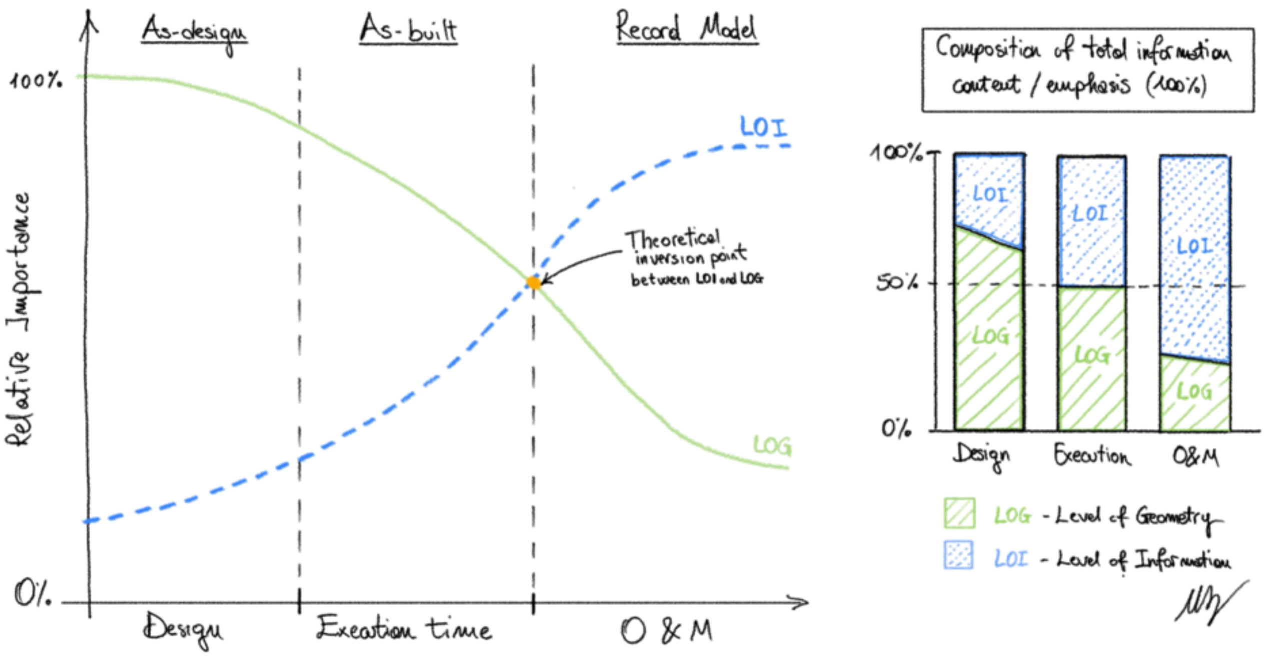


Figure 19 – Qualitative evolution of LOG and LOI from as-design to the Record Model. [Author's elaboration]

This approach is also consistent with more recent studies on BIM information quality for Facility Management. Tsay et al. (2022, 2023) show that BIM can provide an initial source of structured information for the development of asset databases, but that this process requires clear information requirements, defined exchange methods, validation and compatibility between information fields across different digital environments. The same authors question the assumption that all parametric information generated during design is automatically accurate, useful or reusable for management, emphasizing that information quality for FM can only be assessed in relation to needs and requirements explicitly defined by the owner or facility manager (Tsay et al., 2023).

This observation reinforces the methodological meaning of the Record Model: it does not coincide with the richest model, but with the model that is most coherent with the intended operational uses.

From a process perspective, the Record Model must also be considered as a configuration that can be maintained over time. Its usefulness depends not only on the initial quality of information, but also on the possibility of modifying, confirming and updating that information during the operational phase.

Studies on BIM-FM model management show that the use of outdated or incorrect models may compromise BIM implementation in facility management and reduce FM operators' trust in the information system (Lin et al., 2022). It follows that the Record Model cannot be treated as a final and immutable deliverable: it requires update rules, information responsibilities, consistency checks and procedures capable of keeping the physical building, the digital model and the management database aligned.

In light of these considerations, in this research the Record Model is also interpreted as an **as-FM configuration** of the BIM model. This expression is not proposed as an autonomous normative category, but as an operational formulation used to indicate the model prepared for integration with the management system.

The Record Model still exists within the BIM environment and constitutes the selected, verified, simplified and structured base for Facility Management; the FM Model, instead, corresponds to the information configuration generated within the management tool, where the data imported from the model are normalized, catalogued and organized into records and tables.

This distinction makes it possible to separate the BIM model oriented towards management from the management database itself, avoiding any confusion between the information preparation of the model and its subsequent operational use within the FM platform.

In the specific case of the *"Torre della Regione"*, the Record Model is therefore not assumed to be a simple copy of the federated as-built model described in the previous chapter. Rather, it derives from a methodological and operational configuration of the existing BIM model, built through comparison, simplification, updating and selection of the information actually useful for management. Its value does not lie in the highest possible level of completeness, but in its capacity to make the relationship between the physical building, digital objects, management assets and the FM platform governable.

5.1.4 Differences and implications for FM usability

The distinction between **As-built Model**, **As-is Model** and **Record Model** does not concern only the different degree of model updating, but more deeply involves the relationship between temporality, information purpose and management usability.

The three models should therefore not be interpreted as simple variants of the same digital product, nor as progressively more detailed levels of representation. Rather, they correspond to different knowledge configurations of the building: the As-built Model documents the asset at the end of the construction process; the As-is Model describes the actual condition of the asset at a specific moment during its operational phase; the Record Model selects and structures the information required for the model to become effectively usable in management and maintenance processes.

This distinction is particularly relevant because the transition from the As-built Model to the Record Model does not necessarily follow a linear or mechanical sequence. From a theoretical point of view, the Record Model may be understood as a management-oriented selection of the As-is Model, since it should be based on the most up-to-date representation of the actual state of the building. From an operational point of view, however, it may also derive from an As-built Model, especially when BIM-based management is initiated immediately after construction, or when the as-built model represents the most robust information base available. In this case, the as-built may temporarily coincide with the as-is, provided that it has been verified against the actually completed asset and that the building has not yet undergone significant transformations.

This coincidence, however, is always temporary: any maintenance intervention, component replacement, spatial reconfiguration or building services modification may generate a gap between the physical building and the digital model, making it necessary to update the as-is condition and, consequently, to revise the information base intended for management.

In the case of the TRP project, this clarification has a decisive methodological value. The work does not start from an As-is Model reconstructed ex novo through a complete survey of the building in use, but from an already available federated As-built base, produced in previous years as an information representation of the completed asset.

However, as shown in Chapter 4, this base presents non-uniform levels of reliability, incompleteness and margins for verification. Consequently, it cannot be assumed directly either as a fully reliable representation of the current condition of the building, or as a model already ready for FM. Before becoming a Record Model, the available model must be subjected to a process of comparison with the actual state, updating of relevant information, simplification of unnecessary components and critical reduction of contents according to management uses.

The following table (Table 4) summarizes the main differences between the three information configurations, highlighting how they respond to distinct purposes and have different implications for Facility Management usability.

Table 4 – Main differences between As-built, As-is and Record Model configurations. [Author's elaboration].

Features	AS-BUILT MODEL	AS-IS MODEL	RECORD MODEL
Temporal reference	End of construction or refurbishment works	Specific moment during the operational phase	Moment within the operational phase interpreted through FM requirements
Condition represented	Building as delivered	Building as actually existing	Building as it needs to be managed
Main purpose	To document the completed asset and support handover/ commissioning	To represent the current condition of the asset	To support management, maintenance, asset management and integration with FM tools
Geometric information	Representation of the completed asset, generally detailed but not necessarily updated	Geometry verified or updated against the actual condition	Essential geometry, selected and functional to management uses
Alphanumeric information	Data related to construction, materials, systems and components	Data on current conditions, transformations, inspections and previous maintenance activities	Data structured for O&M: assets, spaces, codes, procedures, maintenance plans and management attributes
Prevailing information process	Documentation of the final construction state	Verification and updating of the existing condition	Comparison, simplification, updating and critical reduction
Relationship with FM	Potential starting base	Updated knowledge base	BIM configuration prepared for management integration
Main critical issue	It may not be updated or may not be oriented towards FM	It may describe the existing condition without being structured for management	It requires governance, update rules and information control

This comparison shows that the greater usefulness of the Record Model does not lie in its absolute completeness, but in its capacity to make the information required for management selectable, queryable and updateable. The transition towards FM therefore requires a change in perspective: the objective is not to transfer into the management system everything contained in the BIM model, but to recognize which information is actually necessary, verifiable and maintainable over time. This approach is consistent with BIM–FM literature, which highlights that the quality of information exchange depends on the definition of clear requirements, the verification of contents and the compatibility between model, database and management processes (Matarneh et al., 2020; Tsay et al., 2022; Tsay et al., 2023).

The transition from the As-built Model to the Record Model should therefore be interpreted as a critical transformation, not as a simple technical conversion. It implies checking the correspondence between the physical building and the digital model, selecting the information relevant to FM, simplifying unnecessary contents, integrating management codings and parameters, and preparing update rules. It is from this awareness that the following section addresses the transition from the **Project Information Model** to the **Asset Information Model**, focusing not on the quantity of information transferred, but on its relevance, quality and usefulness for the operational phase.

5.2 From PIM to AIM: selecting and measuring information for FM

The distinction between **As-built Model**, **As-is Model** and **Record Model**, discussed in the previous section, can also be read through a normative and process-based lens: the transition from the **Project Information Model** (PIM) to the **Asset Information Model** (AIM). This transition does not only concern a change in lifecycle phase but implies a deeper transformation in the function assigned to information.

In the PIM, information is mainly produced, coordinated and validated in relation to the objectives of design, construction and handover; in the AIM, instead, it must be made available, queryable and updateable in relation to operation, maintenance, asset management and decision-making processes connected with the use of the asset (ISO 19650-1, 2018; ISO 19650-3, 2020). This transition cannot therefore be interpreted as a simple linear transfer of data from the project model to the management model. The issue is not to preserve everything produced in the previous phases in its entirety, but to understand which information should remain active, which should be verified or updated, which may be archived and which, instead, must be integrated because it is absent or insufficiently structured for Facility Management.

From this perspective, the transition from PIM to AIM becomes a problem of information selection, measurement and governance, in which the Record Model assumes the role of an intermediate and operational model configuration, capable of reorganizing the available information base according to management uses (Matarneh et al., 2020; Tsay et al., 2022; Tsay et al., 2023).

5.2.1 The PIM-AIM transition as an information management problem

Within the ISO 19650 series, the transition from the **Project Information Model** to the **Asset Information Model** represents one of the central aspects of information management throughout the asset lifecycle. The PIM collects and organizes the information produced during the asset delivery phase, progressively incorporating contents developed through design, coordination, construction, verification and handover activities. The AIM, by contrast, concerns the set of information required to support asset management during the operational phase, including data relevant to operation, maintenance, asset management, safety, intervention planning and operational decision-making (ISO 19650-1, 2018; ISO 19650-3, 2020).

The distinction between PIM and AIM is therefore first and foremost functional. The PIM is oriented towards the production and delivery of the asset; the AIM is oriented towards its management over time. This difference in purpose also changes the way in which information must be assessed. Data that are relevant for design, interdisciplinary coordination or the documentation of the completed works may not have the same operational value during the management phase; similarly, some information that is essential for Facility Management may not have been produced, verified or adequately structured within the PIM. For this reason, information continuity between the delivery phase and the operational phase cannot be reduced to the mere preservation of existing information contents. The representation of the information management process proposed by UNI 11337 (Figure 20) highlights the need to define information requirements, decision points, information exchanges and responsibilities across the different phases of the asset lifecycle.

The Italian UNI 11337 framework also reflects this logic, emphasising the progressive structuring of digital information, the need to define information requirements and the central role of the common data environment as the place where information is produced, verified and delivered (UNI 11337; UNI EN ISO 19650-1, 2019). However, although the principle of information continuity is clearly recognisable, the operational translation of the transition between PIM and AIM is less immediate. In particular, the criteria through which information should be selected, validated, updated and reorganized so that it becomes actually useful for management remain critical.

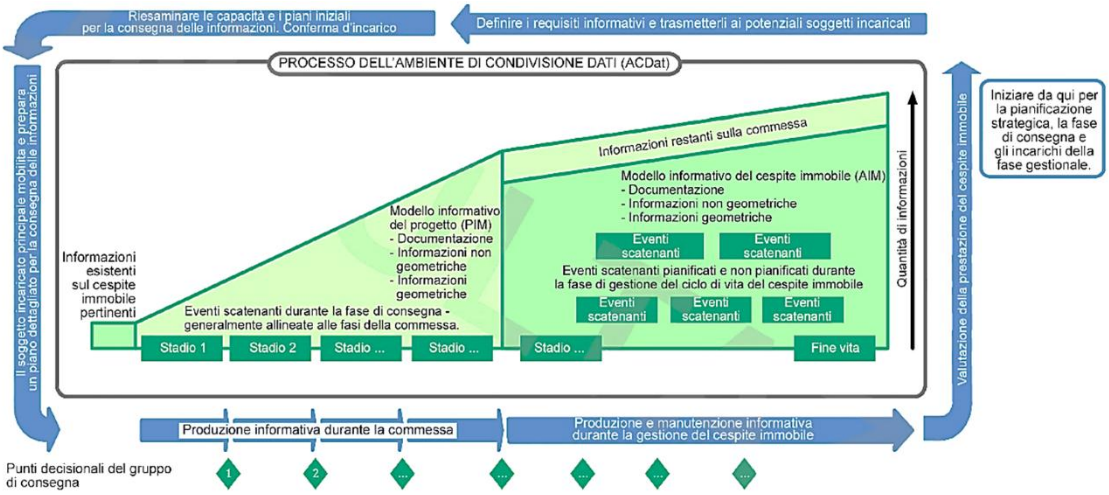


Figure 20 – Extract of the information management process across the asset delivery and operational phases. [source: adapted from UNI EN ISO 19650-1:2019]

This criticality emerges with particular clarity during the handover phase. At this point, the as-built model may be interpreted as the mature outcome of the PIM, or at least as the information configuration that should document the completed asset at the end of the construction process. However, as discussed in the previous section, an as-built model is not necessarily a model ready for Facility Management. It may be rich in content, but not yet aligned with the information needs of the AIM; it may contain information useful for construction but redundant for management; it may include data that are not verified, not updated or not organized according to logics compatible with management systems. This gives rise to the need for a critical transformation, in which information is not simply transferred, but selected and restructured according to the needs of the operational phase. From this perspective, the PIM–AIM transition can be interpreted as a problem of governing information relevance. The aim is not to maximize the amount of data indiscriminately, but to build an information base capable of responding to the intended uses, the requirements of the asset owner and the management processes actually activated. BIM–FM literature shows that information delivery towards the operational phase is often fragile, fragmented or insufficiently governed, especially when the owner's and facility manager's requirements are not clearly defined from the early stages (Matarneh et al., 2020; Pinti et al., 2022; Tsay et al., 2022; Tsay et al., 2023; Liu et al., 2020).

The issue is therefore not only technical, but also methodological and organizational. The development of the AIM requires the information produced in the PIM to be read in relation to future uses, asset information requirements, update responsibilities and the ways in which data will actually be queried during the operational phase. The Record Model is located precisely at this point of transition: not as a duplication of the as-built, nor as a simple quantitative reduction of the previous model, but as a selective and verified BIM configuration oriented towards the construction of an AIM that is genuinely useful for Facility Management.

5.2.2 Information evolution and the handover threshold

If the transition from PIM to AIM can be understood as an information management problem, it is also necessary to examine the temporal evolution of the information contents produced throughout the lifecycle of the asset. Literature and standards generally describe the information model as a structure that is progressively enriched during the design and construction phases, until it reaches, close to handover, a configuration capable of documenting the completed asset and supporting its subsequent management use. From this perspective, the PIM tends to consolidate during the delivery phase and to converge, at least theoretically, towards an as-built configuration, that is, towards an information representation of the asset as delivered at the end of the construction process (Carbonari et al., 2016; Nour El-Din et al., 2022).

However, this progression should not be interpreted deterministically. It cannot be automatically assumed that the moment of handover always coincides with the maximum information value useful for management. The model may reach a high level of geometric, documentary or technical-construction development without those pieces of information necessarily being relevant, verified or reusable in the operational phase.

Conversely, some data that are essential for Facility Management may be absent, incomplete, uncoded or not organized according to a logic compatible with management systems. In this sense, the growth of information during the design and construction process does not necessarily coincide with the growth of its management usability. The handover threshold therefore represents a critical moment. It does not mark only the administrative and technical transition between asset delivery and the operational phase, but also a point at which the value of information is transformed.

Before handover, information is mainly produced to design, coordinate, construct, verify and document the building; after handover, it must instead support activities such as asset localization, corrective and planned maintenance, space management, document consultation, register updating and performance monitoring over time. If not reorganized, the same information may therefore lose part of its effectiveness when moving from a production logic to a use logic.

For this reason, the transition towards the AIM cannot be described as a simple quantitative continuity of the PIM. It requires a critical selection of the contents that must remain active in the management model, the possible archiving of information that is relevant only from a documentary or historical point of view, and the integration of data that are absent but necessary for the operational phase.

The Record Model is located precisely at this threshold: not as a mechanical reduction of the as-built, but as a selective reorganization of information according to FM uses. Its construction therefore involves a different hierarchy among information components: what prevails is not necessarily what is most detailed, but what is most stable, legible, verifiable and useful for management.

The figure 21 schematizes this transformation by distinguishing three main temporal intervals: **strategic planning** (t_0–t_1), **design and construction** (t_1–t_2)and **operation and maintenance** (t_2–t_3). In the initial interval, between $t_0$and t_1, the amount of available information is still limited and generally consists of preliminary data, functional requirements, strategic indications and early feasibility checks. In this phase, the model is characterized by a minimum level of information structuring and cannot yet be considered a fully developed information system. With the transition to t_1, the progressive construction of the PIM begins, gradually enriched with preliminary specifications, conceptual configurations, technical data, disciplinary information, performance constraints and documentary contents.

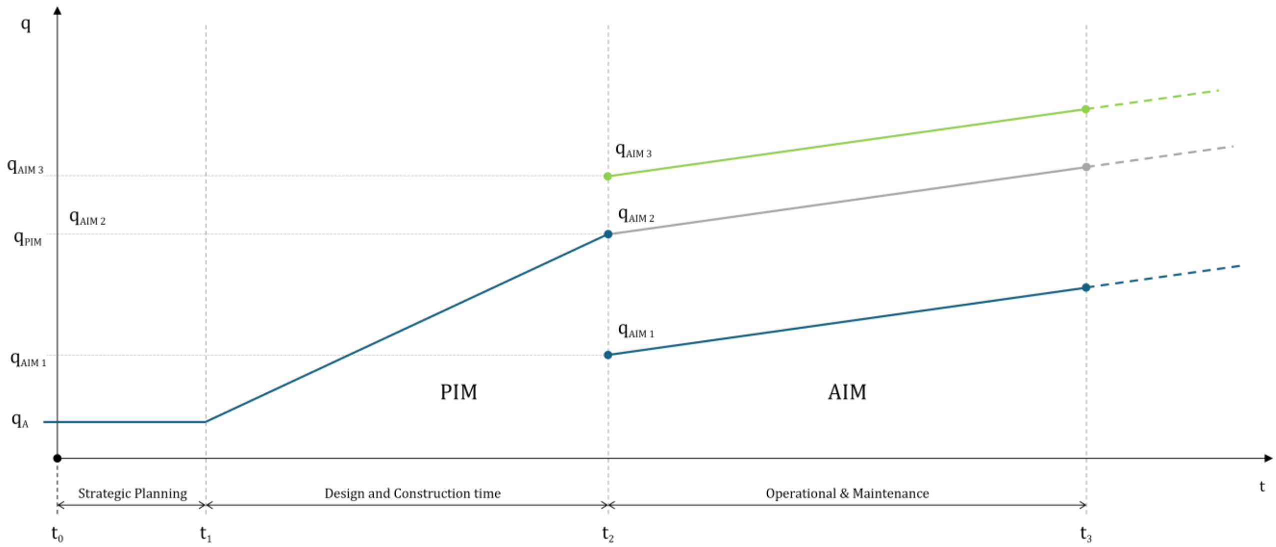


Figure 21 – Conceptual transition from PIM to AIM, illustrating alternative trajectories of information consistency between handover and the operational phase. [source: Author's elaboration]

In the interval t_1–t_2, corresponding to the design and construction phases, information density tends to increase progressively through the integration of geometric, technical, documentary, disciplinary and execution-related contents. At t_2, corresponding to the completion of the delivery phase, commissioning and handover of the asset, the model reaches the information configuration indicated in the diagram as q_{PIM}.

This value should not be interpreted as the absolute maximum of information throughout the entire lifecycle, but as the information consistency reached by the Project Information Model at the end of the design-construction phase. In theoretical terms, this configuration can be associated with the as-built model, that is, the representation of the asset as delivered at the end of construction. It may include as-built geometries, technical specifications, execution data, handover documentation and further contents matured during the construction process.

The point t_2, however, does not necessarily coincide with the maximum information value useful for management. The model may be very rich from a geometric, documentary or technical-construction perspective, but this does not automatically make it suitable for Facility Management processes.

Some information may be redundant for the operational phase; other information may not have been verified according to criteria consistent with operation; still other information may be absent, incomplete or not structured for integration with management tools.

For this reason, the value q_{AIM}, referring to the information configuration of the management phase, should not be assumed a priori as necessarily lower than q_{PIM}. It may be lower, equal or higher, depending on whether the transition to the operational phase mainly involves selective reduction, information continuity or the integration of missing data.

In the transition from $t_2$to t_3, the figure should therefore be read not as the representation of a necessary loss of information, but as the representation of a transformation of its relevance. In some cases, the AIM may contain less active information than the PIM (q_{AIM1} in the Figure 21), because part of the data produced during the delivery phase is archived or excluded from the management model as not directly useful for FM.

In other cases, the AIM may maintain an information consistency similar to that of the PIM (q_{AIM2} in the Figure 21), when the information produced is already relevant, verified and reusable.

In still other cases, the AIM may require an increase in information (q_{AIM3} in the Figure 21), due to the introduction of asset codings, maintenance data, relationships with spaces, operational procedures, management registers or information required by the FM platform.

The central issue is therefore not to establish whether information increases or decreases, but to understand whether it becomes **actually usable during the operational phase**.

The curve should therefore not be read as a universal empirical measurement, but as an interpretative representation of the expected behaviour of information in the transition between PIM and AIM. The central point is not to establish that information must necessarily increase up to a maximum and then decrease, but to highlight that, at handover, the criterion by which information is assessed changes. During design and construction, information value is mainly linked to the model's ability to support production, coordination and verification of the asset; during the operational phase, instead, it depends on its ability to support management processes, updates, queries and operational decisions.

This reading makes it possible to avoid an inappropriate overlap between model completeness and management adequacy. A model that is very dense from a geometric or documentary point of view may not be immediately useful for FM if it lacks coherent codings, reliable relationships with spaces, maintenance attributes, update rules and verification criteria. At the same time, a geometrically more essential model may be more effective in the operational phase if it contains controlled alphanumeric information, relevant documentary references and a structure consistent with management processes. The handover threshold, therefore, does not coincide with the simple transfer of the model, but with the redefinition of its information relevance.

5.2.3 Information selection and critical reduction

The awareness that the information value of the AIM cannot be automatically inferred from the amount of data contained in the PIM makes it necessary to introduce the issue of information selection. The transition to the management phase does not consist in transferring the entire content of the model produced during design and construction, but in distinguishing between information that must remain active, information that can be archived, information that must be updated and information that must be integrated. From this perspective, information continuity does not coincide with the undifferentiated preservation of all data, but with the ability to preserve and make usable what is actually necessary for the operational uses of the asset.

This distinction is particularly relevant in Facility Management, where the quality of the model does not depend on its maximum geometric or documentary extent, but on its capacity to support concrete activities: locating assets, querying technical information, planning maintenance interventions, recording completed activities, linking elements and spaces, consulting relevant documents and updating the information state of the building over time. From this point of view, the management model must be built according to a logic of relevance, in which every piece of information kept active should be traceable to a use, a responsibility, a procedure or a verification. BIM-FM literature shows that inefficiencies in the transition to the operational phase often derive not from an absolute absence of data, but from their weak alignment with the owner's requirements, the poor structuring of information exchanges and the lack of shared criteria for assessing the quality of delivered information (Matarneh et al., 2020; Tsay et al., 2022; Tsay et al., 2023). Information selection therefore entails a critical reduction of the model. The term "reduction" should not be understood as a loss or improper simplification, but as a methodological operation aimed at making the relationship between the digital model and management processes governable. Some contents produced within the PIM may retain documentary, historical or evidentiary value, but may not be necessary within the active management model; other contents, although present, may require consistency checking, updating or a different organization; others may be missing and may need to be introduced ex novo in order to enable integration with the FM system. In this sense, the transition from PIM to AIM does not produce a simple decrease in information quantity, but rather its reorganization according to criteria of use, reliability and maintainability.

The Record Model is located precisely within this process. It constitutes the model configuration through which the information inherited from the PIM, or possibly from an updated As-is Model, is verified, filtered and reorganized according to management uses. Its construction implies a different hierarchy among information components: geometry remains necessary to recognize, locate and contextualize elements, but it does not necessarily have to preserve all the complexity produced during design and construction; alphanumeric information, instead, assumes a central role because it makes it possible to identify assets, connect them to spaces, associate them with systems, procedures, documents and maintenance activities. For this reason, in the transition towards the Record Model, information quality cannot be measured only in terms of detail, but above all in terms of stability, legibility, verifiability and interoperability with management tools.

Critical reduction must also be accompanied by a process of explicit definition of information requirements. The information to be maintained in the management model cannot be defined only retrospectively, on the basis of what the PIM contains, but should be guided by the Asset Information

Requirements and by the information uses expected for the operational phase. This aspect is particularly important in public-sector contexts, where the information model is not only a technical tool, but also a digital asset to be governed over time. If requirements are not clearly defined, there is a twofold risk: on the one hand, transferring into the AIM information that is redundant, not updateable or scarcely usable; on the other, failing to produce during the delivery phase data that are essential for the future management of the asset.

In the case of the *TRP Project*, this issue assumes a precise operational value. The available as-built base constitutes a relevant information asset, but it cannot be assumed as an already complete management model. It requires a process of comparison with the real state of the building, verification of existing information, simplification of unnecessary elements and integration of data useful for management. Information selection therefore becomes the passage through which the model ceases to be only a representation of the completed asset and begins to configure itself as a support for concrete management activities. From this perspective, the Record Model is not the result of an impoverishment of the as-built model, but the outcome of its critical reorganization according to Facility Management needs.

It is precisely at this point that the notion of information quantity must be overcome. It is not sufficient to ask how much information the model contains; rather, it is necessary to assess the extent to which that information is organized, verifiable, relevant and actionable with respect to the intended management uses. Information quantity becomes information consistency only when documents, geometries and alphanumeric data are read not as autonomous containers, but as components capable of supporting a specific process of use.

5.2.4 A theoretical model for information consistency

To describe the transition from PIM to AIM in a more controlled way, this research introduces the concept of **information consistency** q. This expression does not refer to the mere amount of data contained in the model, nor to its level of geometric detail in a strict sense. Information consistency q instead indicates the degree to which the available information is complete, coherent, verifiable, relevant and usable with respect to a specific purpose. In the case of Facility Management, it therefore measures the model's capacity to transform documentary, geometric and alphanumeric data into information that is actually useful for locating assets, querying components, linking objects and spaces, supporting maintenance activities, feeding management registers and keeping the relationship between the physical building and the digital model up to date.

This clarification is necessary because a model may be very rich from a quantitative point of view, but weak from a management perspective. It may contain many geometries, documents and parameters, yet not be actually usable if such information is redundant, unverified, uncoded, not linked to the correct objects or not interpretable by the actors who need to use it. Similarly, a geometrically more essential model may prove more consistent for FM if it contains reliable alphanumeric information, stable relationships between assets and spaces, relevant documentation and controllable update procedures. Information consistency therefore does not coincide with the maximum accumulation of data, but with their capacity to become operational information.

The transition from quantity to consistency therefore occurs through a qualitative and functional assessment of the information components. The components D, G and α do not represent the mere material presence of documents, geometries and attributes, but their degree of adequacy with respect to the intended purpose. A document does not increase information consistency simply because it exists, but because it is retrievable, relevant and linkable to the object; a geometry is not consistent simply because it is detailed, but because it enables recognition, localization and control; an attribute is not consistent simply because it is filled in, but because it is coherent, verifiable and usable within the management process.

On this basis, the information consistency of the model at a given moment of the lifecycle can be described through the following general formulation:

$$q(t) = (D + G + \alpha) f_{HK}$$

where:

- $q(t)$ represents the information consistency of the model at time t;
- D indicates the documentary component;
- G indicates the geometric component;
- α indicates the alphanumeric and attribute-based component;
- f_{HK} indicates the human-knowledge factor.

It is necessary to clarify that, in this research, time t is not understood as a continuous variable, but as a discrete phase variable, articulated according to the main thresholds of the building process considered in the model: **PRG** – programming or strategic planning; **DES** – design; **CST** – construction, handover and as-built configuration; **O&M** – operation and maintenance.

Consequently, $q(t)$ does not describe a continuous variation of information over time, but the information consistency of the model in correspondence with a specific lifecycle phase. The component D includes technical, management, maintenance and administrative documents that can be associated with the model or its elements, such as as-built drawings, manuals, technical sheets, certifications, maintenance plans, reports, minutes or further supporting documentation. The component G concerns the capacity of geometry to represent, locate and make elements recognisable, without necessarily coinciding with the maximum level of graphical detail. The component α includes codes, parameters, classifications, technical data, relationships between assets and spaces, maintenance information, statuses, procedures and fields required for interoperability with management tools. In order to make the attribution of values to these components explicit, the assessment of D, $G$and α is supported by three interpretative scales (Tables 5-7). These scales do not define normative thresholds, but methodological criteria adopted in this research to translate the available documentary, geometric and alphanumeric content into a degree of information consistency. They therefore make explicit how each component is evaluated not only in terms of presence, but also in terms of relevance, reliability, verifiability and usability with respect to the intended purpose.

Table 5 – Interpretative scale for assessing the documentary component D. [Author's elaboration]

***D* value**	**Condition**	**Meaning**
0	Absent	No documents are available that can be associated with the object, space or system considered.
1	Very weak	Minimal, generic or only indirectly associated documentary references exist; their usefulness for the phase considered is very limited.
2	Weak	Documentation is present but partial, fragmented or difficult to retrieve; it allows only limited understanding of the object or requires substantial reworking.
3	Intermediate	Documentation is available and useful, but not fully coordinated, updated or stably linked to the model and its objects.
4	Good	Documentation is relevant, sufficiently complete and associable with the object; it supports verification, comparison and operational decision-making.
5	Very good	Documentation is complete, updated, coherent, easily retrievable and stably linked to the object or management record.

Table 6 – Interpretative scale for assessing the geometric component G. [Author's elaboration]

***G* value**	**Condition**	**Meaning**
0	Absent	The object, space or system is not geometrically represented in the model.
1	Very weak	Geometry is only symbolic, generic or difficult to recognize; it does not allow reliable localization.
2	Weak	Geometry is present but incomplete, unreliable or not adequate for the intended purpose; significant checks or corrections are required.
3	Intermediate	Geometry allows recognition and localization of the element, but presents limitations in terms of detail, coherence or scalability with respect to the intended use.
4	Good	Geometry is adequate to the purpose, coherent and sufficiently reliable for localization, verification and operational use.
5	Very good	Geometry is complete with respect to the purpose, reliable, correctly localized and fully usable for recognition, control and relation with other elements.

Table 7 – Interpretative scale for assessing the alphanumeric and attribute-based component α. [Author's elaboration]

α value	Condition	Meaning
0	Absent	No alphanumeric data, codes, parameters or attributes useful for the object, space or system considered are present.
1	Very weak	Minimal or generic data are present, but they are not structured, not verifiable or not useful for management.
2	Weak	Some parameters or attributes are present, but they are partial, inconsistent, not normalized or insufficient for the intended use.
3	Intermediate	Alphanumeric data are present and partly usable, but not fully complete, coherent or interoperable with the management system.
4	Good	Data are structured, coherent and useful for the intended use; they include sufficiently reliable codings, relationships or management attributes.
5	Very good	Data are complete with respect to the purpose, normalized, verifiable, interoperable and fully usable within management processes or the FM system.

The general formula has theoretical value, since it makes explicit that information consistency derives from the combination of documentation, geometry and alphanumeric information. However, it presents a limitation: it implicitly assumes that the three components always have the same weight. This assumption is not consistent with the nature of the building process, in which the role of information changes according to the phase and purpose. In programming, documentation and requirements play a prevailing role; in design, geometry becomes central for project development and coordination; in construction and handover, documentation, geometry and technical data tend to be balanced; in the management phase, instead, alphanumeric information becomes more relevant, since FM operates mainly through codes, registers, attributes, asset–space relationships, procedures and maintenance statuses. For this reason, specific weighting factors are introduced for the three information components, in order to represent their different roles across the phases of the building process. The formula is therefore reformulated in weighted form:

$$q(t) = [w_D(t)D + w_G(t)G + w_\alpha(t)\alpha]f_{HK}$$

with:

$$w_D(t) + w_G(t) + w_\alpha(t) = 1$$

The weights $w_D(t)$, $w_G(t)$and $w_\alpha(t)$express the relative relevance of documentation, geometry and alphanumeric information in the phase considered.

They do not indicate the absolute amount of available data, but the contribution of each component to the information consistency of the model. The adopted values are therefore intended as a methodological weighting proposed by this research, defined according to the prevailing role of information in the different thresholds of the building lifecycle, and not as universal or normative coefficients.

Table 8 sets out the weighting adopted in this research. The attribution of numerical values makes the model applicable and allows information configurations belonging to different phases to be compared; however, these values must be read as first-calibration methodological coefficients, based on a qualitative assessment of the prevailing function of information in each phase.

Table 8 – Phase-based weighting of documentary, geometric and alphanumeric information components. [Author's elaboration]

Phase	w_D Documentation	w_G Geometry	w_α Alphanumeric	Qualitative logic of weighting
PRG	**0.45**	**0.15**	**0.40**	The phase is driven by briefing documents, requirements, objectives, constraints, preliminary OIR/AIR and information needs. Geometry is still schematic, while the alphanumeric component is already relevant because it structures functions, areas, expected performances and early management needs.
DES	**0.15**	**0.50**	**0.35**	Geometry becomes the dominant component because it supports spatial configuration, disciplinary coordination, design verification and clash control. The alphanumeric component grows with materials, performances, parameters and classifications; documentation supports the process, but does not constitute the main information vector.
CST	**0.30**	**0.35**	**0.35**	The components tend to be balanced: it is necessary to document what has been built, verify the realised geometry and consolidate technical and attribute data. Geometry and alphanumeric information assume slightly greater weight because they define the correspondence between the built asset and the as-built model.
O&M	**0.25**	**0.20**	**0.55**	The alphanumeric component becomes dominant because FM operates through codes, Asset_ID, Space_ID, asset–space relationships, maintenance data, procedures, statuses, registers and interoperability with the management system. Geometry remains necessary for localization and navigation, but does not require the maximum representational detail.

The distribution of weights therefore highlights that information consistency does not always depend on the same components. In the PRG phase, the greatest weight is assigned to the documentary component, since the construction of information depends mainly on requirements, objectives, constraints and early decision structures. In the DES phase, geometry assumes a prevailing role, as the model supports spatial configuration, disciplinary coordination and design verification. In the CST phase, the three components tend towards greater balance, because asset handover simultaneously requires verification of the realised geometry, documentation of what has been built and consolidation of technical data. Finally, in the O&M phase, the alphanumeric component assumes the main weight, because the management use of the model depends above all on codes, relationships between assets and spaces, maintenance data, information statuses, procedures and interoperability with the management tool.

This weighting makes the different phases comparable, since the sum of the weights is always equal to 1. Consequently, if the components D, $G$and $\alpha$are assessed on a discrete scale from 0 to 5, the weighted component of the formula also assumes a value between 0 and 5. The maximum value is obtained when $D = 5$, $G = 5$and $\alpha = 5$, independently of the phase considered:

$$5w_D(t) + 5w_G(t) + 5w_\alpha(t) = 5$$

What changes, therefore, is not the theoretical maximum value of the information component, but the way in which its parts contribute to the result. In O&M, for example, a deficiency in the alphanumeric component has a greater impact on overall information consistency than a geometric deficiency, whereas in the DES phase this relationship tends to be reversed.

The proposed weighting must nevertheless be read as a first methodological calibration. It makes the model applicable and allows different information configurations to be compared, but it does not exhaust the complexity of real cases. The weights may in fact be recalibrated according to the type of asset, the scale of the intervention, the digital maturity of the organization, the intended information uses and the FM processes actually activated. In this sense, the value of the table does not lie in fixing definitive parameters, but in making explicit the criterion through which this research assigns different relevance to the information components across the phases of the building lifecycle.

The weighted information component is then multiplied by f_{HK}, understood as the **human-knowledge factor**. This factor introduces into the model the role of actors, knowledge, competences and operational skills that make information actually usable. The mere presence of documents, geometries and attributes does not in fact guarantee that the model can support management processes: such information must be understood, verified, transferred and correctly used by the personnel involved.

The factor f_{HK} therefore does not measure the material amount of data contained in the model, already described by the components D, G and α, but the degree to which such data can be transformed into operational information. Knowledge concerns the theoretical and methodological understanding required to comprehend the information process, the requirements, BIM–FM logics, the PIM–AIM transition and model uses. Competences concern the ability to apply such knowledge in operational and decision-making contexts, for example by interpreting information requirements, setting parameters, checking data or coordinating information exchanges. Skills, instead, concern the technical-practical ability to perform specific activities, such as filling in parameters, using BIM and FM tools, exporting and importing data, querying registers or updating asset information.

For this reason, f_{HK} is assumed as a multiplicative coefficient and not as a simple additive component. It does not add new data to the model, but modifies the degree to which existing data can be activated within management processes. With the same documentation, geometry and attributes, a model may in fact have different operational effectiveness depending on the ability of actors to read, check and use it. A formally complete model may be weak if requirements are not understood, responsibilities are not defined or transfer to the management environment is not governed; conversely, a competent organization equipped with control procedures can increase the actual usability of the available information.

In this research, f_{HK} is assumed within the following interval (Table 9):

$$f_{HK} \in [0.70, 1.20]$$

The value 1.00 represents an ordinary condition, in which information is understandable and usable with standard competences and checks. Values below 1.00 indicate conditions in which weak information governance, ambiguous requirements, uneven competences, undefined responsibilities or insufficient checks reduce the actual usability of the available information. Values above 1.00 represent conditions in which consolidated competences, explicit requirements, systematic checks, clear responsibilities and governed transfer increase the operational capacity of information.

Table 9 – Human-knowledge factor scale used to assess the operational usability of information [Author's elaboration].

f_{HK} value	Condition	Meaning
0.70	Critical	Requirements absent or ambiguous, responsibilities undefined, uneven data population, checks absent, transfer not governed, personnel lacking sufficient knowledge or skills.
0.85	Weak	Requirements present but partial, checks not systematic, uneven operational competences, strong dependence on individual actors.
1.00	Ordinary	Information understandable and usable with standard competences and checks.
1.10	Good	Clear requirements, coherent data population, traced checks, sufficiently defined responsibilities, adequate competences.
1.20	High	Explicit requirements, clear responsibilities, trained personnel, consolidated competences, widespread operational skills, systematic checks, governed transfer and stable operational use.

The interval 0.70–1.20 is adopted because the human-knowledge factor affects information quality in all phases of the building process and cannot be considered a marginal variable. In programming, it conditions the ability to formulate coherent requirements and objectives. In design, it influences the correct interpretation of requirements and the structuring of the model. In construction and handover, it affects the quality of information population, checks and documentation of the completed works. While, in the O&M phase, and even more in the BIM–FM transition, it determines the possibility of transforming available information into information that is actually usable, updateable and integrable into management processes. It can therefore significantly reduce the effectiveness of information when data, although present, are not understood, checked or correctly transferred; at the same time, it can increase the operational value of the model when knowledge, competences, skills and procedures make information more legible, verifiable and usable. In this case too, the proposed scale constitutes a first methodological calibration and may be further verified and rebalanced in subsequent applications.

It follows that the theoretical value of $q(t)$ranges from 0 to 6. The minimum value is obtained when $D = 0$, $G = 0$and $\alpha = 0$; the maximum value is obtained when $D = 5$, $G = 5$, $\alpha = 5$and $f_{HK} = 1.20$:

$$q_{max} = 5 \times 1.20 = 6$$

Between these two extremes lie real operational conditions, in which information consistency depends on the different balance between documentation, geometry, alphanumeric data and the human-organizational capacity to make them actually usable. For this reason, $q(t)$should not be read as a simple indicator of the amount of data contained in the model, but as a synthetic measure of the model's capacity to support a specific information use in a given process phase.

To make the index more legible and comparable, the value can be normalized on a 0–100 scale:

$$Q(t) = \frac{q(t)}{q(t)_{max}} \times 100$$

where:

$$q(t)_{max} = 6$$

Normalization makes it possible to express information consistency as a percentage of the theoretical maximum defined by the model. A value of 100% does not indicate the absolute perfection of the model in a universal sense, but the achievement of the maximum level of information consistency within the criteria adopted by this research: complete and relevant documentation, geometry adequate to the purpose, structured and verifiable alphanumeric information, and a high human-knowledge factor.

Conversely, lower values indicate a reduction in information consistency due to incompleteness, weaknesses in coherence, lower adequacy with respect to the intended use or limitations in the actors' ability to activate information correctly. Normalization therefore makes it possible to compare information configurations belonging to different phases of the building process or referring to different model elements.

In particular, it allows the information consistency of a PIM or as-built configuration to be compared with that of an AIM or Record Model configuration, without assuming that one must necessarily be higher or lower than the other.

Starting from the normalized index $Q(t)$, the information gap between PIM and AIM can be expressed as:

$$\Delta Q = | Q_{PIM} - Q_{AIM} |$$

where ΔQindicates the magnitude of the difference between the information consistency of the model in the starting configuration and that of the management-oriented configuration. This gap makes the information transformation occurring in the transition from the model produced during delivery to the model prepared for Facility Management more explicit.

It is nevertheless necessary to clarify that ΔQshould not automatically be interpreted as information loss. A high value rather indicates the presence of a significant difference in information consistency between the as-built model and the Record Model, and therefore between PIM and AIM (Figure 22). The meaning of this gap depends on the direction and nature of the transformation carried out.

If $Q_{AIM} < Q_{PIM}$, the gap may indicate a correct selective reduction, due to the exclusion from the active model of information not useful for FM; but it may also signal the loss of information necessary for management.

If $Q_{AIM} \approx Q_{PIM}$, there may be real information continuity, but also an uncritical transfer of redundant information.

If $Q_{AIM} > Q_{PIM}$, the gap may indicate an enrichment of the management model through the integration of information that was absent or insufficiently structured in the PIM configuration, such as asset codings, relationships with spaces, maintenance data or fields required by the management tool.

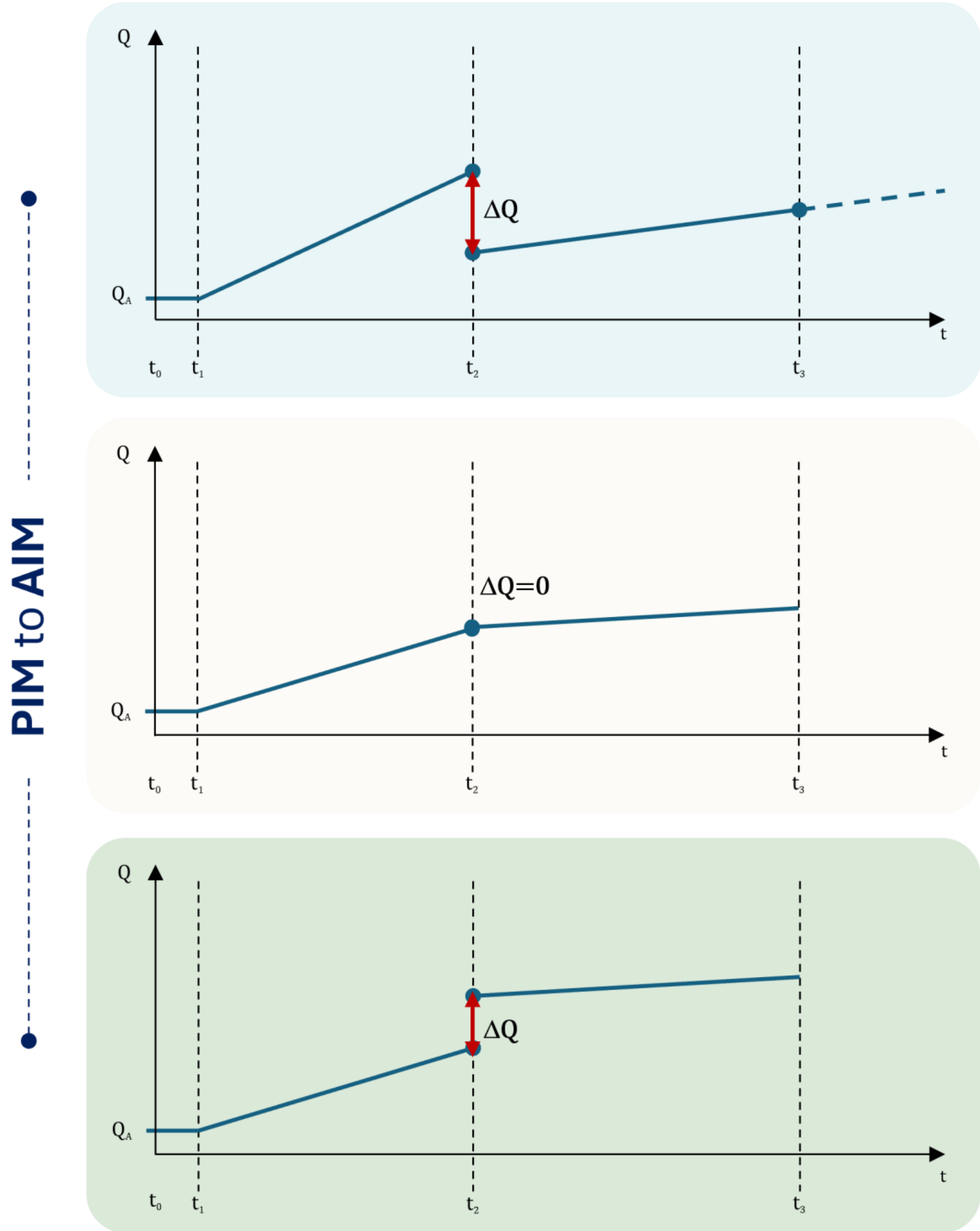


Figure 22 – PIM-to-AIM information gap scenarios based on ΔQ, showing selective reduction, continuity and enrichment of information consistency. [Author's elaboration]

To distinguish not only the magnitude of the gap, but also its direction, it may be useful to introduce an oriented difference:

$$\delta Q = Q_{AIM} - Q_{PIM}$$

In this case, a positive value of δQindicates an increase in information consistency in the transition towards the AIM; a negative value indicates a reduction; a value close to zero indicates a condition of apparent or substantial continuity. This measure, however, must also be interpreted critically: the numerical variation only becomes meaningful when read together with the nature of the information involved, its relevance to FM uses and the possibility of keeping it updated over time.

The same logic can be extended to continuity between subsequent AIM configurations. In the management of a public asset, the operational phase does not necessarily coincide with a stable period governed by the same operating actor. It is often marked by contract cycles, renewals, new procurement procedures and changes in the Economic Operator, also in relation to the principles of competition and rotation that characterize public procurement. Consequently, management information must not be considered only in the initial transition from PIM to AIM, but also in its ability to remain legible, transferable and verifiable from one management cycle to the next.

From this perspective, the transition from AIM_1 to AIM_2 represents a second critical threshold of the information process. If the AIM is not maintained as an information asset of the Contracting Authority, each change of contract may generate a knowledge discontinuity: the new operator may be forced to reconstruct asset registers, reinterpret documents, recheck assets and spaces, realign maintenance data and redefine operational procedures. In this way, part of the information value produced during the previous management cycle risks being dispersed precisely when it should be transferred and made available to the newly appointed actor.

The AIM_1-to-AIM_2 transition may therefore produce different outcomes (Figure 23): continuity, if information remains updated, traceable and transferable; loss of consistency, if the model and registers are not maintained or if information remains in the hands of the outgoing operator; increase, if the previous management cycle has fed the AIM with verified data, maintenance evidence, asset updates and new information relationships. Here too, the issue is not to establish whether information increases or decreases in quantitative terms, but to understand whether it remains actually governable and reusable by the Contracting Authority.

For Public Administration, this transition is particularly relevant. The value of the AIM depends on its ability to survive a change of Economic Operator and not to be reconstructed from scratch at every procurement cycle. In this sense, the Record Model is not only the initial configuration of the model for FM, but also a tool through which the Contracting Authority can preserve, control and transfer its information memory from one management cycle to the next.

The value of ΔQ, therefore, does not serve to establish whether the transition from PIM to AIM, or between two subsequent AIM configurations, is "better" or "worse" in absolute terms, but to make the information transformation produced visible and debatable. In this sense, the information gap becomes a tool for critical analysis: it makes it possible to distinguish between selective reduction, information loss, non-problematic continuity, redundant transfer, management-oriented integration or discontinuity between procurement cycles. Its usefulness lies precisely in the possibility of comparing different model configurations and discussing, case by case, whether the transformation that has occurred is consistent with the objectives of Facility Management and with the information continuity required by the public management of the asset.

The proposed model does not intend to transform the PIM–AIM transition into a purely quantitative measure. Its function is more circumscribed: to make explicit some factors that often remain implicit when assessing whether a model is actually usable for management. The value of $Q(t)$, as well as the gap between Q_{PIM} and Q_{AIM}, therefore does not constitute an absolute judgement on model quality, but a tool for discussing the transformation of information in the passage from delivery to use.

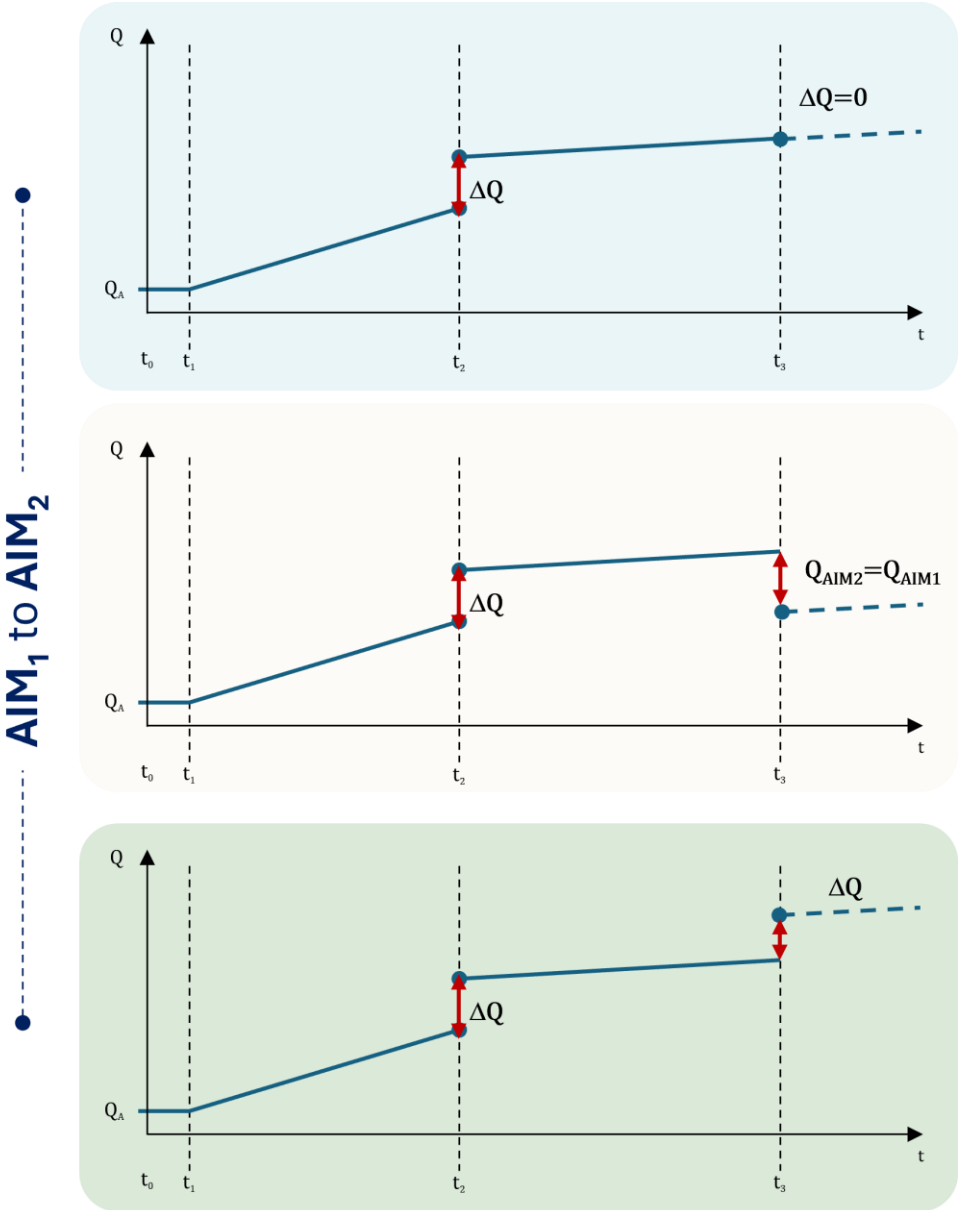


Figure 23 – Theoretical scenarios of information consistency variation between subsequent AIM cycles, highlighting continuity, reduction and increase across the AIM_1–AIM_2 transition. [Author's elaboration]

From this perspective, a reduction in information consistency may represent a correct selection, if it removes contents that are not relevant to FM, or a loss, if it excludes data required for management. Similarly, an increase may indicate useful enrichment, when it integrates missing codings, relationships and maintenance data, but it may also produce overload if it is not governed by clear requirements. For this reason, the reading of the gap must always be accompanied by a qualitative assessment of the contents involved. The adopted weights and the factor f_{HK} should therefore be considered as a first methodological calibration, useful to make the model applicable but not definitive. They may be recalibrated according to the type of asset, the complexity of the building, the digital maturity of the organization and the information uses actually required.

In the following part of the chapter, this interpretative key will be applied to the transition from the as-built base of the *Torre della Regione* to the Record Model configuration, with particular attention to spaces, architectural components, furniture and building services components.

5.2.5 Implications for FM: from information quantity to information need

The considerations developed in the previous sections show that the transition from PIM to AIM cannot be governed by assuming the overall amount of transferred information as the main criterion. For Facility Management, the value of the model depends instead on the capacity of information to respond to specific needs, to be verifiable, updateable and usable within operational processes. From this perspective, the issue is not to transfer into the management model everything that was produced during the design and construction phases, but to define which information is actually necessary, with what level of reliability, in which format, according to which responsibilities and for which uses.

This transition is consistent with the evolution of the technical and regulatory vocabulary from the concept of level of development towards the logic of information need. Within the Italian framework, UNI 11337-4 distinguishes between LOD, LOG and LOI, clarifying that the level of development of a digital object cannot be reduced to its geometric component alone, but must be read as a combination of graphical representation and alphanumeric-documentary information content (UNI 11337-4, 2017). This distinction is particularly relevant for FM, because it makes it possible to recognize that a geometrically highly detailed model may be of limited use for management if it does not contain structured, coded and verifiable data; conversely, a geometrically more essential model may be more effective if it is provided with alphanumeric information consistent with operational uses.

At the international level, the concept of **Level of Information Need** further reinforces this shift in perspective. LOIN does not require an indiscriminate increase in information content, but the definition of the information needed in relation to a declared purpose, a phase, an actor and a specific use (ISO 19650-1, 2018; UNI EN 17412-1, 2021). In this sense, the transition towards the AIM should not be driven by the greatest possible extension of the model, but by the construction of a controllable correspondence between information need, digital object, required attributes, linked documentation and management processes. The central issue therefore becomes the relevance of information to its use, rather than its mere presence in the model.

This approach leads to the centrality of **Asset Information Requirements**. AIR should make explicit which information is required to manage the asset during the operational phase, which data must be produced or delivered, which verification criteria must be applied and which responsibilities must be associated with their production, validation and updating. BIM–FM literature shows that weak information requirements and fragmented handover processes remain among the main causes of information value loss between the delivery phase and the operational phase (Liu et al., 2020; Pinti et al., 2022; Tsay et al., 2022). From this perspective, the problem is not only technical, but also concerns the organizational capacity of the client or manager to anticipate, formulate and control their own information needs.

For MF, the operational consequence is that the management model must be built starting from the uses it will have to support. Information related to construction site logistics, temporary works or execution choices that are no longer relevant may retain archival or documentary value, but does not necessarily have to remain active in the Record Model.

Conversely, information such as unique asset identifiers, relationships with spaces, essential technical characteristics, documentary references, operation and maintenance manuals, maintenance frequencies, operational responsibilities, maintenance status and links with management procedures may be decisive for the actual usability of the model during the operational phase. Selection is therefore not an impoverishment operation, but a process of realignment between the information model and management practices.

This approach also requires the early planning of information deliverables. If the data required for FM are requested only at handover, they are likely to be incomplete, inconsistent or difficult to verify. Conversely, the progressive definition of requirements, responsibilities, delivery times and control criteria makes it possible to guide information production already during the design and construction phases. In this sense, tools such as information delivery plans, responsibility matrices, exchange requirements and verification procedures can reduce the risk that the AIM is built retrospectively through recovery, normalization or information reconstruction activities.

A further aspect, closely connected with the public management of assets, concerns the capacity of the AIM to retain value between one contract and the next. The definition of information requirements should therefore not be limited to the initial delivery of the management model, but should also include the conditions through which data, registers, updates and maintenance evidence remain available to the Contracting Authority at the end of the contractual cycle. Without this attention, the risk is that the AIM may be formally produced, but not actually maintained as a public information asset.

In light of these considerations, the Record Model can be interpreted as the modelling response to the transition from information quantity to information need. It does not coincide with the complete preservation of the PIM, nor with a simple geometric reduction of the as-built model, but with a selective, verified configuration oriented towards FM uses. Its value depends on the capacity to transform available information into necessary, controllable and operational information. In the context of Public Administration, this value also depends on the possibility of preserving and transferring such information between subsequent management cycles, avoiding each new tender or change of Economic Operator from producing a partial reconstruction of asset knowledge. On this basis, the following section addresses the transformation process of the existing model of the *Torre della Regione*, reconstructing the comparison, simplification, updating and information management operations required for the development of the Record Model.

5.3 From the existing model to the Record Model: verification, simplification and information management

The transition from the existing model to the Record Model configuration cannot be understood as a simple operation of export, reduction or technical conversion. In light of the previous sections, it must be interpreted as a process of controlled information transformation, in which the available BIM as-built base is verified, compared with other sources, simplified according to management uses and updated for integration with the FM environment. In the case of the *Torre della Regione*, this transition is particularly relevant because the research does not start from an absence of information, but from an already articulated, federated and documented modelling base that must nevertheless be made consistent with a different objective: no longer only representing the completed asset, but supporting management, maintenance and updating processes over time.

The transformation towards the Record Model is therefore based on three main operations: **comparison**, **simplification** and **updating**.

Comparison serves to assess the degree of reliability of the available base by relating the BIM model to as-built documentation, guidelines, CAD drawings and the actual condition of the building.

Simplification makes it possible to distinguish what is necessary for management from what belongs to the complete representation or to the documentation of the construction process.

Updating, finally, concerns the integration, modification or removal of information and objects that prevent the model from assuming a configuration effectively oriented towards FM. This methodological sequence is summarized in the process diagram shown in Figure 24.

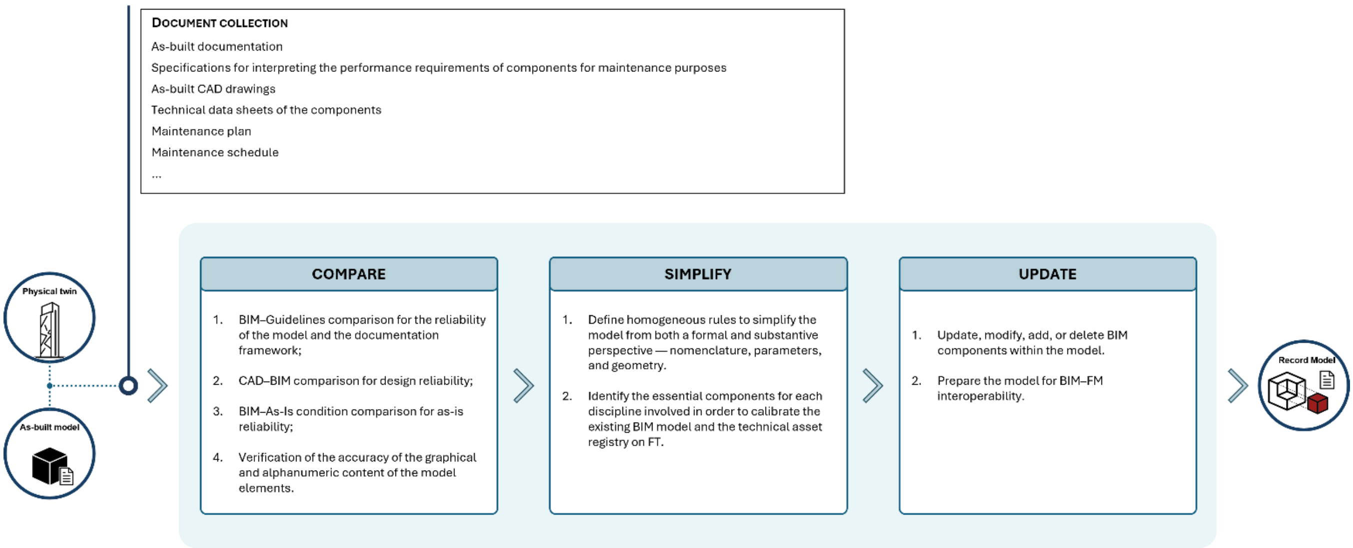


Figure 24 – Methodological workflow for transforming the existing BIM as-built base into a Record Model through comparison, simplification and updating. [Author's elaboration]

5.3.1 The starting information base: BIM model and as-built documentation

The starting point of the process is the federated BIM as-built model described in Chapter 4, together with the set of technical documentation available to support knowledge of the building. This clarification is important because the Record Model is not developed by assuming the BIM model as the only information source, nor by treating it as a fully self-sufficient dataset. On the contrary, the existing model is considered as one component of a broader information system, within which drawings, documents, technical data, datasheets, maintenance plans and information from different sources must be related to one another. In the case of the *"Torre della Regione"*, the documentary collection linked to the as-built configuration includes different types of material: specifications and documents useful for reading the performance requirements of components, CAD as-built floor plans, technical sheets, maintenance plans, maintenance schedules, BIM modelling Guideline and further supporting documentation (Figure 5.25).

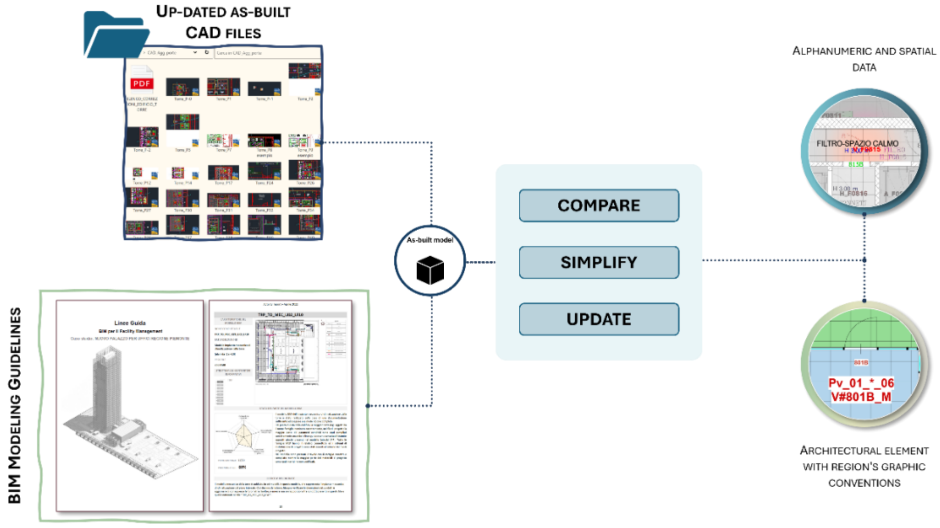


Figure 25 – Documentary sources supporting the verification of the BIM as-built model, including CAD drawings, technical guidelines and component documentation. [Author's elaboration]

These materials do not all have the same degree of structuring, updating or immediate usability, but they constitute the reference framework required to verify and interpret the model contents. Their function is not simply to accompany the BIM model, but to enable a critical reading of its reliability, especially in cases where geometries, parameters or codings are not fully verifiable within the modelling environment alone. The first methodological step therefore consists in recognizing the documentary value of the as-built base and, at the same time, preserving its original configuration. For this reason, the transformation towards the Record Model presupposes the preservation of a reference copy of the as-built model, so as to maintain a trace of the initial information state and clearly distinguish between the documentary model of departure and the model reorganized for management. This distinction prevents the simplification and updating process from producing an uncontrolled loss of the information memory of the completed asset. At this stage, the issue is not yet to decide which information will enter the Record Model, but to understand the quality of the available base. The federated model and the as-built documentation must be read as a potential information asset: rich, articulated and already organized, but not automatically ready for management use. Only through a subsequent comparison and verification process is it possible to establish which contents can be maintained, which must be updated, which must be simplified and which, instead, must be excluded from the operational model.

5.3.2 Comparing: model, guidelines, documentation and actual condition

The comparison phase represents the first operational step in the construction of the Record Model. Its aim is to verify whether the existing BIM model is consistent with the available sources, the adopted information rules and the actual condition of the building. This is therefore not a generic check, but a multi-level verification that involves both the graphical and the alphanumeric dimensions of the model.

A first level concerns the comparison between the BIM model and the adopted information guidelines. This check makes it possible to assess the consistency of the model with respect to rules for organization, naming, parameter structure, element classification and document management. From this perspective, the reliability of the model does not depend only on the fact that elements are present and modelled, but also on their capacity to comply with a shared system of rules. An object may be geometrically correct, yet poorly usable if it is not named coherently, if it does not contain interpretable parameters or if it cannot be traced back to a stable information structure.

A second level of comparison concerns the relationship between CAD drawings and the BIM model. CAD as-built floor plans, when available, constitute a useful verification source for checking the correspondence between delivered drawings and modelled representation. This comparison makes it possible to identify possible discrepancies between the two-dimensional drawing and the three-dimensional model, verifying the consistency of positions, geometries, spatial distributions, components and systems. This step is particularly relevant in cases where the BIM model has been built or updated from different documentary sources that are not always fully aligned with each other.

A third level concerns the comparison between the BIM model and the actual condition. This check introduces a dimension closer to the logic of the as-is model, since it aims to verify whether the modelled configuration actually corresponds to the real condition of the building. In the case of a complex asset already moving towards management use, this comparison is essential: even a model defined as as-built may not fully represent the actual state of the asset, especially if some information has not been verified on site, if subsequent modifications have occurred, or if the original documentation contains gaps and ambiguities.

Finally, comparison concerns the correctness of the graphical and alphanumeric contents of the elements. On the graphical level, it is necessary to verify the presence, location and geometric adequacy of objects; on the alphanumeric level, it is necessary to check parameters, codings, names, relationships with spaces or systems, technical data and information useful for management. This verification makes it possible to distinguish between elements that are modelled but not manageable, elements that are manageable but informationally incomplete, and elements that are effectively ready to be included in the Record Model configuration. The comparison phase therefore produces an initial mapping of criticalities: inconsistencies between sources, missing data, redundant information, uncoded elements, unfilled parameters, unnecessary geometries or contents not aligned with FM uses. It represents the moment in which the as-built model ceases to be assumed as a neutral starting datum and is subjected to a critical assessment of its reliability. Only on the basis of this verification is it possible to proceed to the subsequent simplification phase.

5.3.3 Simplifying: from representational completeness to FM relevance

Simplification is the step through which the model is reoriented from the logic of complete representation to the logic of management relevance. As discussed in the previous sections, the Record Model does not coincide with the most extensive or most detailed model, but with the model that is most coherent with FM uses. For this reason, simplification should not be interpreted as an improper reduction of information content, but as a methodological selection aimed at making the model more legible, queryable and governable.

First, simplification concerns the formal component of the model. This implies the definition of homogeneous rules for naming, parameters, categories, codings and information structures. Elements named inconsistently, duplicated or unusable parameters, non-aligned categories or information inserted in uncontrolled fields can compromise the possibility of querying the model and transferring data to the management environment. Formal simplification therefore aims to reduce unnecessary variability and to build a more stable information base.

Second, simplification concerns the substantive component of the model. It consists in identifying which elements and which levels of detail are actually necessary for Facility Management. Some objects may be relevant during design or construction, but have no direct role in management; others may be geometrically too detailed in relation to the intended uses; others may be necessary only as documentary references and not as active objects in the management model. Substantive simplification does not eliminate the information value of these contents, but redefines their place: some remain in the documentary asset, others enter the Record Model, and others are excluded from the operational model.

A central aspect of this phase is the identification of essential components for each discipline and for each management use. The criterion is not the presence of the element in the BIM model, but its actual relevance to FM processes and its possible correspondence with the technical registry contained in the management tool. In this sense, comparison with *FactotuM* assumes a relevant role: the component to be maintained in the Record Model must be recognizable, coded and connected to the information structure of the FM system. Simplification therefore also becomes an operation of alignment between the BIM model and the management environment.

This logic makes it possible to avoid two opposite risks. The first is information overload, that is, the preservation in the management model of objects, parameters or details that are not necessary and that increase complexity without improving operational use. The second is information loss, that is, the removal of data or elements required for management. Critical reduction is located precisely between these two extremes: reducing what is not needed, maintaining what is necessary, integrating what is missing and ensuring that active information is coherent with the intended uses.

This distinction becomes particularly evident when the process is applied to categories of elements that are not purely building-related, such as furniture, workstations or components subject to asset inventory. In these cases, the transition towards an as-FM configuration requires connecting the model not only to geometric or technical data, but also to registry information, relocation management, quality control and maintenance.

5.3.4 Updating: from verified information to the Record Model / as-FM configuration

The updating phase is the moment in which the outcomes of comparison and simplification are translated into operational modifications to the model. If the comparison phase makes it possible to identify criticalities and misalignments, and the simplification phase makes it possible to define what is actually relevant for FM, updating consists in intervening on the model in order to make it consistent with the Record Model configuration.

This updating may take different forms. It may involve modifying existing components when they are geometrically or informationally inconsistent; adding missing elements when they are required for management; removing or archiving elements that are not relevant to FM uses; correcting parameters, names and codings; or integrating fields required for interoperability with the management platform. In all cases, the objective is not to produce a richer model in an absolute sense, but a model that is more adequate to use.

The transition to the Record Model therefore requires the BIM model to be prepared to communicate with the FM environment. This means that the selected objects must be identifiable, locatable, queryable and linkable to technical data, documents, procedures and registers. BIM–FM interoperability is not only a matter of exchange format, but above all of semantic coherence between what the model contains and what the management platform must receive, organize and use. The model must therefore be structured in such a way as to feed management records, tables and registries without requiring continuous manual reconstruction or subjective interpretation.

From this perspective, the Record Model can be understood as an **as-FM configuration** of the BIM model. It does not coincide with the entirety of the as-built base, nor with the management database produced within *FactotuM*. Rather, it is located between the two: on the one hand, it maintains the link with the BIM model and the spatial representation of the building; on the other, it assumes a selected, verified information structure oriented towards integration with the FM tool. Its value lies precisely in making the transition from modelled object to managed asset governable.

Updating must finally be accompanied by quality control. Every modification to the model should be verified with respect to geometric coherence, alphanumeric correctness, the presence of codings, the relationship with spaces and compatibility with the information structure of the management system. In this sense, the checklist is not a formal requirement, but the tool through which the transformation process becomes traceable and controllable.

The Record Model configuration thus obtained constitutes the basis for the subsequent test phase. In the following section, the method is applied to five representative categories — space, workstation, architectural element, furniture and building services component — in order to verify how the transition from the as-built model to the as-FM configuration behaves in relation to different information requirements.

5.4 Testing BIM–FM integration: spaces, assets and FM tools

After defining the transition from the as-built model to the Record Model as a process of verification, simplification and updating, it is necessary to observe how this transformation behaves when applied to concrete model elements. The issue, in fact, is not only to define in theoretical terms what a model oriented towards Facility Management should contain, but to verify how objects of different nature can be made actually usable within a management environment. In the case of the TRP project this verification was conducted through the integration between the BIM model and **Factotum**, an ARCHIBUS-based platform used for the management of spaces, assets, building services, maintenance activities and associated documentation. The transition towards *FactotuM* cannot be interpreted as a simple export of the Revit model, nor as an automatic transfer of geometries and parameters. On the contrary, it requires each element to be prepared, recognized and translated according to the logic of the management system, which operates through entities, tables, records, attributes and queryable graphical representations. For this reason, the BIM–FM test was developed on a set of representative cases, selected to intercept different information and management conditions: physical space, workstation, fixed architectural element, movable inventory asset and maintainable building services component. The aim is therefore not to describe all the categories present in the model, but to understand how the transformation process changes when the nature of the object, the required data structure, the necessary level of geometry and the type of relationship with *FactotuM* change. As shown in the Figure 5.26, the cases analysed are: **Room**, **PDL – Workstation**, **Door**, **Motorized Double Desk** (MDD) and **Fan Coil Unit**. Each of them makes it possible to observe a different declination of the transition from the as-built model to the Record Model/as-FM configuration. Some elements were already present in the model and mainly required verification, normalization and coding; others were not modelled and required the construction of new families or information entities; still others made evident the need to distinguish between what must be represented geometrically, what must be managed as tabular data and what must be governed through maintenance procedures.

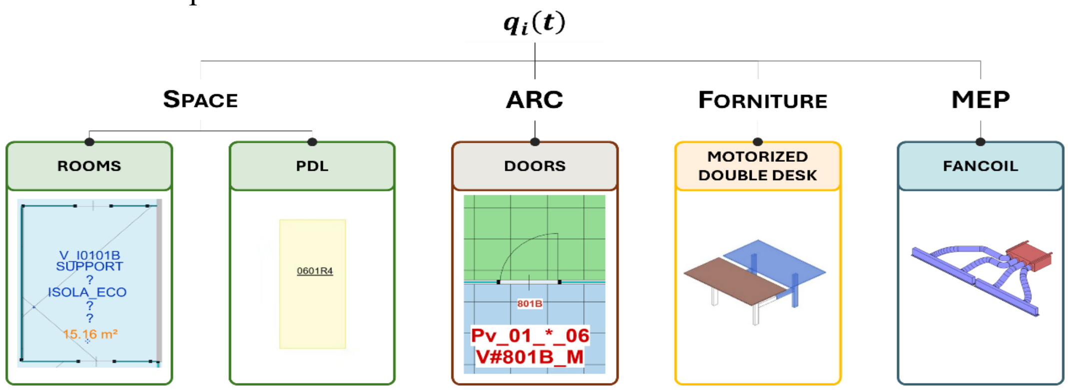


Figure 26 – Representative BIM–FM test cases analyzed in the transition from the as-built model to the Record Model/as-FM configuration. [Author's elaboration]

This section does not intend to anticipate the maintenance processes that will be discussed in the following chapters, nor to describe the functioning of *FactotuM* exhaustively. The objective is more circumscribed: to show how BIM information is prepared to become management information. From this perspective, the tested cases constitute an operational verification of the principle discussed in the previous sections: the Record Model is not a reduced copy of the as-built model, but a selective, normalized and use-oriented configuration.

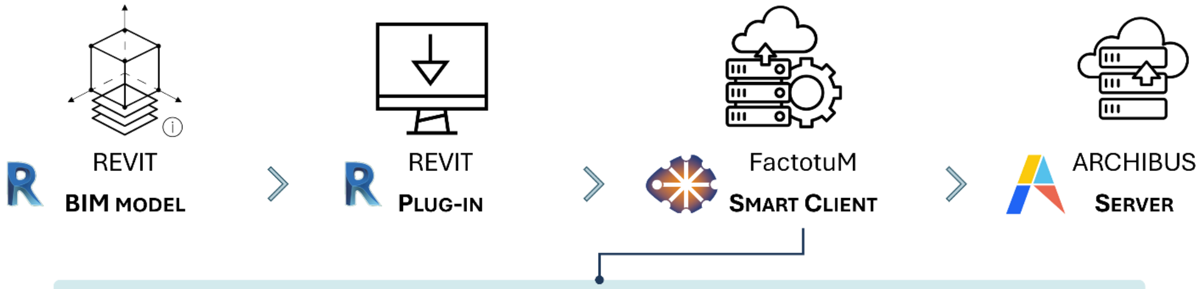
5.4.1 From BIM objects to FM entities: selection criteria and Factotum workflow

The selection of the tested cases responds to a precise methodological logic. The objects were not chosen only because they are present or relevant in the model of the *Torre della Regione*, but because they represent different conditions of the relationship between BIM and Facility Management. In particular, the selection made it possible to consider at least one element referring to each of the areas most involved in building management: space management, workplace management, architectural and access management, movable asset management and building services maintenance.

The first area is represented by **Rooms**, which constitute the minimum spatial basis for locating and organizing any management information. The second is represented by **PDL – Workstations**, which are necessary to associate space with actual use, personnel and furniture. The third is represented by **Doors**, fixed architectural elements that become management-relevant when connected to rooms, access, codes and keys. The fourth is represented by the **Motorized Double Desk**, selected as an example of furniture and movable inventory asset, therefore connected not only to localization but also to asset management. The fifth is represented by the **Fan Coil Unit**, a maintainable building services component that highlights the complexity of the transition between BIM object, equipment, technical data and maintenance procedures.

This articulation makes it possible to avoid a uniform interpretation of the Record Model. Not all objects require the same operations, the same geometric level or the same alphanumeric structure. A Room must be uniquely identifiable and usable as a spatial container; a PDL must make the organization of workstations legible; a door must connect geometry, room, access and safety; a furniture item must be modelled, inventoried and catalogued; a Fan Coil must be recognized as equipment, localized and connected to a maintenance strategy. The construction of the Record Model therefore does not proceed through a simple lightening of the as-built model, but through differentiated transformations. To understand the meaning of this transformation, it is necessary to briefly clarify the logic through which *FactotuM* organizes information. *FactotuM*, based on ARCHIBUS, does not manage objects as simple elements of the BIM model, but as information entities organized within a database. Each entity corresponds to a table and each instance of the entity corresponds to a record. This structure determines the way in which an element modelled in Revit can be recognized, connected, updated and used within the FM system (Figure 5.27).

The information hierarchy first distinguishes territorial and spatial entities, such as **site**, **building** (bl), **floor** $(fl)$and **room** (rm), together with their categories and types, such as **room category** $(rm_cat)$and **room type** (rm_type). These are complemented by organizational entities, such as departments, divisions and employees, and by technical entities, including **equipment** $(eq)$and **equipment extended** (eq_ext). As a consequence, a room, a workstation, a door, a furniture item or a building services component does not enter the management system in the same way. Each must be related to the correct management entity, reference table and required attributes.



Nome tabella	Dati contenuti
site	Elenco dei siti
bl	Elenco edifici
fl	Elenco piani edificio
rm	Elenco locali e pdl
gros	Elenco aree lorde di piano
rm_cat	Elenco categorie di locale e pdl
rm_type	Elenco tipologie di locale e pdl
dp	Elenco dei dipartimenti
dv	Elenco delle divisioni
em	Elenco dipendenti
Eq	Elenco degli equipment
Eq_ext	Elenco degli eq estesa

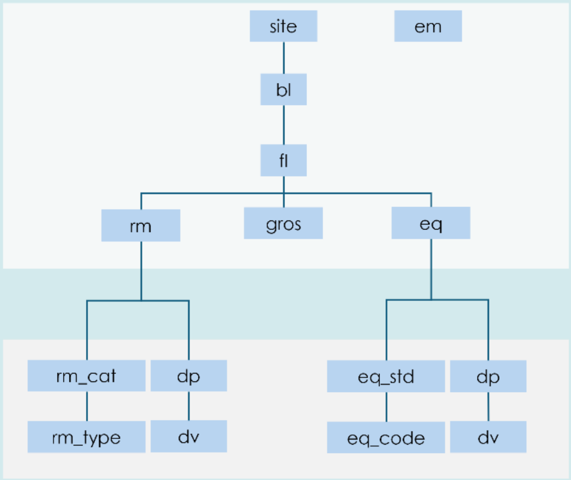


Figure 27 – FM process and Smart Client table hierarchy used to structure FM entities. [Author's elaboration]

This structure explains why the preparation of the BIM model requires an alignment between Revit categories and *FactotuM* categories. A Room must be recognisable as a record in the **rm** table; a furniture item or technical component must be catalogued as **equipment** in the **eq** table, with possible additional information in the **eq_ext** table; a PDL, although not a traditional three-dimensional object, must be represented and queried as a management entity connected to space and workplace organization. The central issue is therefore not only whether the object is modelled, but whether it contains the fields, codings and relationships required to be recognized by the FM database.

From an operational point of view, the transition from the BIM model to *FactotuM* can be traced back to three main actions: **normalization**, **cataloguing** and **publication** (Figure 5.14).

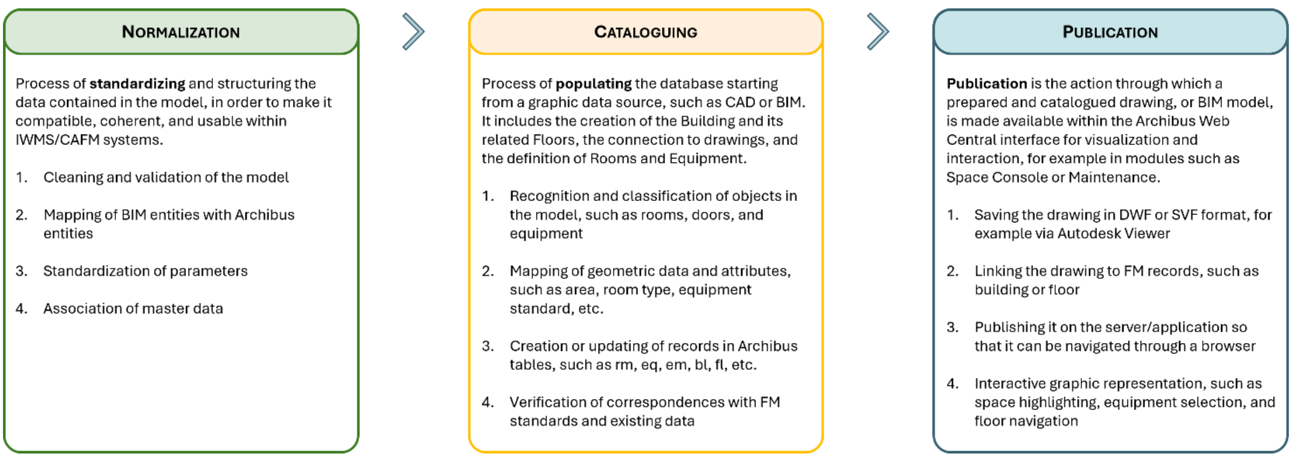


Figure 28 – Main operational actions for BIM–FM integration in Factotum. [Author's elaboration]

Normalization concerns the preparation of information within the BIM environment. It includes model checking and cleaning, parameter standardization, correction of codings, preparation of views and schedules, and alignment between BIM elements and corresponding management entities. In this phase, the model is not simply made more orderly, but made legible for the FM system.

Cataloguing concerns the population of the management database. It is the moment in which the object is recognized, classified and associated with a record. In the case of rooms, this means creating or updating spatial records; in the case of furniture and building services components, it means recognising the object as equipment and associating it with the relevant fields; in the case of other entities, it means establishing the most appropriate management structure. Cataloguing is therefore the step through which the BIM object is translated into an FM entity.

Publication finally concerns the availability of the 2D/3D graphical component within the management interface. It allows drawings, views or models to be linked to records contained in the database, making information consultable and queryable. This step is particularly important because it clarifies that geometry and information do not automatically coincide: they may be associated, dissociated and reassociated, but this relationship must be constructed and controlled.

The operation of this sequence is supported by the Revit plug-in for *ARCHIBUS-FactotuM* (Figure 29). The main commands make it possible to associate the model with the building registered in *FactotuM*, catalogue elements, number rooms and PDLs, modify the data linked to a specific entity and publish the graphical component in 2D or 3D. In this sense, integration does not occur through a generic data transfer, but through a series of commands that relate model objects, attributes and records of the management system.

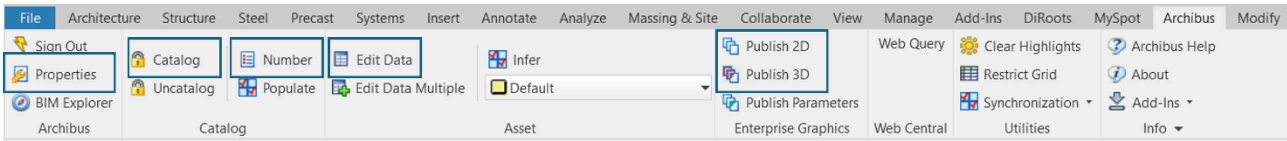


Figure 29 – Revit plug-in commands used for BIM–FM data synchronization. [Author's elaboration]

This approach makes it possible to understand why the five tested cases require specific workflows. Some elements, such as Rooms and Doors, were already present in the as-built model and mainly required checking, normalization and integration of management parameters. Others, such as PDLs and furniture, required the construction of new information entities or newly modelled families. Still others, such as Fan Coil Units, highlighted a deeper criticality, connected not only to cataloguing as equipment, but also to the need to decide which information should remain in the model and which should be governed through maintenance procedures in the FM environment.

The value of the test therefore lies in the possibility of observing the transition from **BIM object** to **management entity**. The model is not operational in *FactotuM* simply because it contains geometries and parameters; it becomes operational when its elements are normalized, catalogued, published and made coherent with the structure of the FM database. This translation, different for each category of objects, constitutes the core of the experimentation described in the following subsections.

5.4.2 Space: Room

The first case analyzed concerns the **Room**, assumed as the minimum information unit for the localization and organization of data in space management. In the transition from the as-built model to the Record Model, the room cannot be interpreted only as a geometric element of the architectural model, but as the basic structure through which assets, furniture, workstations and technical components can be located, queried and managed. In this sense, the Room constitutes one of the preliminary conditions for BIM–FM integration: if space is not correctly identified, coded and transferable, the objects contained in or related to it also risk losing localization and management meaning.

In the case of the *Torre della Regione*, rooms were already present in the Revit 2019 as-built model as **Rooms**. Their presence in the model therefore constituted a significant starting point, but not a sufficient one. As already observed for the entire information system of the case study, the availability of the BIM object does not automatically coincide with its full usability in the FM environment. It was necessary to verify that rooms were correctly bounded, consistent with the actual state of the building, equipped with reliable parameters and compatible with the *FactotuM* structure.

A first aspect concerns the correct geometric definition of rooms. In the as-built model, structural elements, in particular columns contained in the structural model, were set with the **room-bounding** property active, so as not to interfere improperly with the calculation of surfaces. This apparently technical aspect is relevant because it shows that the quality of the room does not depend only on the presence of the spatial perimeter, but also on the correct interaction between the architectural model, the structural model and the rules for calculating spaces. The Room becomes useful for management only if it returns surfaces, perimeters and spatial relationships consistent with operational reality.

From an alphanumeric point of view, rooms were already included in a rather rich information system. All delivered as-built models contained a set of fourteen shared parameters already filled in and populated: **Project**, **Building**, **Classes of Technological Units**, **Technological Units**, **Classes of Technical Elements**, **MasterFormat Code**, **MasterFormat Title**, **Category Code**, **Identifier**, **Parent Code**, **Existing Code**, **Reliability**, **Family Code** and **Subdiscipline**. These parameters constituted the common structure of the model and made it possible to read objects according to a classification and traceability logic already defined during the as-built phase.

In addition to this general structure, rooms included a further set of specific parameters more directly oriented towards spatial management. These included **Construction Room Code**, **Room Name**, **Room Category**, **Sub-zone**, **Zone**, **Existing Code**, ***Codice Factotum***, **FM_Floor Semantic Code**, **FM_Floor Number**, **FM_Real Estate Unit Number**, **FM_Room Semantic Code**, **FM_Room Number** and **FM_Communicating Rooms**. This information set shows that the room was already prepared not only as a spatial element, but also as a possible management record, provided that the codes were coherent and correctly interpretable.

The central parameter of this structure is the ***Codice Factotum***, which in the case study functions as the unique management identifier of the space. It must be assigned to each room and must be unique for each instance in the project. Its compilation derives from the rules of the *FactotuM* manual provided by *Regione Piemonte*. In particular, the code is built through five fields, for a maximum of eight characters, including the semantic code of the room, the underscore separator, the semantic code of the floor, the room number and the possible indication of communicating rooms.

This structure (Table 10) makes the code not a simple progressive number, but an information string capable of condensing the location, belonging and management identification of the room.

Table 10 – Structure of the *Codice Factotum* used for room identification [Author's elaboration].

Room Semantic Code	Semantic code underscore	Floor	Room Numeber	Interconecting rooms	*Codice Factotum*
V	_	F27	01		**V_F2701**
V	_	F27	03	A	**V_F2703A**

The first operation carried out on the rooms concerned checking the correspondence between the Rooms present in the model and the actual rooms of the building. This check made it possible to verify the consistency between modelling, naming and real condition, identifying possible misalignments or required corrections. In some cases, it was necessary to intervene on the room name, in order to make the relationship between modelled information, management coding and operational recognizability more coherent.

A second step concerned the issue of integration with *FactotuM*. In theoretical terms, the *Codice Factotum* already represented the key information for the management recognition of the room. However, from a technical point of view, the FM database retrieved the necessary information from the **Number** parameter of the room. For this reason, the *Codice Factotum* was also duplicated in the Number parameter. This choice was not an end in itself, but a technological strategy required to allow the management system to correctly populate the required attribute during integration. The case therefore shows that the theoretical coherence of the data structure is not sufficient: information must also be placed in the field that the FM system is actually able to read. Room normalization also required the preparation of specific views and control tools. View templates and plan views were generated to simplify BIM–FM verification and integration (Figure 30). These views did not have a merely representational function, but constituted operational tools for checking rooms, their codes, their correspondence with reality and their legibility in the cataloguing and publication process. In this sense, the view becomes part of the information process: not only a graphical output, but a control device.

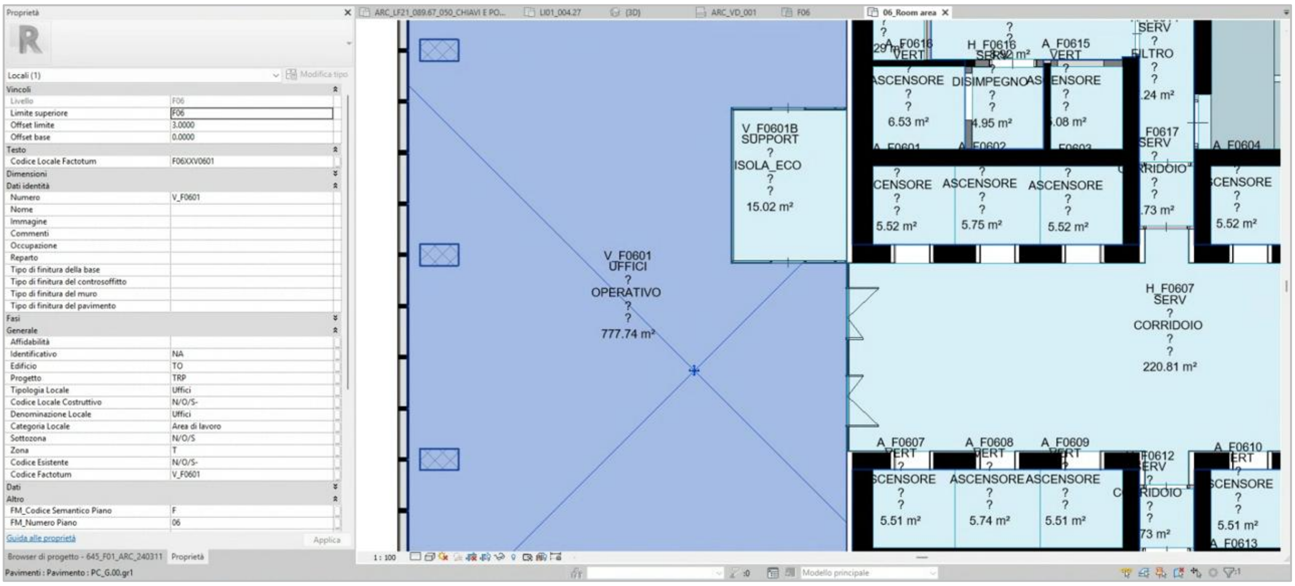


Figure 30– Normalized Room parameters in Revit 2019, including the Factotum Code. [Author's elaboration]

The workflow followed for Rooms can therefore be traced back to the general sequence introduced in the previous section. Normalization took place in the BIM environment, through room checking, parameter verification, correction of naming and duplication of the *Codice Factotum* in the Number parameter. Cataloguing concerned the recognition of rooms as spatial entities of the management system, traceable to the logic of the **rm** table. Publication finally made spatial and graphical information available in the FM environment, according to the structure required by *FactotuM*.

The Room case therefore highlights a first fundamental issue: for Facility Management, space is not only the physical container of assets, but the information support that enables localization. The quality of the Record Model depends to a large extent on the capacity to ensure that each object can be related to a uniquely identified space. In this sense, the Room is not simply a modelled room, but the relational basis on which the management of furniture, workstations, equipment and operational activities depends. For this reason, the construction of the Record Model cannot dispense with rigorous normalization of spaces and their management codes.

5.4.3 Workstation: PDL

The second case concerns the **PDL – Workstation**, introduced as an information entity required to describe and manage the organization of the workplace. Unlike Rooms, PDLs were not present in the Revit as-built model. Their introduction therefore required a specific information construction, aimed not at representing a new building element, but at defining a management unit capable of linking space, personnel, workstation and furniture.

The PDL identifies the workstation assignable to a public employee and makes it possible to know which workstation is located on a given floor or in a given room. It does not coincide with the Room: the Room represents the physical space, whereas the PDL represents a unit of use within that space. This distinction is relevant because space management does not concern only the knowledge of rooms, but also their occupancy, the distribution of workstations, their relationship with furniture and the possibility of querying the organization of work.

In the case of the *Torre della Regione*, the PDL was treated as a management record with its own identifier, the **Codice_PDL**. This code makes it possible to recognize the workstation and to link it both to the space in which it is located and to the furniture that composes or supports it. The PDL, therefore, is not simply a graphical element added to the model, but an information structure that makes it possible to govern the relationship between room, workstation and equipment.

From a modelling point of view, PDLs were created in Revit through the use of **Areas**. This choice made it possible to represent the extent and position of workstations in plan view, making them visible and queryable in dedicated views. Modelling through Areas, however, also constitutes a technological limitation: since they are two-dimensional entities, PDLs are not visible in 3D as traditional model objects. This limitation, however, does not compromise their management function, since the main purpose is not the three-dimensional representation of the workstation, but its identification and localization in relation to space and furniture.

The operations carried out first concerned the creation of PDLs as Areas in Revit and the population of the related parameters (Figure 31). Specific views were then prepared, in particular area plans, aimed at reading and checking the workstations. Here too, the view is not simply a graphical drawing, but an operational tool for verifying the coherence between space, workstation and management information.

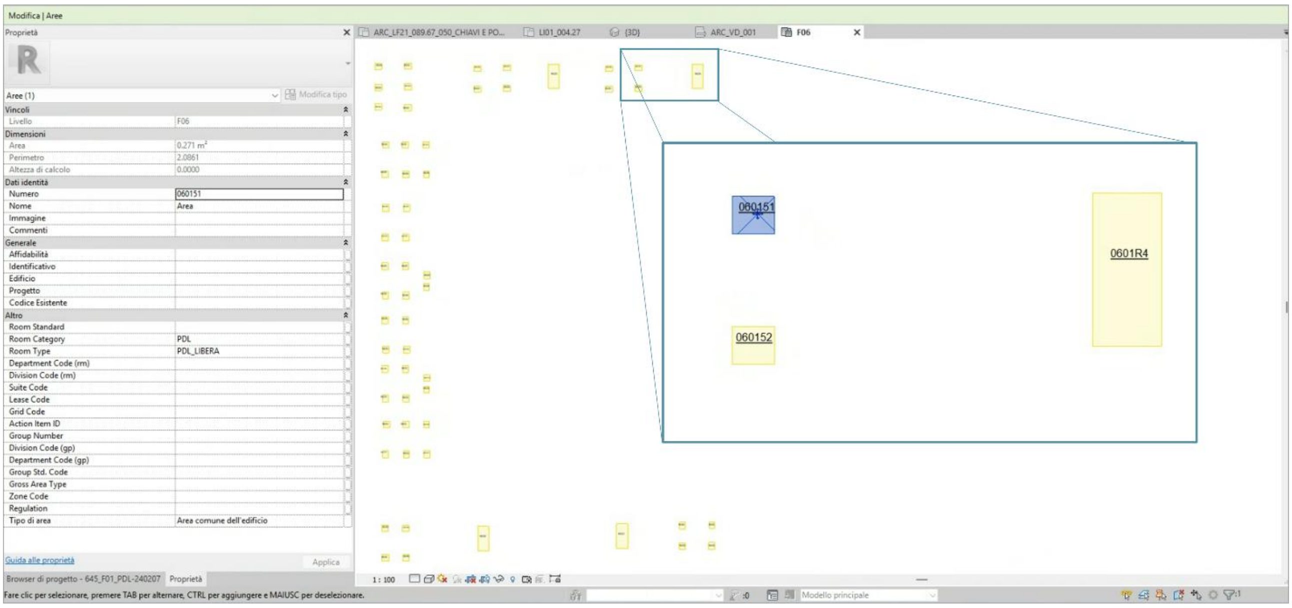


Figure 31 – PDL representation through Revit Area with its parameters. [Author's elaborations]

A decisive step was the connection between PDLs and furniture. To preserve this relationship also on furniture objects, the **Codice_PDL** parameter was loaded and populated within the furniture families as well. This choice allows the link between workstation and equipment to be transferred directly into the modelled elements, preventing the PDL from remaining information separated from the furniture system. In this way, the workstation becomes a relational node between Room, furniture and personnel management.

The PDL case therefore shows a different condition from the Room case. While the Room was already present in the model and had to be verified, normalized and made compatible with *FactotuM*, the PDL was constructed as a non-pre-existing management entity. Its introduction demonstrates that the Record Model does not only select or correct objects already available in the as-built model, but may also require the creation of new information structures when these are necessary to support FM uses. From the point of view of the operational sequence, normalization concerned the definition of the PDL representation logic, the creation of Areas, the population of parameters and the construction of dedicated views. Cataloguing concerned the recognition of the PDL as a management entity linked to space and furniture. Publication made this information legible within the BIM–FM process, although with the limitation of a predominantly two-dimensional visualization.

The methodological value of the PDL case lies precisely in this controlled ambiguity: the workstation is not a building object, it is not furniture and it is not simply a room. It is a management entity constructed to make the use of space queryable. In this sense, it shows that modelling for Facility Management may require hybrid solutions, in which information does not always coincide with a 3D object, but with a formalised relationship between space, use, personnel and equipment.

5.4.4 Architectural element: Door

The third case concerns the **Door**, considered as an example of a fixed architectural element that, in the transition towards the Record Model, assumes a management value connected not only to its physical presence in the model, but also to its relationship with rooms, access, codings and keys. Unlike PDLs and furniture, doors were already present in the TRP architectural as-built model. They were, however, characterized by a heterogeneous condition, consistent with the real variety of elements present in the building, and by families and types organized according to a nomenclature already aligned with the coding logic adopted during the execution phase.

The test involved all the doors in the building, not a single instance or a limited sample. This choice is relevant because the door is a widespread and repetitive element, but at the same time strongly dependent on the spatial context in which it is located. The objective was not simply to verify the presence of doors in the model, but to check their correspondence with the actual condition, verify their types, consolidate door codes and define an information logic for key management (Figure 32). In this sense, the door becomes a useful case for observing how an apparently ordinary architectural element can become a management node.

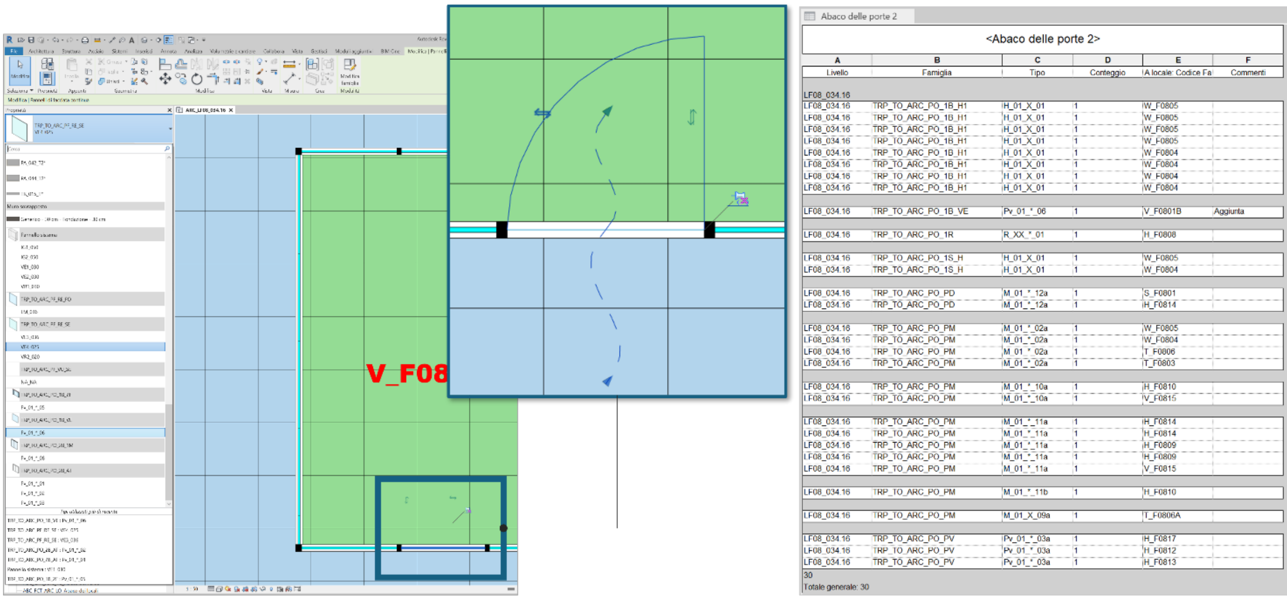


Figure 32 – Door element in the TRP as-built model (left), normalised door view (centre), and control schedule used to verify door normalisation in the BIM model (right). [Author's elaboration]

From an information point of view, the doors already contained the fourteen general shared parameters present in the as-built model. However, in order to make them usable with respect to the identified management objectives, it was necessary to characterize them through three specific parameters: ***Codice Factotum***, ***Codice Porta*** and ***Codice Chiave***. The *Codice Factotum* was extended to the Door category in order to make explicit the reference room of the element. The general rule adopted establishes that the door belongs to the room towards which it opens, while recognising the presence of exceptional cases to be assessed individually. The *Codice Porta* identifies the individual door within the coding system linked to the room, while the *Codice Chiave* makes it possible to associate the door with the corresponding key.

To make this relationship between door and room effective, it was necessary to activate the element's **room calculation point**. This operation allows the door to recognize its spatial belonging, making it possible to connect it with the *Codice Factotum* of the room. This issue is not secondary: without a controlled relationship with the room, the door would remain a modelled object but not a fully manageable one, because it would not be possible to assign it reliably to a spatial context, a door code and a key code.

The coding logic can be clarified through an example (Figure 33). If the reference room has the *Codice Factotum* **V_F2101B**, the first door opening towards that room may assume **2101B** as *Codice Porta*, while a second door referring to the same room may assume **2101C** as *Codice Porta*. Consequently, the *Codice Chiave* can be built by combining the *Codice Factotum* with a progressive code, for example **V_F2101B#01B** for the first door and **V_F2101B#01C** for the second.

This structure makes the relationship between room, door and key legible, reducing ambiguity in access management.

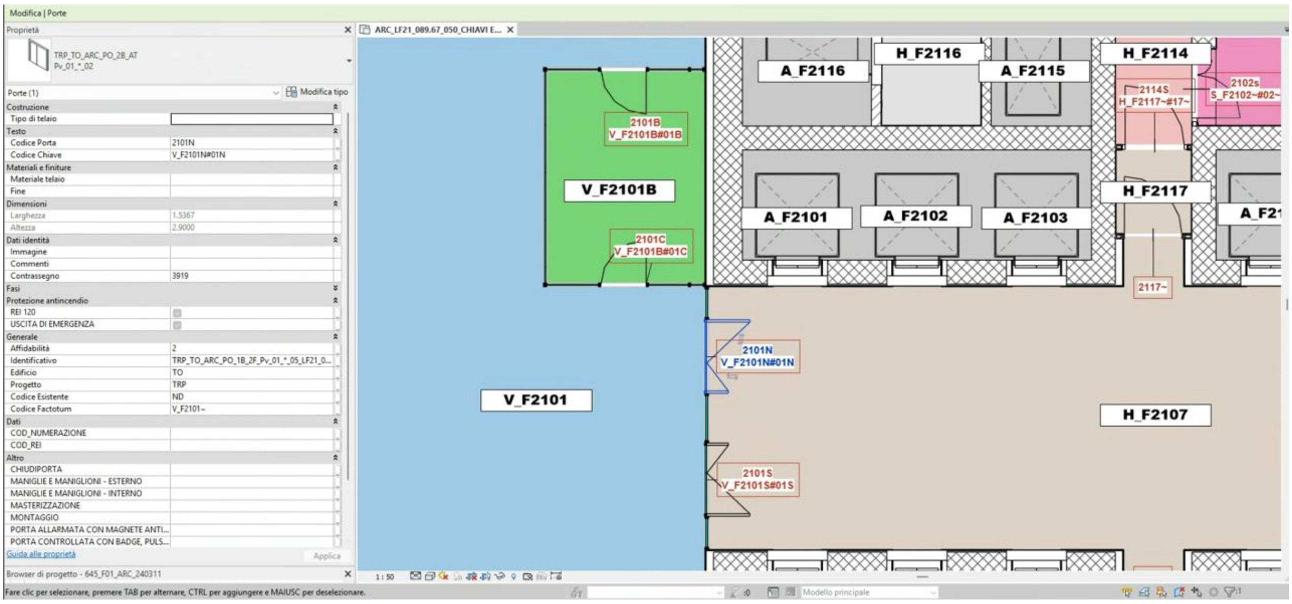


Figure 33 – Example of the relationship between *Codice Factotum*, *Codice Porta* and *Codice Chiave* for door and key management. [Author's elaboration]

The operations carried out on the doors were articulated. First, the insertion of the shared parameter .txt file was checked, in order to ensure the availability of the required information fields. Subsequently, the *Codice Factotum* parameter was extended to the Door category; the shared parameters *Codice Porta* and *Codice Chiave* were created; and door tag families were prepared so that both codes could be displayed in the floor plans. This phase transformed information from tabular data into content that could also be read graphically through tags and dedicated views.

The work was then carried out by groups of floors, according to slots of approximately ten levels. Common corrections concerned the verification of the *Codice Factotum* of the rooms, with particular attention to modified connecting spaces; the insertion of new doors according to updates (Figure 34); the compilation of *Codice Factotum*, *Codice Porta* and *Codice Chiave*; the insertion of the *Codice Porta* in floor plans; the completion of views; and the cross-checking between schedules, tags and floor plans. These operations were accompanied by specific corrections linked to individual doors or particular floor conditions.

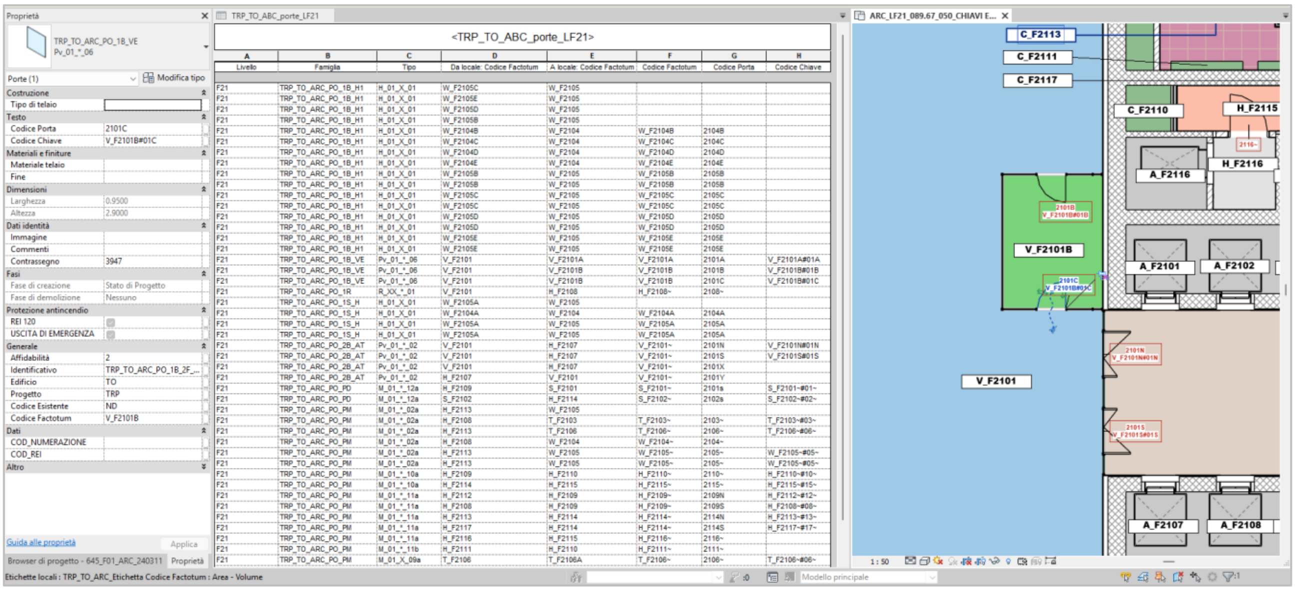


Figure 34 – Door management views and schedules in Revit 19 used to verify the consistency between *Codice Factotum*, *Codice Porta*, *Codice Chiave*, labels and floor plans. [Author's elaboration]

An important aspect concerns the relationship with *FactotuM*. Unlike other cases, the door was not treated as equipment to be catalogued in the management system. Key management does not pass directly through *FactotuM*, but through a graphical-information structure constructed within the model and its views. The door is therefore managed as an information-rich architectural element linked to rooms, not as an autonomous technical asset of the FM database. This aspect is methodologically relevant because it shows that not all objects in the Record Model necessarily have to become equipment records: some elements maintain a management function through relationships, codings and controlled representations.

The Door case also highlights a more general aspect of architectural model quality. To code a door correctly, it is not enough to intervene on the single element; it is necessary to know the arrangement of rooms, their use, the opening direction, the relationships between spaces and the exceptions to the rule of belonging. Work on doors therefore becomes a sort of indirect verification of the spatial organization of the building and of the coherence of the architectural model. In particular, the relationship between door, room and key assumes a management meaning also connected with security and access control.

From the point of view of the operational sequence, normalization concerned the verification of families, the creation and population of parameters, the extension of *Codice Factotum* to the Door category and the preparation of tags. In this case, cataloguing does not translate into the creation of equipment in *FactotuM*, but into the organization of doors as information elements linked to rooms and keys. Publication mainly concerns the availability of floor plans, tags and schedules capable of making the coding system legible.

The methodological value of the Door case therefore lies in its relational nature. The door shows that an apparently simple architectural element becomes management-relevant when connected to a network of information: room, opening direction, door code, key code, floor plan, schedule and security. In this case, information consistency does not derive from greater geometric detail, but from the capacity to construct and verify reliable relationships between objects, spaces and codes.

5.4.5 Furniture element: Motorized Double Desk

The fourth case concerns the **Motorized Double Desk**, selected as an example of furniture and, more precisely, of a movable inventory asset. Unlike Rooms and Doors, this element was not present in the Revit as-built model. Its introduction into the BIM–FM process therefore required ex novo modelling, but above all the definition of an information strategy capable of connecting geometry, patrimonial identity, workstations, integrated accessories and cataloguing within the management system.

The furniture case is particularly relevant because it does not concern only the representation of objects in space. In the management of a public building, some movable assets must be identified, localized, inventoried and related to the patrimonial consistency of the public body.

The Motorized Double Desk was therefore selected as a significant case because it is not simply a furniture family, but an object with its own management identity, intended to be associated with a space, one or more workstations and a specific management cycle. Furniture modelling was preceded by a broader decision-making process, based on the intersection between the movable asset classification provided by the manager and the furniture specifications (Figure 35).

From this comparison, a decision table was developed to establish, for each type of object, whether it should be inventoried, modelled, catalogued as an asset in the FM system and associated with a PDL. This preliminary phase is essential because it shows that the decision to model a furniture item does not derive from an exclusively graphical criterion, but from its management, patrimonial and operational relevance.

Starting from this analysis, the structure of the Revit furniture families was defined. The process led to the progressive expansion and refinement of the family system: from an initial draft of seven families to thirty-eight furniture families. The MDD is one of these families. The main sources used for modelling were the manufacturer's datasheet, the furniture specifications and the on-site survey, in order to ensure a minimum coherence between the modelled object, the actually installed object and the information required for management.

The Motorized Double Desk was modelled as a **nested family**, composed of two half-desks (Figure 36). This choice responds to a specific management condition: from an inventory and patrimonial point of view, the desk is a single movable asset with a single inventory code; from the point of view of use, however, it serves two workstations and can therefore be associated with two users or operational responsibilities. Nested modelling makes it possible to preserve the unity of the object as an inventory asset, without losing its relationship with two PDLs.

Since furniture was not present in the as-built model, there were no parameters already populated on the object. It was therefore necessary to insert both the fourteen general shared parameters already adopted in the model's information structure and a set of specific parameters linked to the nature of the furniture item and its integration with *FactotuM*. At this stage, a distinction was made between parameters intended to remain in the Revit model and parameters intended to be imported or populated also in the FM environment.

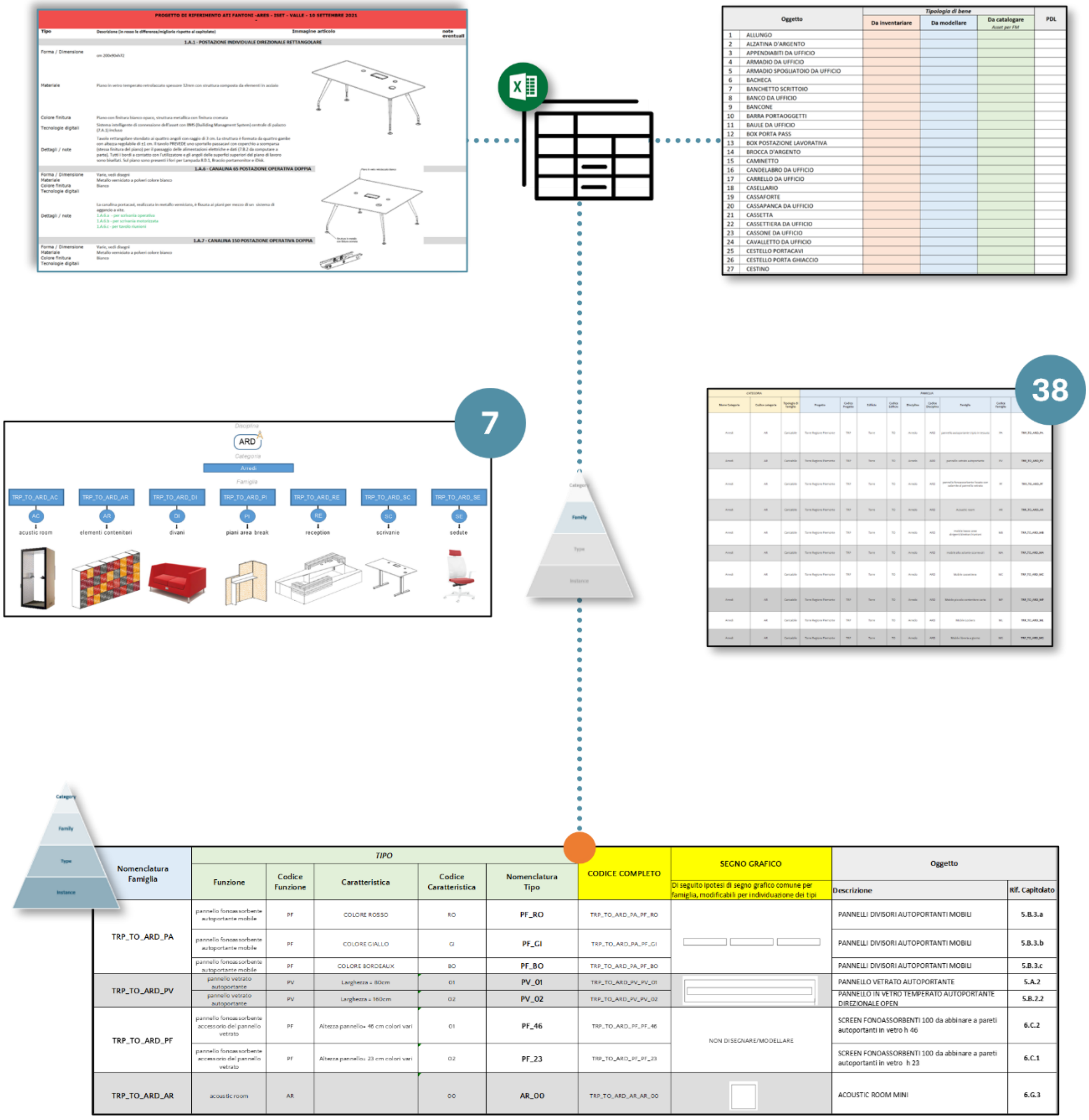


Figure 36 – Decision-making process for furniture modelling and FM cataloguing, based on movable asset classification, furniture specifications, inventory requirements and Factotum integration. [Author's elaboration]

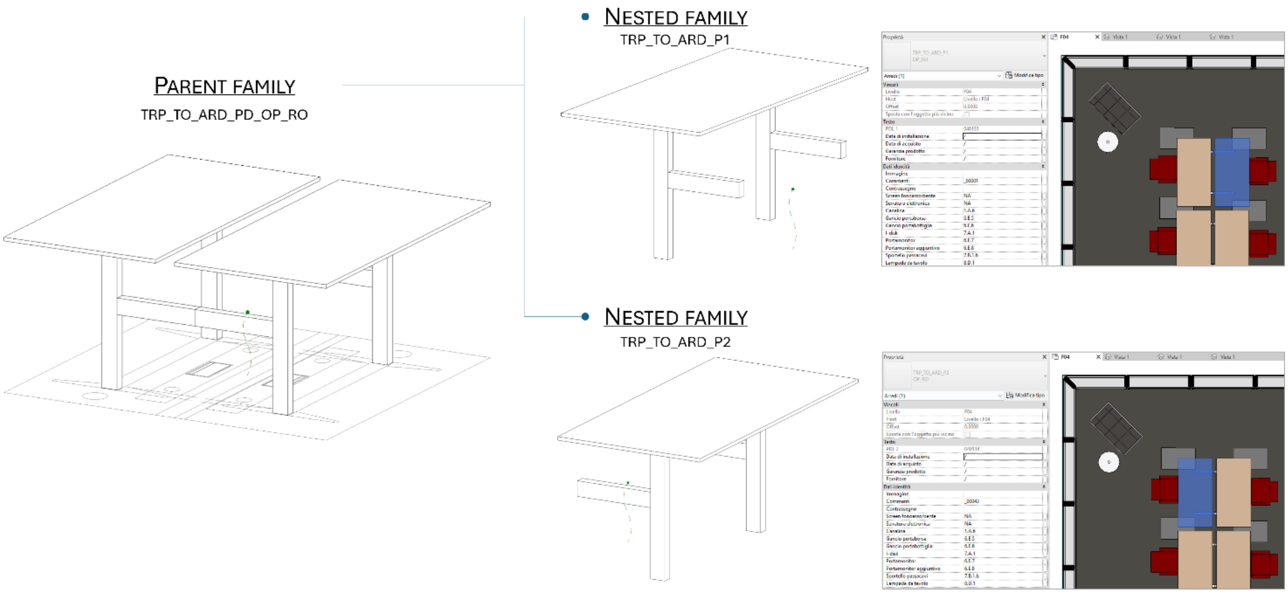


Figure 35 – Nested Revit family of the Motorized Double Desk (MDD). [Author's elaboration].

Parameters kept in Revit include, for example, the **Specification Code**, useful for maintaining the link with the corresponding item in the furniture specifications, and the **Supplier**. Other parameters were instead prepared to be transferred or populated also in the FM environment. These include information relating to integrated equipment and accessories (Figure 37), such as acoustic screen, electronic lock, bag hook, bottle holder, I-Disk, monitor arm, desk lamp, back panel, additional monitor arm, height-adjustable and anti-collision system, cable grommet with cover and cable duct. These are accompanied by more directly management-oriented parameters, such as Loan, PDLA, PDLAB, Inventory Code, EQ_ID and EQ_STD.

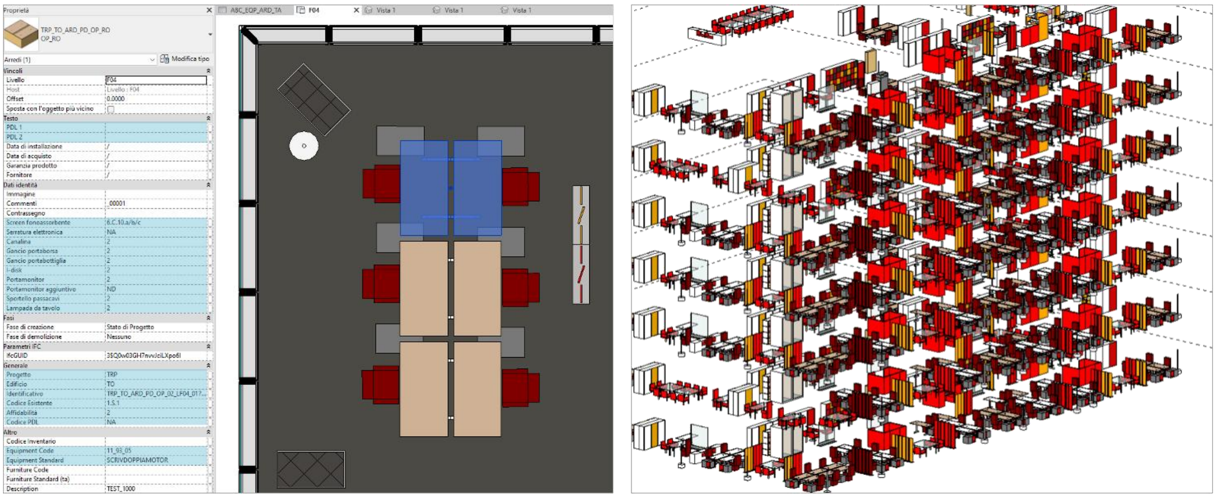


Figure 37 – MDD representation with populated parameters. [Author's elaboration]

The decision to manage some equipment as parameters, rather than as geometrically modelled sub-objects, is methodologically relevant. Elements such as accessories, integrated components or specific fittings were not necessarily modelled as autonomous objects, but described through alphanumeric fields. This solution confirms the logic of the Record Model: not everything that is relevant for management must be represented geometrically. In some cases, the most effective form of management representation is clear, verifiable and transferable alphanumeric information. From a geometric point of view, furniture modelling was deliberately simplified. The objective was not to produce families with a high level of graphical detail, but objects that were sufficiently recognisable, locatable and coherent with management needs. Particular attention was paid to colour and visual recognisability, while the geometric level was kept essential. This choice also shows the shift from a logic of complete representation to a use-oriented modelling logic.

A decisive operational step was the on-site survey aimed at entering inventory codes. Each individual object was checked and the **Inventory Code** parameter was populated. This step distinguishes the MDD from generic furniture: the object enters the model as a movable asset with patrimonial identity and not only as a layout element. The relationship with PDLs was managed through the **PDLA** and **PDLB** parameters, consistently with the double nature of the object and with the need to associate the desk with two workstations. In the transition to *FactotuM*, the MDD is treated as **Equipment**, in particular as an asset of the Apparecchiatura type. The object therefore enters the management system through the **eq** table and the extended **eq_ext** table (Figure 38). This aspect is central because it clarifies that the furniture item, once normalized and catalogued, no longer remains only a Revit family, but becomes a management record with attributes, localization and identity.

Publication in *FactotuM* therefore makes the object available as part of the public body's information asset.

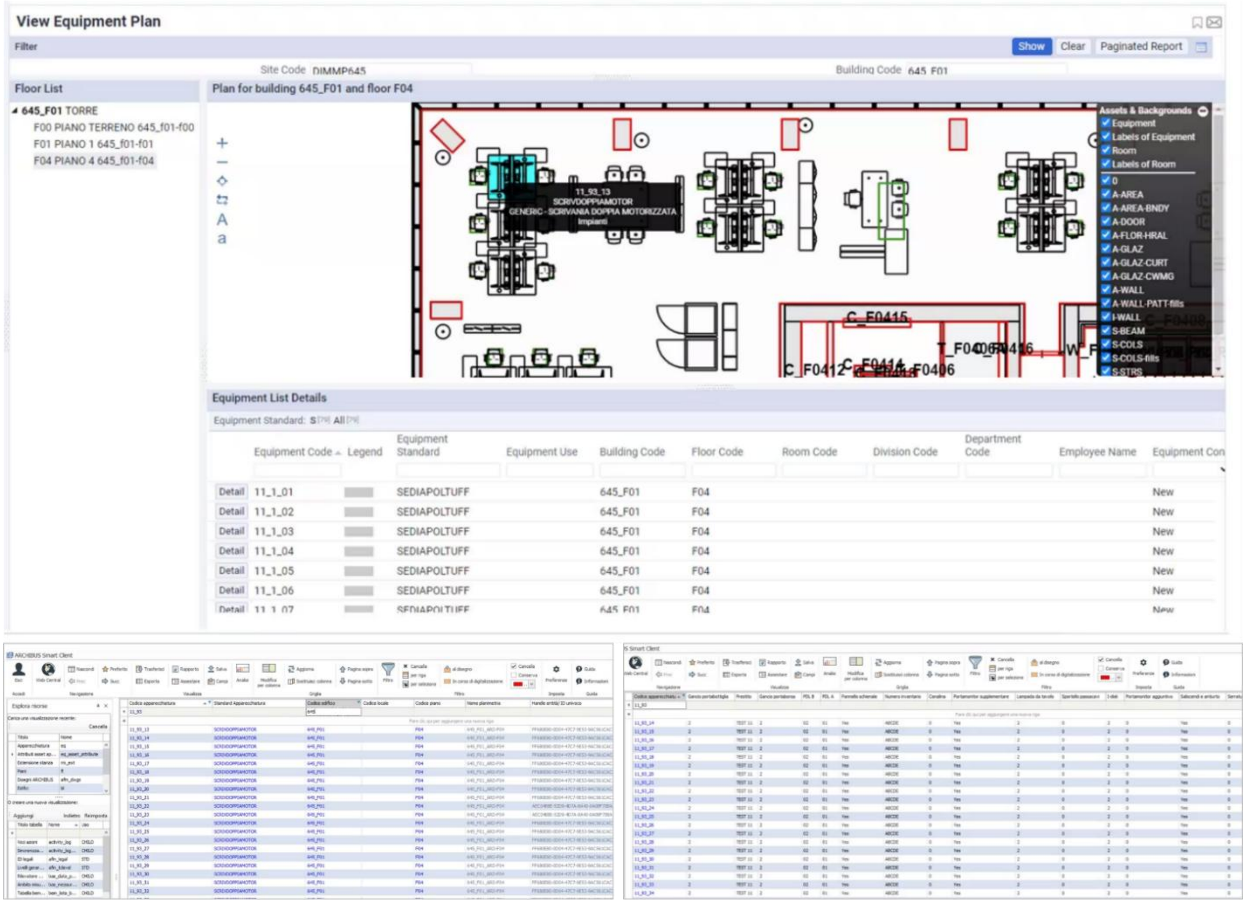


Figure 38 – Factotum equipment records for the MDD, showing FM asset in the eq and eq_ext tables. [Author's elaboration]

The operations carried out can be traced back to the general sequence already described. Normalization concerned the definition of the furniture strategy, the construction of families, geometric simplification, the creation of parameters and their population, with particular attention to EQ_ID, EQ_STD and Inventory Code. Cataloguing concerned the recognition of the desk as Equipment and its association with the *FactotuM* data structure. Publication finally made the object available in the FM system as a consultable and queryable asset. The case highlights a specific criticality: the MDD is a single object from an inventory point of view, but double from the point of view of use. It has only one inventory code, but it is connected to two PDLs and therefore to two workstations. Moreover, it contains or integrates a series of accessories that were not modelled as autonomous geometries, but must nevertheless be recognized as management information. This condition shows how, for movable assets, the construction of the Record Model requires a strategy capable of holding together patrimonial identity, localization, equipment, workstations and FM data.

The methodological value of the Motorized Double Desk therefore consists in showing that a furniture item cannot be treated as a simple graphical object. In the transition to the Record Model, it becomes a movable asset with patrimonial identity, localization, a relationship with workstations and its own management cycle. In this case, information consistency does not depend on geometric detail, but on the capacity to construct a light, coded, inventoried object that can be coherently published in the management system.

5.4.6 MEP element: Fan Coil Unit

The fifth case concerns the **Fan Coil Unit**, selected as an example of a maintainable building services component. Compared with the previous cases, the Fan Coil introduces a different type of complexity: it is not only a matter of verifying an already modelled element, nor of constructing a family or a management entity ex novo, but of understanding how a technical asset, distributed within a complex building services system, can be made identifiable, locatable, cataloguable and connectable to maintenance logics. Fan Coils were already present in the BIM as-built model, within the MEC discipline, as part of the mechanical models described in Chapter 4. The starting point was therefore different from the furniture case: the objects already existed in the model, with a high geometric level and with alphanumeric content that was already partly structured, However, their availability in the model did not automatically coincide with the possibility of using them effectively in the BIM–FM process.

The first criticality concerns the very structure of the mechanical modelling base. The mechanical systems were not contained in a single model, but distributed across several files, articulated by portions and floor ranges. In particular, Fan Coils were located within a federated structure composed of six different MEC (Figure 39).

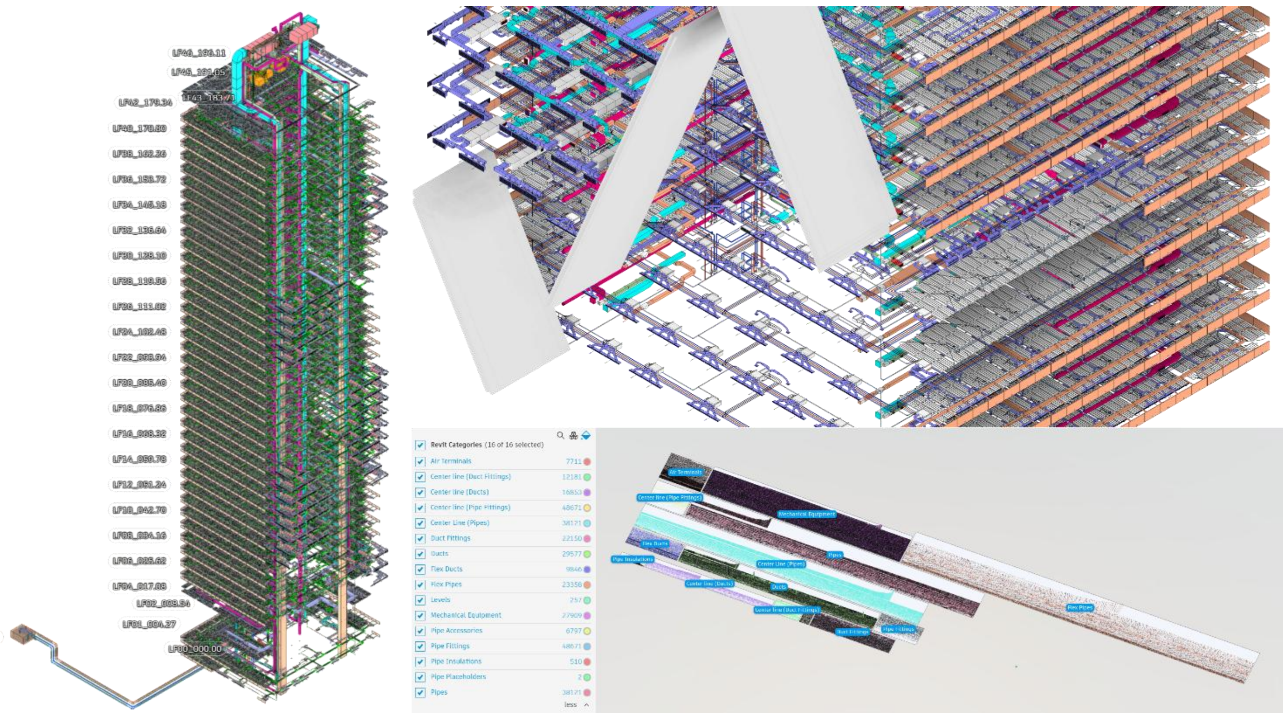


Figure 39 – Representation of the BIM-based MEP model. At the bottom, the segmentation of Revit elements into their respective categories can be observed. [Author's elaboration]

This articulation, coherent with the federation logic required to govern a complex building, becomes problematic when the objective is to construct a unified information base for management. The problem is not only technical or related to file size: it concerns the possibility of recognising, querying and governing the same category of components distributed across multiple models, multiple floors and multiple systems.

The test concerned the overall logic of the Fan Coils, not a single isolated instance. To make these elements manageable in *FactotuM*, the first step concerned their identification as **Equipment**. For this purpose, some fundamental management parameters were considered, including **EQ_ID**, **EQ_STD**, **CSI_ID**, **SITO_ID**, **BL_ID** and **FL_ID**. These fields are not simple descriptive attributes, but make it possible to connect the BIM object to the FM database structure, allowing the equipment to be recognized, localized and catalogued in the management system.

Starting from this need, the Fan Coil case raised two main problems. The first concerns the geometric simplification and scalability of MEP models. The second concerns the information strategy for maintenance, that is, the choice of which data should be maintained in the BIM object and which should instead be governed through maintenance procedures in the FM environment.

A first line of experimentation (Figure 40) concerned the geometric simplification of the building services models. The 16th floor of the tower was selected as a test case. The model exported in its original configuration, considering the ventilation systems, had a size of approximately 24 MB. On this basis, three simplification hypotheses were tested. The first hypothesis concerned the simplification of Revit family geometries, reducing geometric elements considered not to affect future maintenance. The resulting file reached approximately 19.2 MB, with a processing time of about six hours for a single floor. The second hypothesis involved replacing ducts with a line capable of describing their dimensions and typical maintenance-related elements. In this case, the file was reduced to approximately 18.1 MB, with about three hours of work for one floor. The third hypothesis involved removing part of the straight ducts, while retaining the bends as elements capable of tracing the system route. The resulting file had a size of approximately 19.1 MB, with about two hours of work for one floor.

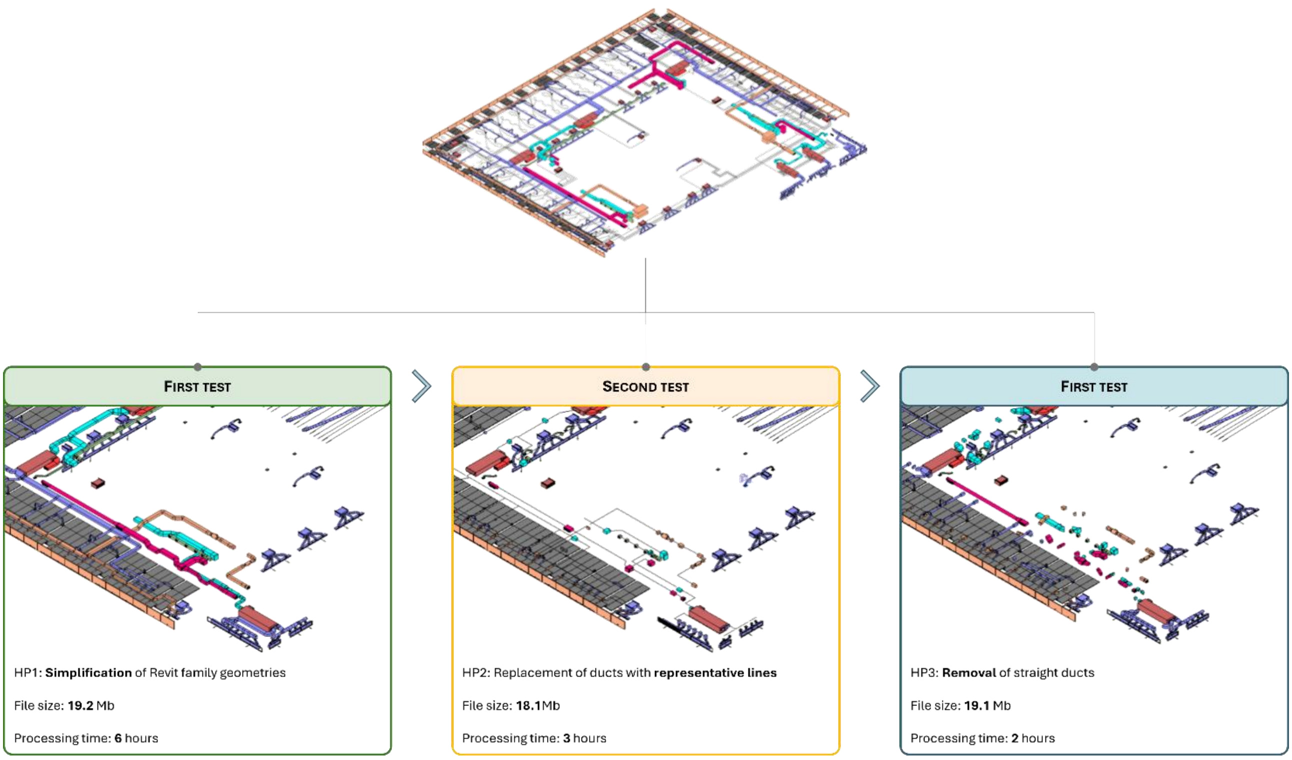


Figure 40 – Geometric simplification tests on the 16th-floor mechanical model: original configuration and three alternative simplification strategies. [Author's elaboration]

The results of these tests were not fully satisfactory. File size reduction was effectively achieved, but not to an extent capable of structurally solving the problem of MEP model management. Moreover, the time required to manually intervene on a single floor made clear the difficulty of extending such a procedure to the entire building. This experimentation therefore showed that geometric simplification, although useful, cannot in itself be considered a sufficient solution for the construction of the building services Record Model.

A second line of experimentation attempted to address the problem more radically, trying to simplify the model drastically without completely losing the building services logic. The reference logic was that of a system composed of **source – network – accessories – terminal**. The hypothesis consisted in reducing or eliminating the network and accessories, considered less central for some planned maintenance activities, while preserving sources and terminals. In the case under consideration, Fan Coils precisely represent a particularly relevant category of terminals.

This strategy also showed important limitations. Reducing the network can lighten the representation and make terminal management more immediate, but at the same time it risks weakening the understanding of the overall functioning of the system.

For an MEP component, in fact, the localization of the object is not sufficient: it is necessary to understand its relationship with the system, the networks, the sources and the maintenance activities that concern it. To nevertheless verify the feasibility of the process, a unified model containing only Fan Coils (Figure 41) was created and used to test the cataloguing and publication of elements in the FM environment.

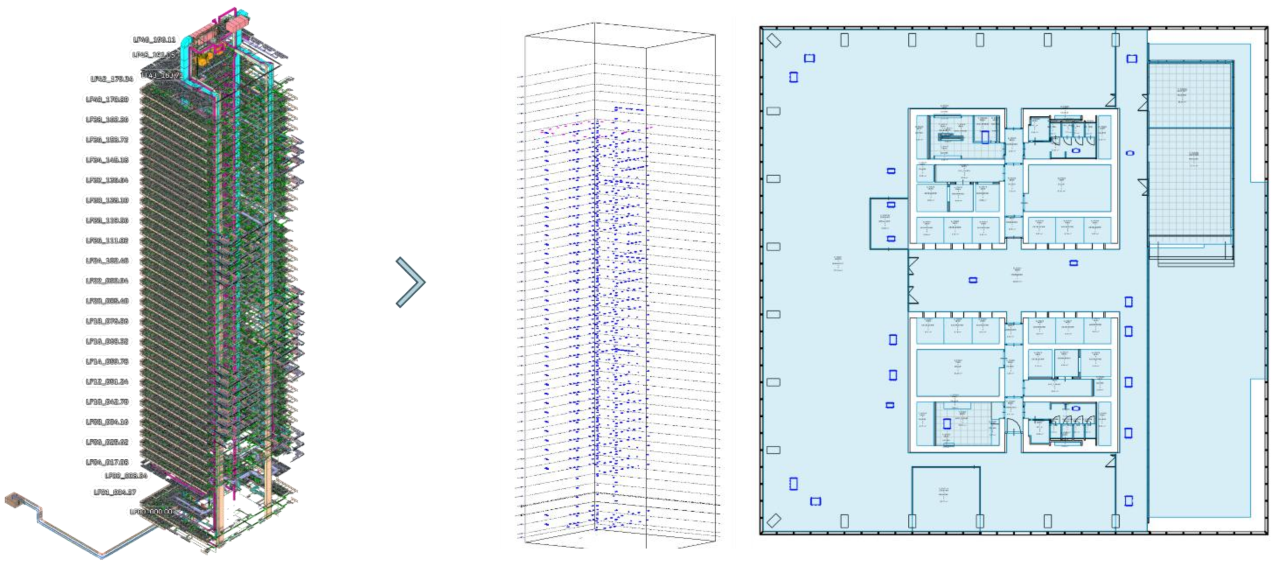
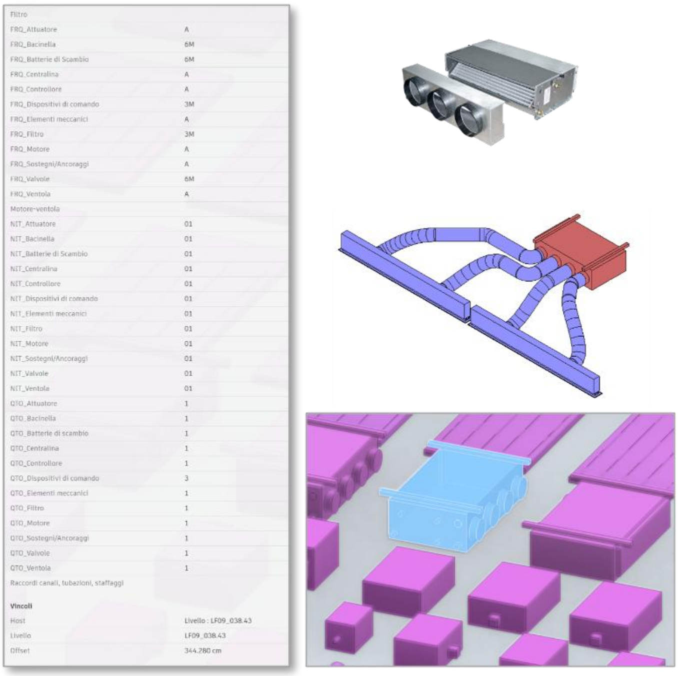


Figure 41 – Transition from the as-built model to the Record Model for the Fan Coil Unit. [Author's elaboration]

The second major problem concerns the information strategy for planned maintenance. A first hypothesis was to avoid geometrically modelling the subcomponents of the Fan Coil, transferring this information into the object through parameters instead. The subcomponents considered included, among others, actuator, drain pan, heat exchange coils, control unit, controller, control devices, mechanical elements, filters, motor, supports and anchors, valves and fans.

For each subcomponent, two groups of parameters were hypothesised: a quantitative parameter, for example **QTO_Filtri** or **QTO_Attuatore**, and a parameter related to maintenance frequency, for example **FRQ_Filtri** or **FRQ_Attuatore**. A second hypothesis involved introducing a further parameter to record the number of interventions carried out on the subcomponent, for example **NIT_Filtri** or **NIT_Attuatore** (Figure 42).



N.	Sottocomponenti	Qto	Freq Man	N. Interventi
1	Attuatore	1	A	1
2	Bacinella	1	6M	1
3	Batterie di scambio	1	6M	1
4	Centralina	1	A	1
5	Controllore	1	A	1
6	Dispositivi di comando	3	3M	3
7	Elementi meccanici	1	A	1
8	Filtri	1	3M	2
9	Motore	1	A	1
10	Sostegni/Ancoraggi	1	A	1
11	Valvole	1	6M	1
12	Ventola	1	A	1

Figure 42 – Experimental parameter-based structure for Fan Coil subcomponents, defining quantity, maintenance frequency and number of interventions. [Author's elaboration]

This strategy would have made it possible to avoid the geometric modelling of subcomponents while maintaining information useful for maintenance within the main object. However, the experimentation also revealed an opposite risk: parameter proliferation. Considering the high number of Fan Coils, the distribution of objects across multiple models and the number of subcomponents considered, inserting three parameters for each subcomponent would have significantly increased the information complexity of the model. In other words, a solution intended to simplify geometry could have produced an alphanumerically overloaded model, difficult to control, update and scale.

For this reason, neither of the two parametric strategies was adopted as a definitive solution. The reflection led to a different, more hybrid logic, more consistent with BIM–FM integration. The BIM object must carry the information required to be identified, localized, catalogued and connected to the management system; however, the detailed maintenance activities do not necessarily have to be entirely contained in the object parameters. A relevant part of this information can be governed through maintenance procedures defined in the management environment, attached to the equipment once it has been recognized as such.

From this perspective, the Fan Coil in the Record Model must contain geometric information sufficient for localization, spatial data, management identifiers, codes for cataloguing as Equipment and the minimum information required to establish the relationship with the maintenance process. The operational detail of procedures, instead, is governed within the FM system.

This distinction makes it possible to avoid both excessive geometric modelling and parametric overload, maintaining the BIM model as a basis for identification and connection, while assigning procedure management to the FM system.

The Fan Coil case therefore shows that the construction of the Record Model for building services elements is particularly delicate. On the one hand, in the FM phase, geometry does not necessarily have to reach the maximum representational detail; on the other hand, it is not possible to decide what to simplify without in-depth knowledge of the system. Geometric reduction can be effective only if it does not compromise the understanding of the system; similarly, alphanumeric enrichment can be useful only if it does not produce unmanageable complexity.

From the point of view of the operational sequence, the Fan Coil was also treated according to the general logic of normalization, cataloguing and publication. Normalization concerned the verification of the available MEP models, the analysis of file fragmentation, the definition of required parameters and the assessment of simplification strategies. Cataloguing concerned the recognition of the Fan Coil as Equipment, through parameters such as EQ_ID, EQ_STD, CSI_ID, SITO_ID, BL_ID and FL_ID. Publication concerned the possibility of making the elements consultable and queryable in *FactotuM*, also through the test model composed only of Fan Coils.

The methodological value of the case lies precisely in the difficulties that emerged. The Fan Coil shows that, for MEP assets, it is not enough to be a good modeler or to have geometrically accurate objects. The quality of BIM–FM transformation depends on the ability to understand the logic of the system, distinguish between information to be modelled and information to be managed procedurally, and construct an effective relationship between BIM object, management identifier and maintenance. In this sense, the Fan Coil case represents one of the main bottlenecks of the process, especially in terms of scalability, and requires further investigation in the subsequent phases of the research.

5.5 Why the Record Model matters: comparative evidence from the test cases

The comparative reading of the analyzed cases makes it possible to draw together the path developed throughout the chapter and to clarify the role of the Record Model in the BIM–FM transition. In the previous sections, the transition from the as-built model to the model for management was first defined theoretically, through the distinction between As-built Model, As-is Model and Record Model; it was then framed as the information transition between PIM and AIM; finally, it was observed through five application cases referring to objects of different nature: Room, PDL, Door, Motorized Double Desk and Fan Coil Unit.

The objective of this concluding section is not to demonstrate that the AIM always contains more information than the PIM, nor to argue that the transformation towards the Record Model automatically produces an improvement in every condition. Rather, the central point is to show that the PIM, even when rich, structured and geometrically developed, does not necessarily coincide with a model usable for Facility Management. Management requires a different information configuration: more selective, more queryable, more coded, more aligned with operational processes and more coherent with the structure of the management system. In this sense, the Record Model is not a simple lightened copy of the as-built model, but a device for the critical reorganization of information.

To make this transformation more explicit, the tested cases were read through the information consistency model introduced in Section 5.2.4. The assessment is not intended as a certification, but as an interpretative tool: it does not measure the quality of the model in absolute terms, but makes it possible to compare, in a controlled way, the variation in information consistency between the **PIM** configuration, assimilable in content to an as-built model, and the **AIM** configuration, assimilable in content to a Record Model or as-FM model.

The values assigned to the components D, G, α and f_{HK} derive from the operations actually carried out on the individual objects and from the different nature of the information available before and after the processes of **checking–simplification–updating** and **normalization–cataloguing–publication**.

The weighting of the components was applied according to what was discussed in Section 5.2.4, distinguishing between the PIM configuration, referring to the construction/handover phase, and the AIM configuration, referring to the O&M phase. This distinction is necessary because information consistency does not depend on the same components in the two configurations. In the PIM, geometry, handover documentation and coherence with the construction phase assume greater weight; in the AIM, the alphanumeric component becomes prevalent, as it is necessary for localization, identification, querying, interoperability, updating and management use.

The following table 11 summarizes the assigned values and the results obtained.

Table 11 – Comparative assessment of information consistency for the five BIM–FM test cases. [Author's elaboration]

Test case	Configuration	D	G	α	f_{HK}	q	Q	ΔQ	δQ
Room	PIM	4	5	2	0.90	3.29	54.8%	26.8	+26.8
	AIM	5	5	4	1.10	4.90	81.6%		
PDL	PIM	1	0	0	0.70	0.21	3.5%	68.2	+68.2
	AIM	3	4	5	1.00	4.30	71.7%		
Door	PIM	4	5	3	1.00	4.00	66.7%	7.5	+7.5
	AIM	5	5	4	1.00	4.45	74.2%		
Motorized Double Desk	PIM	3	0	1	0.70	0.88	14.6%	53.7	+53.7
	AIM	3	3	5	1.00	4.10	68.3%		
Fan Coil unit	AIM	2	3	3	0.90	2.48	41.3%	18.7	-18.7
	AIM	2	3	3	0.90	2.48	41.3%		

The values assigned to the individual components must be read in light of the nature of each case. In the case of **Rooms**, the PIM presented very solid geometry and a good documentary base, but an alphanumeric component not yet fully oriented towards management. Rooms were already modelled and correctly bounded; however, the ***Codice Factotum*** was not yet fully normalized and, above all, was not located in the field that *FactotuM* was actually able to read. The transition to the AIM does not substantially increase the geometry, which was already adequate, but increases information consistency through room verification, normalization of the *Codice Factotum*, duplication in the **Number** parameter, preparation of dedicated views and publication in the management system. For this reason, Qincreases from **54.8%** to **81.6%**, with $\delta Q = +26.8$. The result indicates that the AIM does not simply contain more information, but information that is more legible, transferable and activable for space management.

The **PDL** case shows an even more radical dynamic. In the PIM, the workstation was not present as a modelled or information entity. At most, indirect references or external knowledge existed, but there was no geometric representation, no **Codice_PDL**, and no structured relationship between workstation, room, furniture and personnel. Initial information consistency is therefore almost null, equal to **3.5%**. In the AIM, instead, the PDL is constructed as a management entity through Revit Areas, equipped with a Codice_PDL, connected to furniture and made legible in dedicated plans. The increase to **71.7%**, with $\delta Q = +68.2$, does not represent the improvement of an already existing object, but the ex novo construction of management information absent from the as-built configuration. This case shows that the Record Model may require not only selection or normalization, but also the creation of new information entities necessary for the operational phase.

The **Door** case presents a more limited variation. The door was already highly consistent in the PIM as an architectural element: it was modelled, positioned, equipped with families and types coherent with the execution phase and legible to an expert technician. For this reason, the initial value is already relatively high, equal to **66.7%**. The transition to the AIM, however, introduces a different information function, connected to the management of rooms, access and keys.

The extension of the *Codice Factotum* to the Door category, the creation of the ***Codice Porta*** and ***Codice Chiave*** parameters, the activation of the room calculation point and the cross-checking between schedules, tags and floor plans increase information consistency to **74.2%**. The value $\delta Q = +7.5$therefore indicates a moderate increase: the transformation does not consist in creating or substantially correcting the object, but in reconfiguring it as a relational graphical-information element.

The **Motorized Double Desk** highlights another condition. In the PIM, furniture was not present, but an external documentary base existed: furniture specifications, manufacturer datasheets, movable asset classification and information to be verified through survey. For this reason, the PIM is not equal to zero, but presents very low consistency, equal to **14.6%**. In the AIM, the desk is modelled ex novo as a nested family, equipped with shared and specific parameters, connected to two PDLs, populated with Inventory Code, EQ_ID and EQ_STD, and catalogued as Equipment in *FactotuM*. The transition to **68.3%**, with $\delta Q = +53.7$, shows a very significant increase. In this case too, the increase does not depend only on the geometric insertion of the object, but on the construction of its patrimonial and management identity. The furniture item becomes a movable asset that is locatable, inventoriable, connected to workstations and queryable in the FM system.

The **Fan Coil Unit** is the only case showing a negative variation, with Qdecreasing from **60.0%** in the PIM to **41.3%** in the AIM, and $\delta Q = -18.7$. This result should not be interpreted as a simple failure of the process, but as evidence of a transformation that is not yet fully stabilised. In the PIM, Fan Coils were already present in the MEC models, geometrically developed and equipped with a significant technical base. However, this consistency belonged mainly to the logic of as-built building services modelling. In the transition towards the AIM, the tested strategies — geometric simplification of the models, reduction of network and accessories, Fan Coil-only model, parametrisation of subcomponents — revealed scalability issues. Information becomes more oriented towards *FactotuM* thanks to Equipment parameters, but the AIM configuration does not yet reach sufficient stability, because part of the maintenance management must be governed through procedures in the management environment and not loaded entirely into the BIM object.

This reading is important because it shows that **a negative value** of δQdoes not necessarily mean that the PIM is more suitable for management. Rather, it indicates that, in the case of MEP assets, the transition towards the Record Model requires further methodological steps. The as-built model may be very rich in geometric and technical terms, but this richness does not automatically translate into management usability. Conversely, the construction of an effective AIM for building services requires a more mature strategy to govern the relationship between object, system, subcomponents, maintenance procedures and scalability.

From an aggregate point of view, the results show an overall positive trend, but they must be interpreted with caution. Summing the $q$values, the overall information consistency of the five cases increases from:

$$\sum q_{PIM} = 11.97$$

to:

$$\sum q_{AIM} = 20.22$$

However, since $q(t)$is an absolute value calculated case by case and then normalized on a 0–100 scale, the most effective reading is provided by the average of the Qvalues. Considering all five cases, the average normalized information consistency increases from:

$$\bar{Q}_{PIM} = 39.9\%$$

to:

$$\bar{Q}_{AIM} = 67.4\%$$

with an average increase of:

$$+27.5 \text{ percentage points}$$

This value indicates that, overall, the AIM configuration presents greater information consistency than the PIM configuration. However, this average increase is not sufficient, by itself, to demonstrate the general and automatic convenience of the Record Model. The average includes very different cases: some already strongly structured in the PIM, others almost absent from the as-built configuration, and one case — the Fan Coil Unit — in which the transformation towards the AIM remains methodologically critical.

For this reason, it is useful to complement the overall average with a second reading, limited to the cases in which the normalization, cataloguing and publication process proved more consolidated: **Room**, **PDL**, **Door** and **Motorized Double Desk**. In these four cases, the average increases from:

$$\bar{Q}_{PIM} = 34.9\%$$

to:

$$\bar{Q}_{AIM} = 74.0\%$$

with an increase of:

$$+39.1 \text{ percentage points}$$

This second reading makes the operational convenience of the Record Model more evident in the cases where the BIM–FM process was effectively stabilized. The increase of almost forty percentage points shows that the AIM configuration does not simply produce a quantitative increase in information, but a greater capacity of information to be localized, coded, queried, transferred and used within *FactotuM*. In the consolidated cases, therefore, the Record Model proves advantageous because it transforms an as-built base, sometimes rich but not management-oriented, into an information structure more coherent with FM uses.

The **Fan Coil Unit** must instead be read separately, not because it is marginal, but because it represents the main methodological bottleneck that emerged from the experimentation. Unlike the other cases, the Fan Coil starts from an already highly consistent PIM, with a value of:

$$Q_{PIM} = 60.0\%$$

but reaches an AIM configuration of:

$$Q_{AIM} = 41.3\%$$

with:

$$\delta Q = -18.7$$

This negative value does not indicate that the PIM is more suitable for management, nor that the Record Model is useless for building services. Rather, it indicates that, for MEP assets, the transformation towards the AIM is not yet sufficiently stabilized. The Fan Coil is affected by a set of specific criticalities: fragmentation of mechanical models into multiple files, difficulty of simplifying geometry without losing the building services logic, risk of parametric overload on subcomponents, and the need to distinguish between information to be maintained in the model and information to be governed through maintenance procedures in the management environment.

In this sense, the Fan Coil does not weaken the thesis of the research, but clarifies its field of validity. It shows that the Record Model is convenient when the transformation process is governed; conversely, when the methodology is not yet sufficiently defined, the transition from PIM to AIM may produce a reduction in information consistency. The problem is therefore not the lack of usefulness of the Record Model, but the need to develop more robust strategies for building services elements, where information quality depends on the relationship between BIM object, technical system, equipment, subcomponents, maintenance procedures and scalability.

The conclusion deriving from the results is therefore not that the AIM must always contain more information than the PIM. The conclusion is more precise: in the cases where the Record Model process is stabilized, the information consistency useful for management increases significantly; in the cases where the process is not yet mature, as in the Fan Coil Unit, the quantitative comparison makes the critical point to be solved visible. The Record Model is therefore necessary not as a simply lighter or richer model, but as a methodological device for transforming handover information into management information.

Its convenience depends on the capacity to govern this transformation. In the spatial, architectural and furniture cases, the procedure appears scalable because the operations of normalization, coding, cataloguing and publication can be replicated on larger sets of elements. In the MEP case, however, scalability remains problematic: the quantity of objects, the federated structure of the models, the complexity of the systems and the need for building services and maintenance knowledge make it more difficult to define a single and immediately replicable procedure. In this sense, the case study confirms the methodological validity of the Record Model as an FM-oriented configuration, but also shows that its construction must be calibrated according to the nature of the objects and the management processes they will have to support.

At the same time, the transformation towards the Record Model should not be interpreted as a mere reduction of the original as-built model set. As shown by the updated coordination scheme in Figure 43, the TRP modelling structure has, in fact, expanded with respect to the initial as-built federation. Alongside the original disciplinary models, new FM-oriented models and information structures were introduced, including, for example, the models related to **PDL** and **ARD**, together with further articulated links between architectural, furniture and management-related information.

This means that the passage from the as-built configuration to the Record Model is not simply a process of subtraction, but a selective reconfiguration: some information is simplified or excluded, while other information layers and model components are added in order to support uses that were absent or only implicit in the original construction-oriented configuration. The Record Model is therefore not “smaller” in an absolute sense, but more intentionally organized around management purposes.

The chapter therefore closes with a clear methodological position. The availability of a BIM as-built model represents a highly valuable starting condition, especially in a public-sector context where such availability cannot be taken for granted. However, the as-built model is not in itself sufficient to support management. To become truly operational, it must be verified, selected, normalized, integrated and published according to a logic oriented towards FM uses. The Record Model represents precisely this threshold of transformation: the passage from a model that documents the completed asset to a model that makes information usable, updateable and governable over time.

This conclusion leads directly to the following chapter. If the Record Model represents the information configuration required to make the model usable for management, it is now necessary to understand which processes, roles, responsibilities, documentary tools and updating rules are required to keep it coherent over time. The problem is no longer only to construct the model for FM, but to govern its use throughout the public lifecycle of the asset.

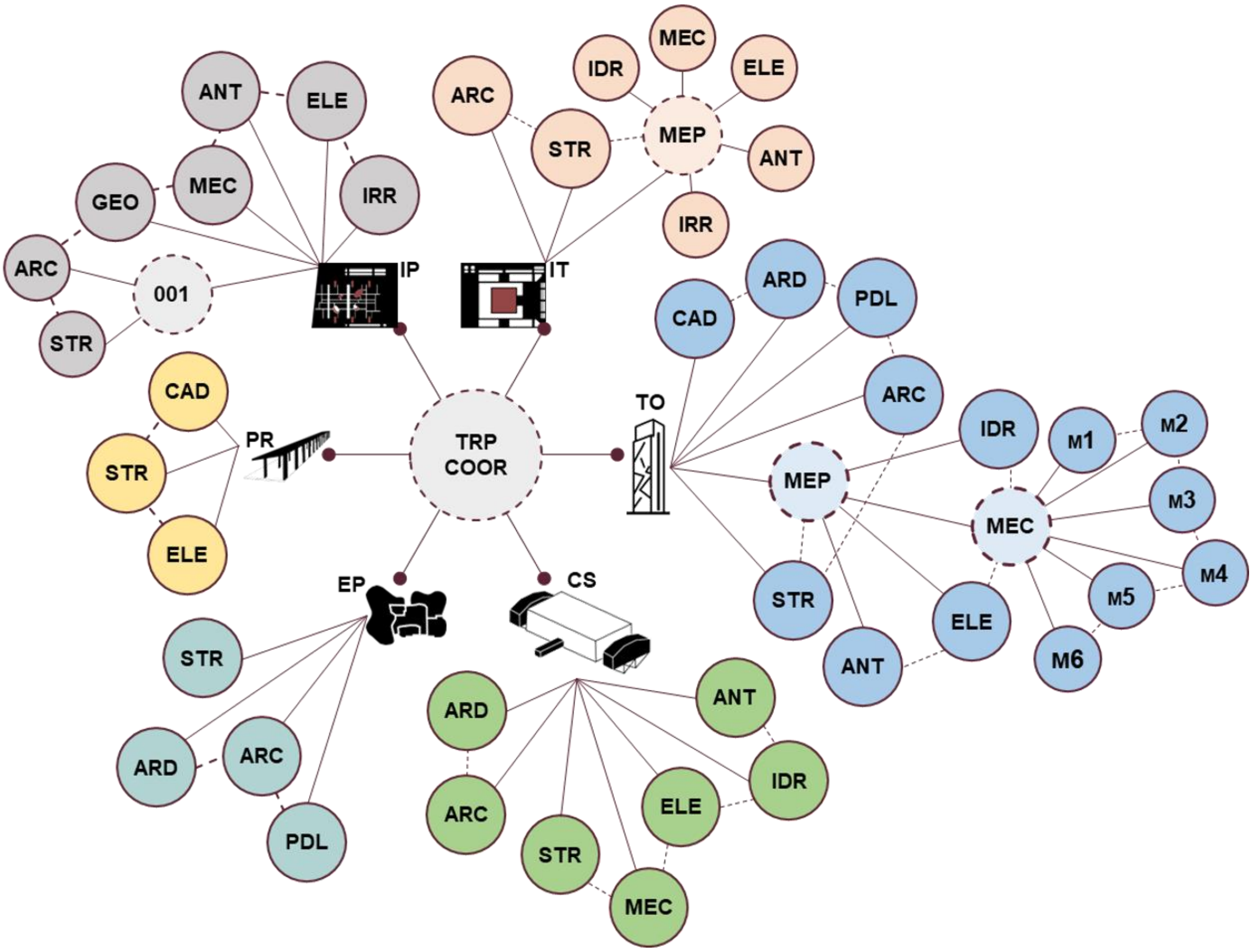


Figure 43 – Updated coordination scheme of the TRP model system, showing the integration of new FM-oriented models within the original as-built federation. [Author's elaboration]

Chapter 6

Documents and processes in public building lifecycle for FM

6.1. Introduction

Within the life cycle of a public building, continuity across planning, design, procurement, construction, and operation does not usually break down because of a lack of digital tools or because technology itself is inherently insufficient. More often, discontinuity arises from the fact that the transition from one phase to the next is not supported by a coherent system of **processes, documents, information exchanges, responsibilities, and verification procedures** capable of ensuring the persistence, readability, and updatability of data over time. From this perspective, the **BIM–FM transition** in Public Administration cannot be understood as a simple transfer of information from design to management but must instead be interpreted as an issue of **information governance**. What matters is not merely that data exists, but that they can be requested, produced, delivered, checked, accepted, updated, and ultimately used in a truly operational way.

This interpretation is consistent with the framework set out in ISO 19650, in which **information requirements** constitute one of the core components of the broader information management ecosystem. In the case of PA however, this perspective acquires even greater relevance, since the building process unfolds through formally distinct **technical-administrative phases**, each of which produces documents, deliverables, and checks that do not always correspond to the needs of operation. What is sufficient to authorize a phase, close a contract, or approve a delivery does not necessarily coincide with what is required to maintain, monitor, and govern a building during use. It is precisely within this gap between the **logic of the phase** and the **logic of management** that one of the most critical issues in **BIM–FM continuity** is located.

Within this framework, the **information model** alone is not enough. Even a model that is formally correct or rich in content does not automatically become a useful tool for FM unless it is embedded within a clear chain **of objectives, requirements, deliveries, controls, and updates.** Otherwise, the risk is that BIM remains only superficially advanced: a file stored on a server, a digital deliverable produced merely to comply with tender requirements, a model that exists but fails to become a living information base for management. In other words, the issue is not simply to **"have the model,"** but to create the conditions that allow that model to be read, verified, related to assets, updated, and therefore effectively governed by the public client.

This issue has become even more significant in light of the most recent Italian regulatory framework. Article 43 of Legislative Decree 36/2023 (2023) and the related **Annex I.9** (2023) further reinforce the idea that digital information management methods and tools must be situated within a structured and conscious process, rather than being treated as a merely accessory technical apparatus.

For the **Contracting Authority**, this means that digitalization cannot be limited to requiring BIM as a label, an obligation, or an award criterion, but must instead translate into the ability to formulate a clear, verifiable, and life-cycle-oriented information demand, extending through to the **FM phase**.

It is against this background that the present chapter positions its contribution. Its underlying assumption is that **BIM–FM continuity** in **PA** depends on the ability to construct a coherent architecture between **processes and documents**, one in which information is not treated as the final attachment to a phase, but as part of a governance chain that must remain stable as it passes across different actors, environments, tools, and purposes. From this perspective, the formula guiding the entire chapter may be summarized in Figure 44.

Figure 44 – A logical approach to the chapter. [Author's elaboration]

This sequence does not merely represent a logical scheme, but rather provides a genuine interpretative key for understanding both the **quality of public demand** and the possibility of transforming digital information into operational management information.

On the basis of this framework, the chapter is organized into **two complementary parts**. The first addresses the issue from the perspective of the **Contracting Authority's processes**, reinterpreted through an FM-oriented lens, with particular attention to the points at which information is lost, fragmented, or fails to pass effectively into operation. This part includes a reinterpretation of the public building process as a sequence of information gates, an analysis of the transition from AS-IS to AS-FM, the role of the Record Model as the information base for management, the issue of the operational identity of assets, and the need for a figure capable of safeguarding data continuity throughout the entire process: the **Digital Information Continuity Officer Manager** *(Responsabile della continuità informativa digitale)*.

The second part focuses instead on the **Information Requirements** (IR) **document**, understood not as an accessory attachment, but as the principal document of Public Administration in the BIM environment. It is within the **Exchange Information Requirement** (EIR) **/ *Capitolato Informativo*** (CI) that public demand should cease to be generic and begin to take shape as structured, controllable, and use-oriented content. For this reason, the chapter first develops a brief overview of the growing role of IR documents in public procurement, and then moves towards a critical reading of a corpus of Italian Information Requirements documents, before proposing a **drafting protocol** and a **modular CI prototype for PA,** with reference to the case of *Regione Piemonte.*

The value of this chapter, therefore, does not lie simply in adding yet another commentary to the theme of BIM in PA, but in bringing into focus an often underestimated point: the quality of the transition towards FM depends not only on richer models or more sophisticated platforms, but on the ability of the public client to govern its own **processes, documents**, and **information rules** in a conscious and structured manner. In this sense, the chapter introduces one of the central pillars of the thesis as a whole: without a solid infrastructure of processes and documents, the potential of BIM–FM risks remaining formally acknowledged, yet never truly implemented.

6.2. The Public Building Process through an FM Lens: Where Information Is Lost

When observed according to its traditional articulation, the **public building process** (Figure. 45) appears as an orderly sequence of technical-administrative phases: planning, design, procurement, construction, commissioning, handover, and operation.

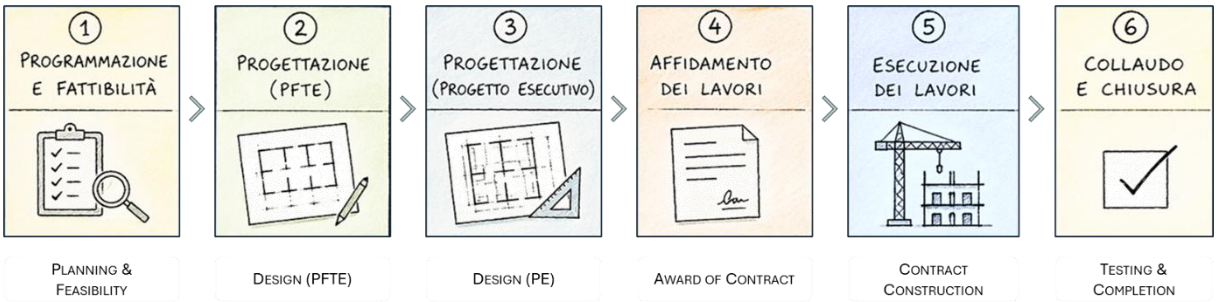


Figure 45 – Phases of public building process. [Author's elaboration]

When read through a Facility Management lens, however, it reveals a different kind of fragility from that normally attributed simply to digital delay or to a lack of tools: the main problem lies not so much in the quantity of information produced as in the **discontinuity of its use**. Information exists, but all too often it fails to pass coherently from one phase to the next; it is produced to fulfil a local function, tied to the procedural moment in which it originates, rather than being structured to endure and remain useful in the following phase. In other words, data are often conceived to **close a phase**, not to **enable the next one**. In the case of *Regione Piemonte*, and in particular the *"Torre della Regione"* building, this critical issue emerges with particular clarity. Information loss does not coincide with a single isolated event, but rather with a progressive phenomenon that accumulates throughout the process and becomes especially visible when operations must begin to work with the documents, models, and registers received at handover. The most critical point is undoubtedly the transition between handover and FM start-up, yet this passage is problematic precisely because it concentrates and makes visible a series of weaknesses that have developed much earlier: during construction supervision, within technical-administrative commissioning practices, in methods of archiving, in the construction of coding systems, in the production of the as-built, and in the relationship between documentation and real assets.

The first point to be stressed is that, in these contexts, the difficulty does not lie simply in the absence of documents. In many cases, the documents do exist: drawings, technical attachments, product sheets, certifications, user manuals, maintenance plans, as-built documents, model extractions. The problem is that they are delivered in a scattered manner, in **heterogeneous formats**, sometimes formally open but not genuinely **interoperable**, and above all without any clear organization that would allow them to be linked back to the assets and spaces to which they refer. What is at stake, then, is a form of information loss that should not be understood merely as absence, but as disorder, misalignment, weak traceability, and limited updatability. In the case of the *"Torre della Regione"*, this situation is further aggravated by a second set of problems: the fragility of the correspondence between the **designed object**, the **constructed object,** and the **object to be managed.** The **as-built**, for example, does not always coincide with what has actually been constructed, but often with what "should have been built," that is, with a representation that retains a design-based imprint more than a real adherence to the executed work. As a result, when operations need to use these data to locate an element, understand how it functions, or schedule a maintenance activity, they often find themselves working on an information base that is only partially reliable. The same applies to manuals and maintenance plans, which often exist, yet remain outside any fully integrated logic linking them to both the assets and the management system. A third issue concerns **coding**.

Across the sequence **design – construction – FM**, identification rules too often change or fail to remain fully consistent. This means that the same object may be named differently in the model, in the technical documents, in the handover files, and in the management systems. When common standards, unique codes, and stable relationships between documents and assets are missing, operations are forced to reconstruct retrospectively what should already have been received in an ordered and verified form. In this sense, **information loss is not a final-stage accident**, but the outcome of a process in which data were never conceived as operational data. Finally, the issue becomes even more significant because it involves a first explicit attempt at **BIM-based management**. This aspect is decisive, because it changes the very nature of the problem: the issue is no longer simply how to organize existing documents more effectively, but whether the established practices of PA are still adequate in a context where the model must interact with an **FM platform** (*FactotuM*), feed registers, support work orders, historicise interventions, and make the relationship between the real object and the informational object governable. In other words, the *"Torre della Regione"* case, does not merely expose a number of documentary shortcomings; it also calls into question the implicit paradigm of:

"This is how it has always been done!"

From this perspective, the public building process can no longer be read simply as a sequence of administrative acts or discipline-based deliverables, but rather as a chain of transformations in which information may be **preserved, degraded, fragmented, or lost**. For **FM**, what matters is not merely possessing a set of files but having a system in which it is possible to recognize clearly what has been delivered, which asset it refers to, with what degree of reliability, according to which updating rules, and for what use. It is on this basis that the following two sections first propose a reinterpretation of the process as a sequence of **information gates** and then define the **handover gap** (Figure 46) not as a documentary void, but as a genuine **governance problem**.

Figure 46 – An evocative image of the handover gap. [Author's elaboration]

6.2.1. From the Technical–Administrative Sequence to the Information Sequence

To understand where information is actually lost, it is necessary to shift attention from the mere succession of procedural steps to the sequence of information transitions. In other words, the public building process should not be read solely as a chain of phases to be authorized or closed, but as a series of information gates in which it is decided whether what one phase produces is effectively readable, verifiable, and reusable by the next. This change in perspective is crucial, because it transforms handover from a simple final documentary act into a genuine condition of informational acceptance.

In the case under examination, at least three transitions must be reinterpreted in this way.

The first is the transition from design to construction. Here, the issue is not only the technical completeness of the design, but the presence of a coherent information base: coding systems, naming rules, document structure, and the relationship between modelled objects and intended uses. If, at this stage, the rules are unclear or left too open, the construction phase tends to generate its own reorganizations, simplifications, or distortions, which are then reflected in the quality of the final handover.

The second gate is from completion of works / commissioning to handover. This is a particularly delicate moment, because it is here that a large body of material is concentrated which should form the basis for management: as-built documentation, technical sheets, manuals, maintenance plans, certifications, attachments, and systems-related information. Yet it is precisely here that one of the most recurrent ambiguities emerges: the formal presence of documents is often confused with their actual capacity to be used. An as-built that has not been correctly coded, documentation that has been archived but not structured, or a set of attachments not linked to assets may formally constitute a handover; informationally, however, they still represent a fragile system.

The third gate, and in the case of *"Torre della Regione"* is the most critical, is from handover to FM start-up. At this point, PA is forced to assess in concrete terms the quality of what it has received. The transition is all the more delicate because operations do not work with abstract families of documents, but with spaces, assets, tickets, work orders, registers, and interventions. It is at this moment that it becomes clear whether the delivered material was structured to support maintenance or merely to close a procedural phase. It is here that the absence of technical asset registers, the weakness of coding systems, the lack of relationships between documents and objects, and the limited updatability of data become no longer theoretical but operational problems.

Reinterpreting the process as an information sequence therefore means adopting a precise principle: every transition between phases should be governed not only by a logic of transmission, but by a logic of reusability verification. In this sense, the right question is not, "Have the documents been delivered?" but rather, "Have the information outputs been structured in a form that allows the next phase to use them without having to reconstruct them?" In the public building cycle, and even more so from a BIM–FM perspective, this means that continuity is not determined by the mere presence of deliverables, but by the quality of their transfer as governed information.

6.2.2. The Handover Gap as a Governance Problem

If the process is read as a sequence of information gates, then the so-called handover gap ceases to appear as a problem of the final handover alone and reveals its deeper nature: that of a governance problem. What matters is not simply that some documents arrive late, are incomplete, or prove unreliable; the real issue is that throughout the process it has never been sufficiently clarified who should produce what, according to which standards, at what level of verification, in what form of archiving, according to which updating rules, and with what orientation towards subsequent use.

In the case of the *"Torre della Regione"*, this interpretation is particularly important because the issue cannot be traced back to a single triggering factor. There is no single cause: the problem simultaneously concerns rules, roles, standards, workflows, updating practices, and information responsibilities. The as-built may be available but inconsistent with what was actually constructed; documentation may exist but be weakly archived; coding systems may have been designed for the purposes of design or construction, but not for management; manuals may have been collected, but without any clear relationship to the assets; data may be theoretically available, yet not organized according to a logic compatible with *FactotuM* platform. All of this shows that the handover gap is not simply a void, but a break in governance. This point is crucial because, in the absence of clear direction, each actor tends to produce information according to its own local logic. The construction supervision team is concerned with controlling execution, the commissioning body organizes documentation in order to certify compliance, the designer reasons according to the logic of the model, the economic operator according to the logic of contractual fulfilment, while operations require an information base consistent with tickets, work orders, registers, and updates. In the absence of a function capable of holding these different levels together, the transition to operation inevitably becomes the point at which all the discontinuities that the process has failed to absorb come fully to light. For PA, this is even more problematic because BIM-based management does not simply represent a technical improvement, but a change in the implicit rules through which public assets have traditionally been handled. In this case, the transition to FM calls established practices into question: it is no longer sufficient to have documents "somewhere," nor is it enough that they have been delivered in a merely formal sense. They must be traceable, relatable, readable, consistently coded, and above all updatable. This means that the introduction of BIM-based management does not simply require more technology; it demands a rethinking of the way in which PA produces and governs its own information.

From this follows an important implication for the thesis as a whole: the handover gap cannot be resolved simply by asking for "***more data***" or "***more BIM***." A generic information request, not accompanied by verification rules, standards, responsibilities, and updating criteria, may in fact amplify disorder rather than reduce it. The problem is not just about the availability of data, but also about its ability to be transmitted consistently throughout the entire building process. In this sense, the handover issue is not documentary in the strict sense, but structurally organizational. It therefore becomes clear that, if information loss also arises from the fact that traditional maintenance processes are not designed to make effective use of data, then those very processes must be rethought in a BIM-based, model-driven, and Record Model-oriented form.

6.3. From AS-IS to AS-FM: Designing Two BIM-Based Maintenance Processes Oriented towards the Record Model

If the previous section showed that, within the public building life cycle, information loss gradually accumulates until it becomes particularly evident in the transition between handover and the start of operations, the next step is to examine whether this discontinuity can be addressed not only at the documentary level, but also at the level of operational processes. In this research, BIM–FM continuity has not been interpreted as an abstract problem of interoperability between platforms alone, nor as a simple digital transposition of already existing procedures. Rather, it has been understood as an issue of process design, that is, as the need to rethink the way in which maintenance is initiated, qualified, executed, verified, and above all brought back into a coherent system of information.

For this reason, this section does not adopt a generic TO-BE vocabulary, which would be too broad and insufficiently grounded in the logic of the thesis; instead, it proposes the transition from AS-IS to AS-FM (Figure 47).

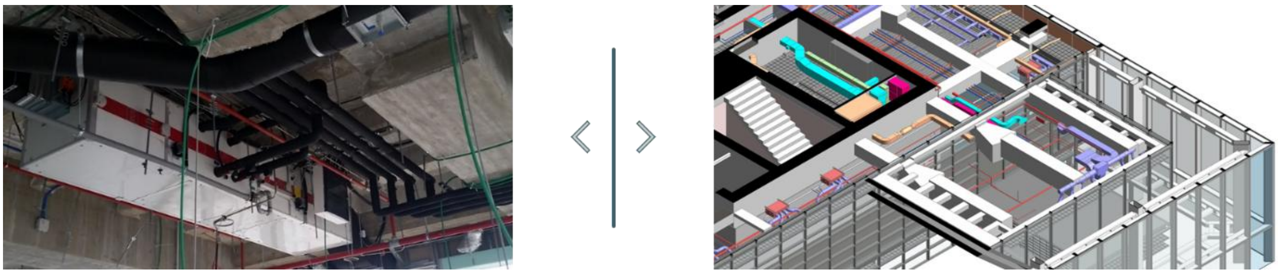


Figure 47 – Transition from the “as-is” to “as-FM”. [Author’s elaboration]

This terminological choice is not secondary. Speaking of AS-FM makes it clear that the aim is not to outline an indistinct ideal scenario, but to construct a configuration explicitly oriented towards management and founded on the assumption that the model is not the final outcome of design, but an active basis for operations. In this sense, the central issue is not simply to “improve” the process, but to transform it into a model-driven process, capable of interrogating the Record Model, feeding the FM platform, and returning verifiable updates (Figure 48).

Figure 48 – Overview of the model-driven process. [Author’s elaboration]

The key methodological point is that a BIM-based maintenance process does not simply coincide with a process that "uses a model" in a generic sense. It requires that each phase of the workflow be associated with informational inputs, responsibilities, produced evidence, controls, and updates. In other words, the model and the platform do not constitute two separate environments, but two components of the same information chain. The Record Model thus becomes the support through which the asset can be identified, located, linked to procedures and maintenance histories, while the management platform activates its use within tickets, work orders, schedules, and activity records.

On this basis, the research focused on two fundamental maintenance processes: corrective maintenance, or fault-based maintenance, and planned maintenance. The former makes it possible to observe the typical problem of transforming an initially vague report into a localized and operational technical datum; the latter tests the possibility of constructing a management logic in which the object is defined not only by the place in which it is located, but also by the set of procedures, frequencies, and activities to which it is subject over time. In both cases, what changes is not merely the tool, but the very way in which information is conceived. It should also be clarified that, in the case study, the experimentation was developed primarily on building services elements, with particular attention to fan coils, which were adopted as the reference case for both fault-based and planned maintenance.

Spaces, rooms, and workstations (PDL) also follow a model-driven logic, but one that is more properly linked to space management processes, which do not coincide with technical maintenance in the strict sense. For this reason, these elements will be referred to as a parallel process, while the focus of this section remains on building services assets and on their treatment within the BIM–FM system.

Finally, one aspect of particular importance concerns the role of the Economic Operator (EO). In the traditional process, it tends to occupy a position mainly on the execution side; in the AS-FM process, by contrast, it becomes an active part of the information flow. It not only performs the intervention, but also receives structured data, returns coded evidence, contributes to the traceability of activities, and participates in the continuity of maintenance data. In this sense, the experimentation concerns not only a different technical configuration, but also a different organizational arrangement of the relationship between the Contracting Authority, the platform, and the parties entrusted with maintenance.

The section is therefore organized into four steps: the reconstruction of the AS-IS process; the definition of the minimum information requirements of the objects; the design of the two AS-FM processes, corrective and planned; and their verification on the case study through operational implementation in the platform. In this way, the transition from AS-IS to AS-FM does not remain a theoretical construct, but becomes a procedural proposal grounded in a real case, already tested and potentially transferable to other PA contexts.

6.3.1. AS-IS Analysis of Maintenance Processes

The first step consisted in reconstructing the AS-IS condition, with particular reference to the fault-based maintenance process. This point is important because it shows that the critical issue does not arise only from the quality of the initial datum, but from the way in which data are transformed, translated, and often dispersed throughout the process. The analysis was therefore not intended merely to describe an existing procedure, but to identify the points at which information continuity is interrupted or weakened.

In the observed process (Figure 49), the fault report originates from a generic user, who communicates the problem to the floor manager by email. Already at this initial stage, a decisive aspect emerges: the information is generated in an essentially descriptive and often non-technical form. The user does not identify an asset, does not use a code, and is rarely able to localise the problem according to a precise management logic; rather, they report a perceived effect, such as a thermal malfunction or an abnormal environmental condition. The floor manager then translates this information into an initial internal report, which is recorded in the so-called *"valigetta",* that is, a shared Excel file used as a collection tool.

\The next step is handled by the building maintenance manager, who analyses the report and decides whether to reject it or proceed with a further level of formalization. If the issue is considered unfounded or irrelevant, the cycle is closed. If, however, an intervention is required, the process re-enters the FM platform, where the problem is redefined as a ticket and transformed into a service order / work order addressed to the competent maintenance service. This is followed by execution of the intervention, verification of the activity performed, and finally closure of the ticket.

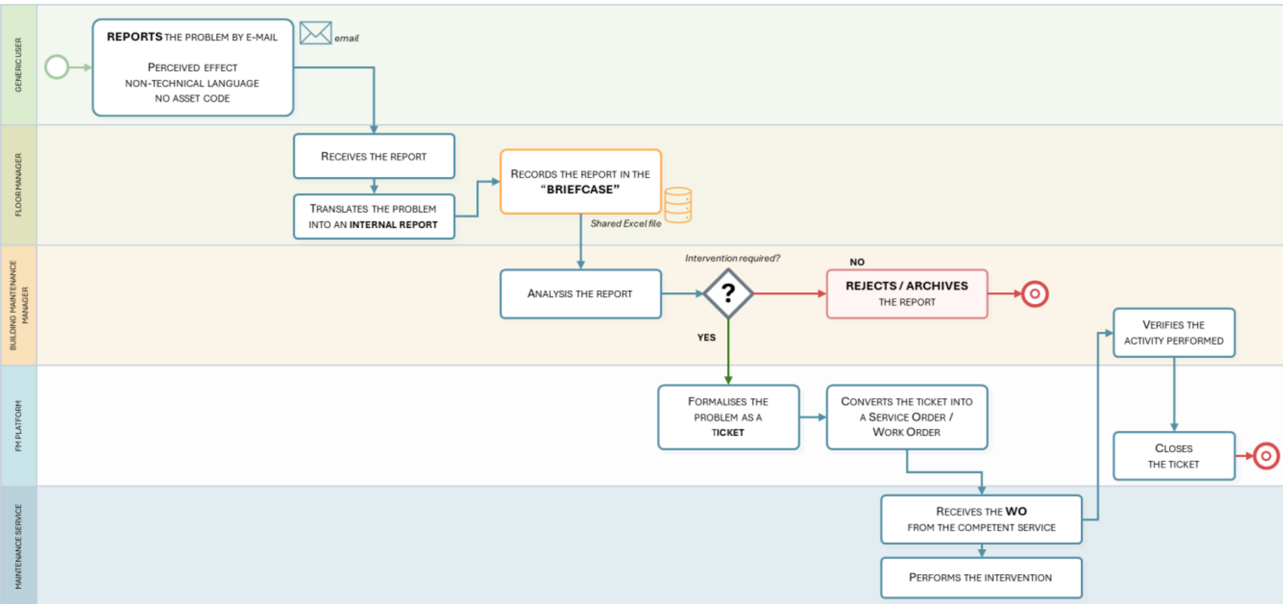


Figure 49 – Reconstructed BPMN schema of the observed fault-report process. [Author's elaboration]

At first glance, the process may appear functional, since it still makes it possible to manage the fault until resolution. However, from an informational point of view, it presents numerous weaknesses. The first concerns the continuous transitions between different people and systems: from the email to the floor manager, from the floor manager to the shared file, from the file to the platform, from the platform to the work order, and from the intervention to the final verification. This fragmentation means that information does not circulate within a single environment, but is reformulated several times, with the risk of losing precision, context, and traceability.

The second critical issue concerns the transformation of data from generic to technical. In the **AS-IS** process, the request does not originate as already localized and coded information, but is only turned into technical information at a later stage, when the maintenance manager translates the problem into a logic of the type

building → floor → room → building services category → fault type.

This means that the most specialised element of the process is not so much the intervention itself as the ability of an intermediate actor to interpret a vague report correctly and convert it into a usable maintenance request. In essence, the system is not yet designed to capture data that are already coherent with management, but depends heavily on the mediation of whoever interprets them.

The third critical issue is the lack of proper historicisation of maintenance data. The intervention is closed, but this does not always result in a structured update capable of tracing the asset's history, the recurrence of problems, the behaviour of the system, or the relationship between the fault and its location. Even more significant is the fact that the model remains entirely external to this process: it is not queried, it is not updated, it does not support localization, and it provides no contribution to the construction of a maintenance memory. In this sense, the AS-IS allows the intervention to be completed, but it does not build a genuine information base for FM.

The AS-IS analysis therefore highlights a fundamental point: the problem is not that the process fails to close requests, but that it does so in a way that is poorly suited to producing information continuity. The flow works as a reactive mechanism, but not as an infrastructure for learning from and updating the system. It is precisely from this weakness that the need arises to clarify, even before redesigning the workflow, what the minimum information requirements are for an object to be genuinely manageable within a BIM-based logic.

6.3.2. Defining the Information Needs of Objects

Once the **AS-IS** has been reconstructed, the next step is not yet to design the new process, but to clarify what information must exist for an AS-FM process to be truly possible. This point is methodologically decisive, because it shows that BIM-based maintenance does not depend only on the presence of the model, but on the definition of a **minimum information set** capable of turning the asset into an **operational entity**.

In the experimental work, the focus was placed on **fan coils** and, more generally, on building services elements. For these objects, the AS-IS process relied on a fundamentally localising logic: the object was recognized through a sequence such as **building, floor, room, building services category, fault type**. This scheme is certainly useful, but it becomes insufficient if the goal is not only to locate the problem, but to construct a management system capable of associating the object with its own procedures, maintenance frequencies, history, and relationships with the information system. The transition to AS-FM therefore requires a **paradigm shift.** The object must no longer be conceived merely as something that "knows where it is," but as something that also knows which maintenance activities it is subject to, which procedures govern it, which evidence describes it, and what relationship it maintains with the management environment. In other words, the object must become **procedure-based**, meaning that it must incorporate not only a spatial dimension but also an operational one. It is at this point that the asset begins to turn into a genuine **management unit**. From this perspective, the information requirements do not coincide with an indiscriminate proliferation of parameters. The issue is not to accumulate attributes, but to define those that are truly necessary for the object to be queried, managed, and historicized. For building services elements (Figure 50), this means at least being able to relate the asset to a logic of **identification, localization, technical typology, reference standard, associated procedure, and intervention traceability**. In this sense, the transition from vague information to specific information is not merely a descriptive improvement, but the real foundation of **model-driven maintenance**.

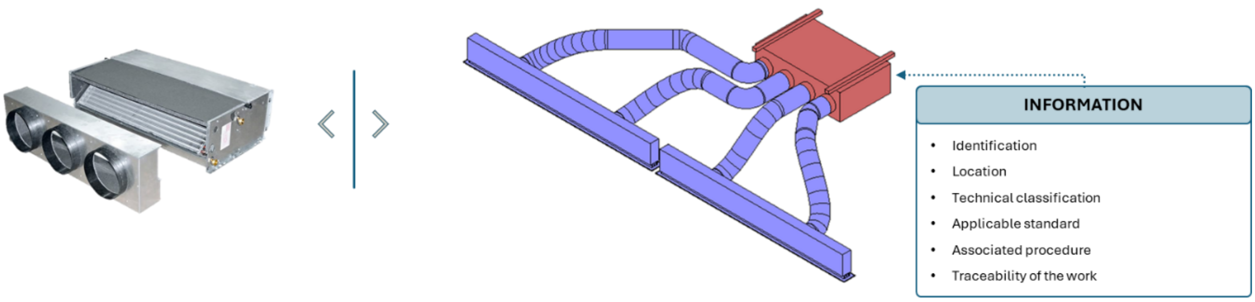


Figure 50 – Physical asset (AS-IS) e Digital asset for management (AS-FM). [Author's elaboration]

It should also be clarified that **spaces, rooms, and workstations (PDL)** follow a partly different logic. Here too, management is model-driven, but the managed object is not an element subject to technical maintenance in the strict sense; rather, it is an entity related to **space management**, the availability of environments, their organization, and their use. For this reason, these elements constitute a parallel process that is not developed here in detail, but which confirms an important point: in the transition to FM, there is not a single informational object, but a plurality of entities—**assets, spaces, workstations**—that require different rules, even within the same management ecosystem.

The main contribution of this subsection therefore lies in showing that the new process cannot be built unless it is first made explicit **what information the object genuinely requires**. Only on this basis is it possible to design maintenance workflows in which the request, the intervention, and the update do not remain isolated events, but are linked to a coherent and durable information base. It is on this foundation that the following subsection develops the two AS-FM processes, corrective and planned.

6.3.3. Designing the as-FM Processes: Corrective and Planned Maintenance

The design of the AS-FM processes is based on a simple yet radical principle: the maintenance process must originate as a model-driven process, that is, as an operational sequence fed by an information system structured around the Record Model and integrated with the FM platform. In this scenario, the model is not a passive attachment, but the carrier of the information that enables the platform to function coherently. Maintenance information is therefore not reconstructed downstream each time, but prepared upstream and made operational from the outset.

In the **corrective process**, the proposed logic overcomes the fragmentation of the AS-IS. The request no longer originates from an informal communication subsequently translated by intermediate actors, but is opened directly in *FactotuM* according to an already structured framework. The requester submits a report by associating it with a location and a problem; the request is then taken over by the **supervisor**, who analyses it and either approves or rejects it. If approved, the system generates the **work order**, which is assigned to the Economic Operator for execution. Once the activity has been completed, the supervisor reviews what has been carried out and may either close the process or reopen it, should the intervention prove ineffective or require further action. The crucial point is that, in this new configuration, the request no longer passes through a weak chain of manual translations, but moves within a **formalised, traceable, and informationally coherent workflow** (Figure 51).

The **planned process** (Figure 52) requires a different logic, because it is not triggered by a fault but by a structure of **procedures and frequencies associated with the object**. Here, the most important shift is that the object is no longer described solely by its position, but by its expected **maintenance behaviour**. The first step consists in defining the object within the BIM authoring environment; the second in importing it into the FM environment, where processes of normalization, cataloguing, and publication are activated. At this stage, several parameters become central in structuring the relationship between model and platform: **CSI_ID**, as the object's standard reference; **EQ_ID** and **EQ_STD**, as the identifiers of the equipment and its standard; and **SITO_ID, BL_ID, and FL_ID**, as the codes for site, building, and floor.

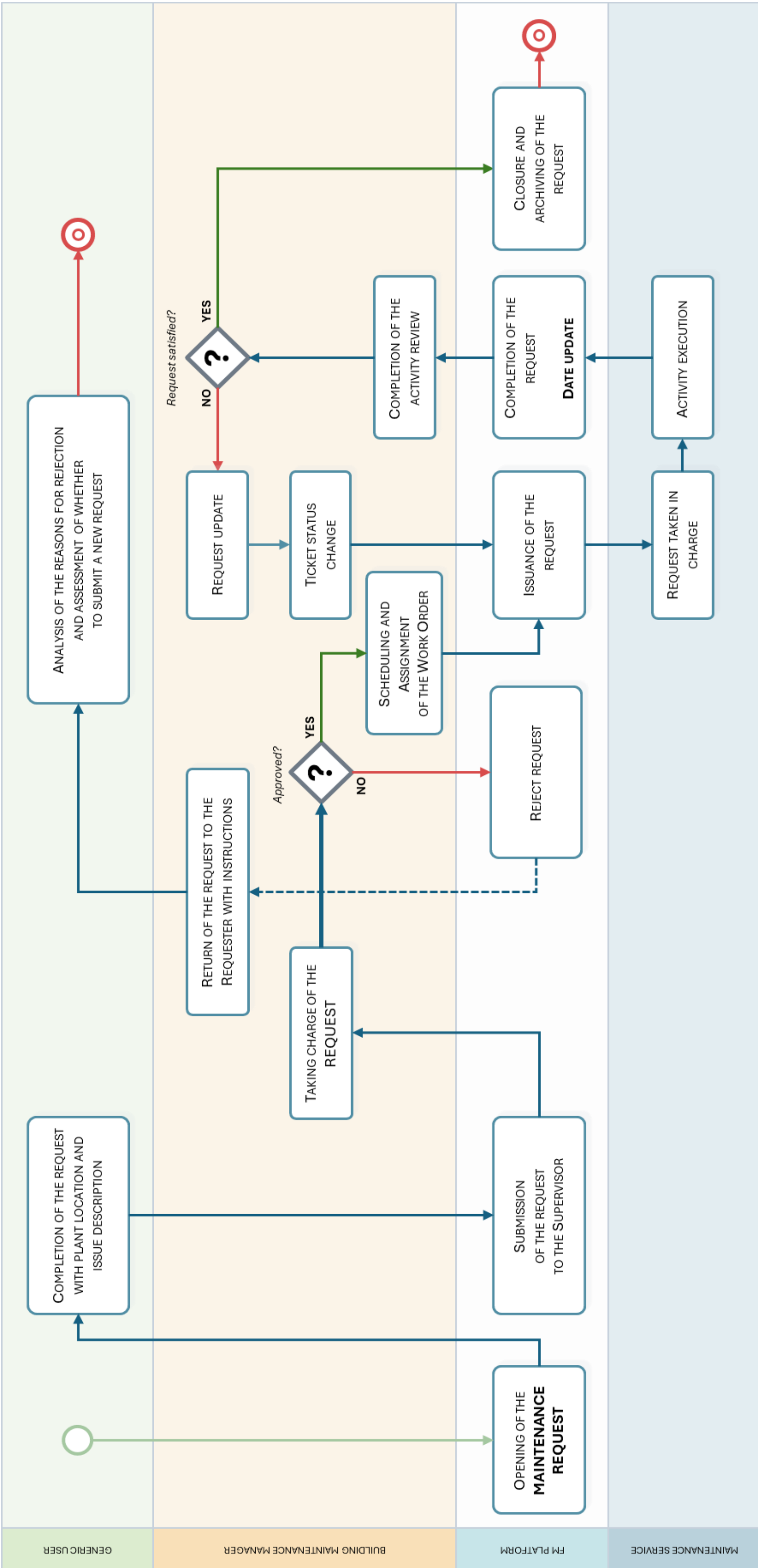


Figure 51 – BPMN schema of the proposed fault-based maintenance management process. [Author's elaboration]

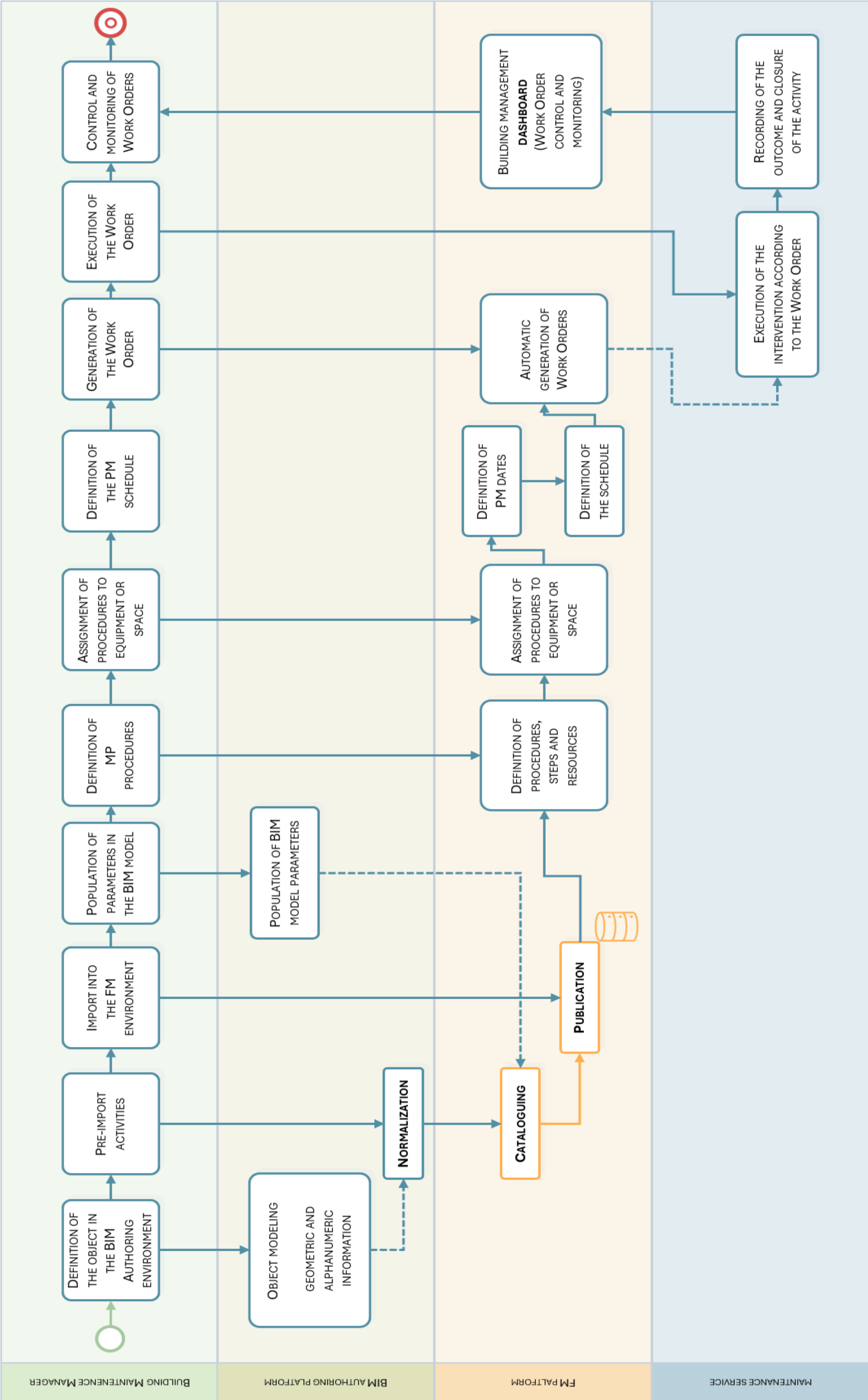


Figure 52 – BPMN schema of the proposed schedule maintenance management process. [Author's elaboration]

Once these parameters are in place, the system can construct the logic of **planned maintenance**. Within the platform, **PM procedures** (Figure 53) are defined by specifying, for each of them, at least the description, procedure type, primary supply, and equipment standard. These procedures are then assigned to the specific piece of equipment or to the space (Figure 54), linking the object code to the relevant reference procedure. On this basis, it becomes possible to create the schedule by defining **frequencies and dates** (Figure 55), and to generate **work orders automatically** (Figure 56) , which are then carried out by the OE and monitored through a dedicated **management dashboard** (Figure 57).

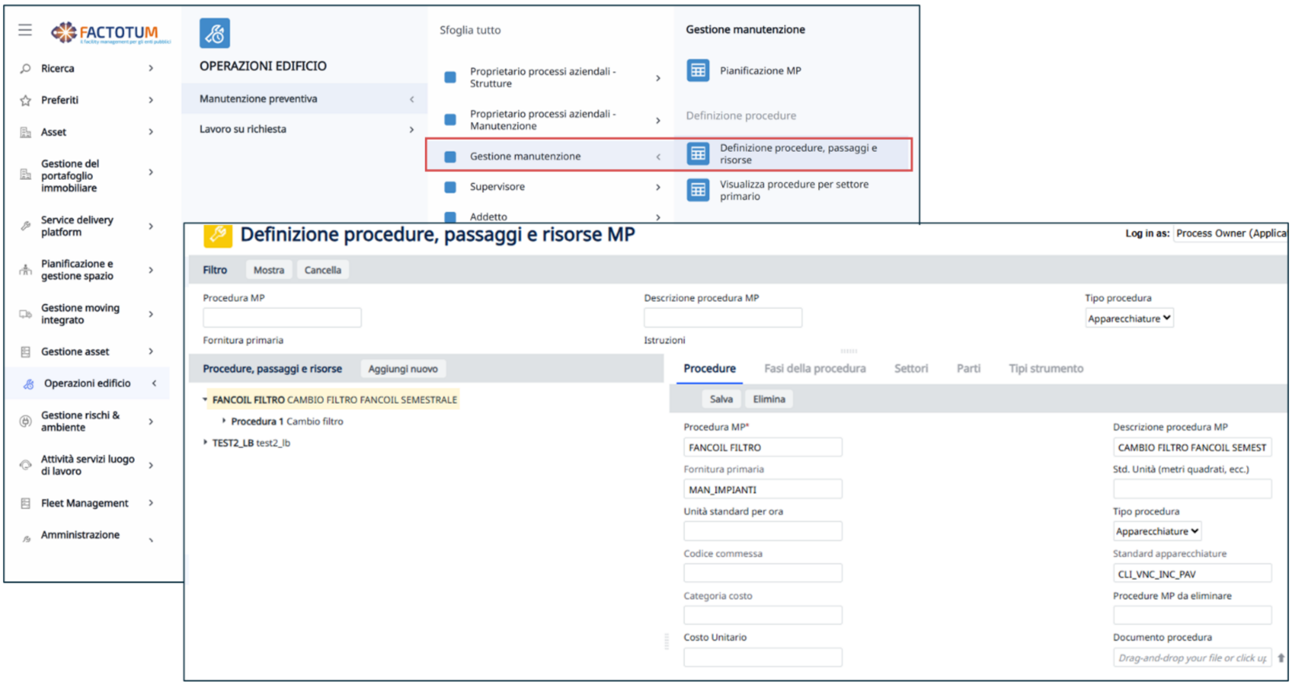


Figure 53 – Definition of FM procedures on FactotuM (Management Tool). [source: FactotuM. Author's elaboration]

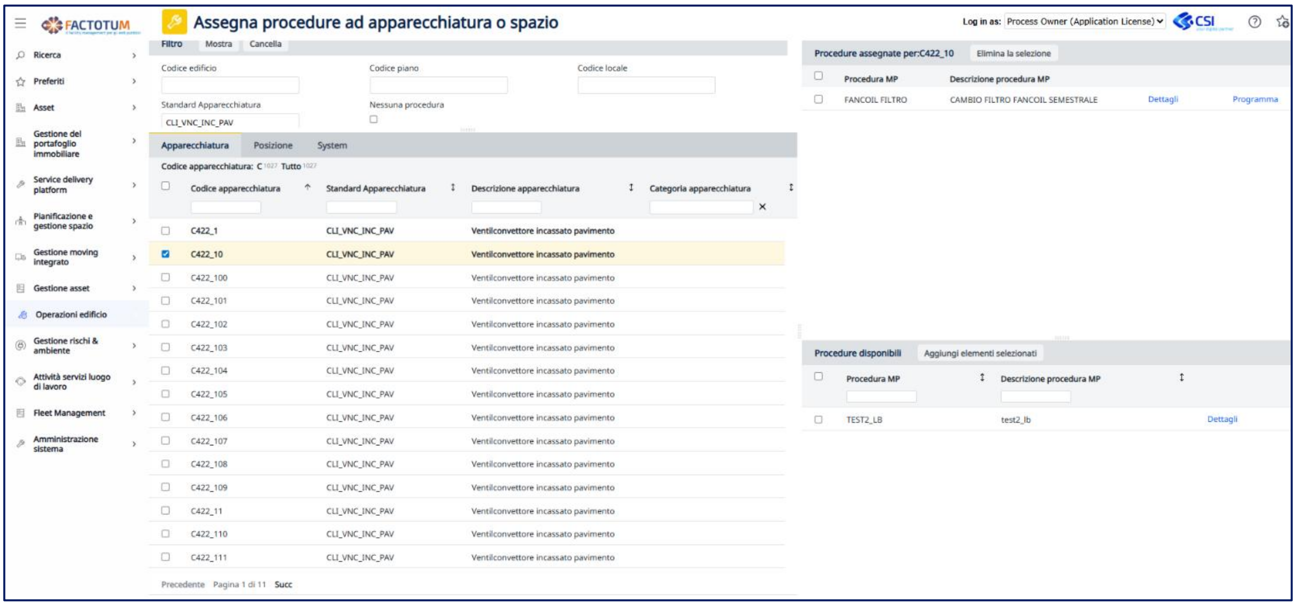


Figure 54 – Assigning the procedure to the equipment on FactotuM. [source: FactotuM. Author's elaboration]

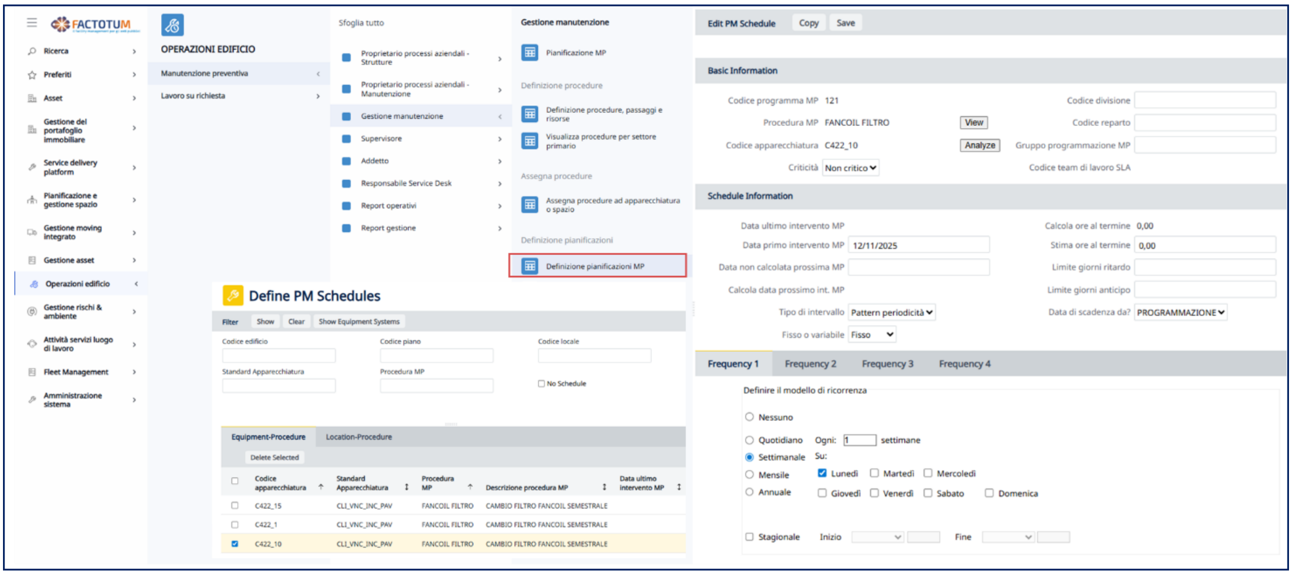


Figure 55 – Definition PM schedules on FactotuM. [source: FactotuM. Author's elaboration]

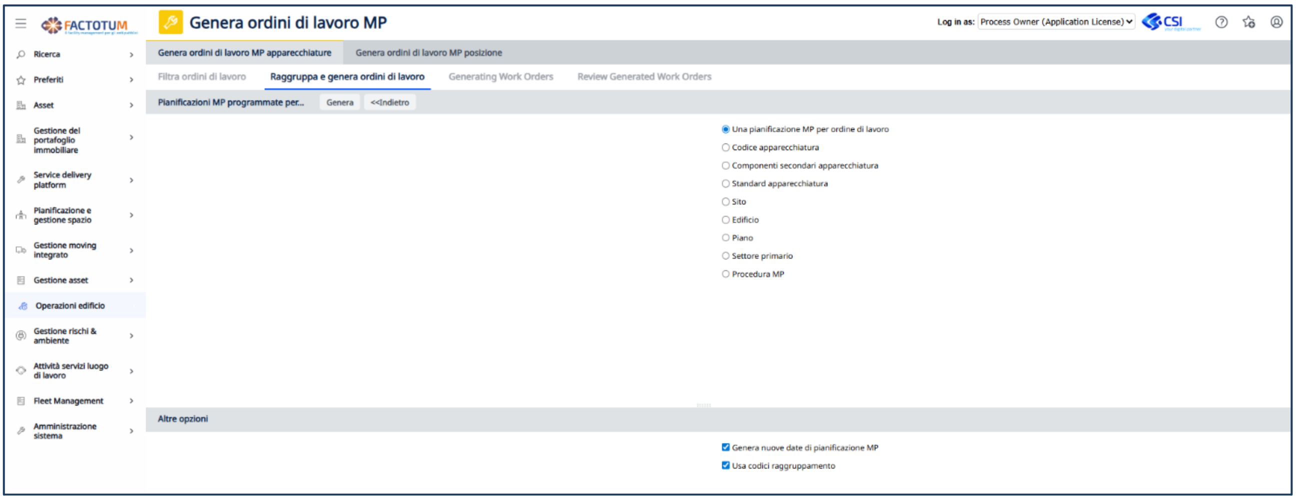


Figure 56 – Generation of work orders on FactotuM. [source: FactotuM. Author's elaboration]

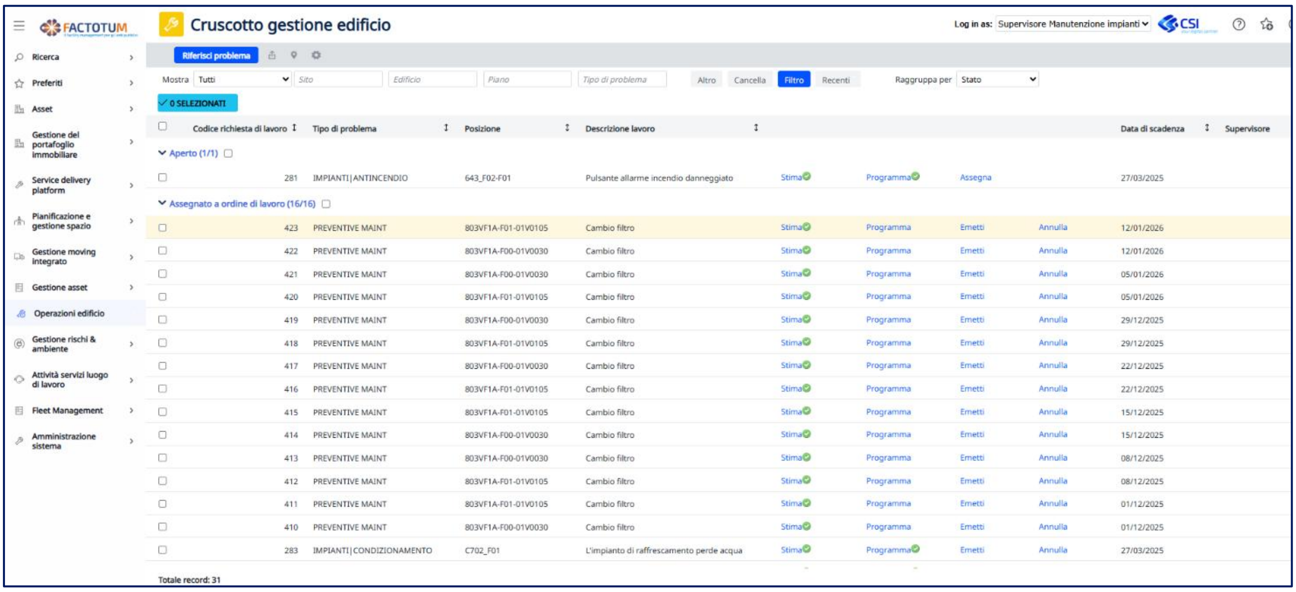


Figure 57 – Dashboard on FactotuM. [source: FactotuM. Author's elaboration]

A particularly significant aspect of the experimentation concerns the decision not to push the logic of **parameterised subcomponents** too far. A solution was also tested in which each object carried specific parameters relating to quantities, frequencies, and numbers of interventions for each subcomponent (Figure58). However, this approach led to a rapid proliferation of parameters, with the risk of making the model excessively heavy and difficult to manage.

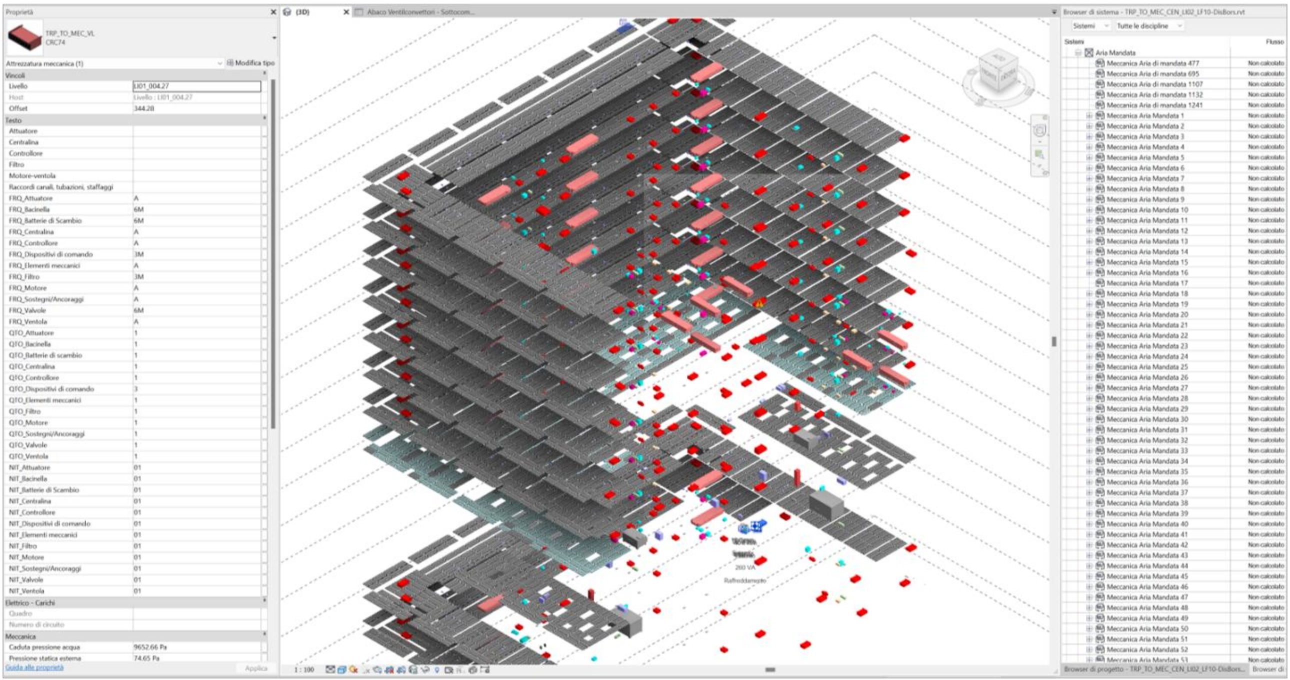


Figure 58 – MEP model test with subcomponent parameters compiled for equipment elements, such as Fan Coil Units, showing the risks of parameter proliferation in planned maintenance modelling. [Author's elaboration]

The adopted solution was therefore to govern planned maintenance through **procedures associated with the object**, rather than through an explosion of informational subcomponents. This step is important because it shows that a BIM-based approach for FM does not necessarily require greater granularity, but rather a **sustainable granularity**, consistent with operational use and with the need for updating over time.

In both processes, corrective and planned, the Economic Operator assumes a much more active role than in the traditional logic. It no longer merely performs a technical activity on an object, but reads structured data, returns coded evidence, feeds historicization, and contributes to **information continuity**. For this reason, the experimentation also required a specific training phase for the Economic Operator (Figure 59), which was essential in order to make clear that the new process concerns not only the act of "doing maintenance," but of doing it within an **integrated information system**.

Taken as a whole, the AS-FM processes therefore show a very clear shift: from maintenance as a reactive and fragmented sequence to maintenance as a model-driven process, in which object, procedure, platform, and historicization all contribute to building a living information base. It is on this basis that the next subsection addresses the verification of the case study and its operational translation into the platform.

Figure 59 – Training of the Economic Operator on the new process. [Author's elaboration]

6.3.4. Testing on the Case Study and Translation into a Platform

The validation of the proposed processes took place in the case study through the combined use of Revit 19, as the BIM authoring environment, and *FactotuM*, as the FM platform. This step is important because it demonstrates that the proposal does not remain on a purely theoretical level, but engages with a real operational environment in which the relationship between the modelled object, management platform, work order, and information feedback is effectively tested. The experimentation was initially conducted on fan coils, chosen as the pilot case because of their maintenance relevance and because they allowed both a fault-based logic and a planned logic to be constructed. Starting from this test, the process was then also used as a basis for a subsequent procurement procedure relating to the management of a number of buildings within the *Regione Piemonte* property portfolio. This aspect considerably strengthens the value of the experimentation, because it shows that the process redesign was not conceived solely for an isolated case, but has already found an initial translation into a broader contractual context. From the point of view of the results, the experimentation first and foremost demonstrated an improved connection between the model and FM. The process no longer requires the data to be reconstructed each time, but makes use of a structured basis that allows the object to be identified, associated with a maintenance logic, used to generate the work order, and linked back to the outcome of the intervention within a coherent information memory.

Secondly, it resulted in greater process controllability: work orders become readable, verifiable, and monitorable within the system, instead of being dispersed across different communications and tools. Thirdly, the involvement of the EO as an active part of the flow made it possible to achieve better historicization of activities and a clearer return of operational evidence. However, the positive results do not eliminate the limits of the experimentation. The first concerns scalability. The test was developed in a targeted way on a single element, the fan coil, and although this was sufficient to demonstrate the validity of the principle, the sustainability of the process remains to be verified once extended to a much wider plurality of assets and to different systems families, such as electrical systems. The second limitation is the risk of proliferation and entropy: if the system is not governed carefully, the increase in parameters, procedures, exceptions, and special cases can quickly compromise the practical usability of both the model and the platform. A third point of attention concerns the strong dependence on the quality of the initial setup. In order for planned maintenance to function coherently, whoever structures the system must have an in-depth understanding of the procedures, frequencies, technical standards, and contractual logics governing the different objects.

This means that the process cannot be left to an approximate or purely automatic configuration, but requires an extremely conscious setup phase. For this reason as well, the extension of the system to the subsequent tender represents a crucial testing ground for understanding how far the approach is genuinely transferable and to what extent it requires further adaptations. Overall, the verification on the case study nevertheless makes it possible to state that the transition from as-is to as-FM is not only theoretically grounded, but already technically feasible. What it produces is not simply a more efficient process, but a new form of relationship between model, platform, object, intervention, and management. It is precisely this new relationship that makes the next step of the chapter possible: if processes are to remain coherent over time, then there must also be a figure capable of safeguarding their **information continuity**. Hence the need to introduce the **Digital Information Continuity Officer (DICO)**.

6.4. Digital Information Continuity Officer as a Key Figure for the Contracting Authority

If **BIM–FM continuity** depends on the ability to keep processes, documents, models, registers, platforms, and information uses coherent, then it is difficult to argue that such continuity can emerge spontaneously simply by adopting digital tools or by requiring BIM in procurement procedures. On the contrary, it requires an organizational function capable of overseeing the way in which information is conceived, structured, verified, transferred, used, and updated throughout the entire process. It is within this space that the figure proposed here – the **Digital Information Continuity Officer** – finds its place, understood not as a mere relabeling of already familiar roles, but as a transversal safeguard of the **Contracting Authority's informational coherence.**

The point is crucial because, in the context of PA, the issue is not simply to obtain more data, but to ensure that such data retain meaning, stability, and usability as they pass through procurement, design, construction, commissioning, handover, and operation. Without a subject capable of "holding together" these thresholds, each phase inevitably tends to produce information according to its own local logic: the designer according to the logic of the model, the construction supervision team according to the logic of execution control, the commissioning body according to the logic of certification, the EO according to the logic of contractual fulfilment, while operations require data organized according to criteria of readability, traceability, updatability, and relation to the real asset. In the absence of an overseeing function, what is often produced is an overlap of formally correct yet poorly integrated information.

In the TRP case, this need becomes even more evident because the transition towards BIM-based management does not simply introduce new tools, but calls into question long-established operational practices. Here, the issue is not merely to "coordinate" already existing flows, but to design, test, adapt, govern, and validate them in light of a final use that, for PA, is both new and more demanding. For this reason, the term coordinator proves inadequate. The figure proposed here does not merely connect actors or documents, but intervenes in the very construction of the conditions that make data continuity possible. In this sense, it is a figure that must keep the end in view, that is, read the entire process starting from the final use of information during the FM phase. From this perspective, the **DICO** may be understood as a **hybrid figure**, positioned between the functions normally associated with the *BIM Manager* and the *BIM Coordinator*, but explicitly oriented towards management. It therefore does not coincide with a generic BIM expert, nor with a mere technical-documentary support role. Its field of action is broader and more demanding: to ensure that what is required, produced, delivered, and verified in the various phases of the process is genuinely coherent with the operational use of data and with the evolution of the Record Model. In other words, it does not oversee BIM merely as a tool, but BIM as an information infrastructure for FM.

This figure is also strategically important because, in the public context, information continuity is never a purely technical matter. It concerns the ability of the CA to maintain control over its own data, models, and the rules according to which they are produced and transformed over time. Without such a function, the risk is that BIM remains a formally innovative yet substantively fragile object: a file stored on a server, a model produced to comply with tender requirements, an information system that is neither truly alive nor genuinely integrated into management.

By contrast, DICO (Figure 60) makes it possible to treat the model as a controlled, updated, and verifiable, and reusable information base, that is, as a real device for governing the asset portfolio.

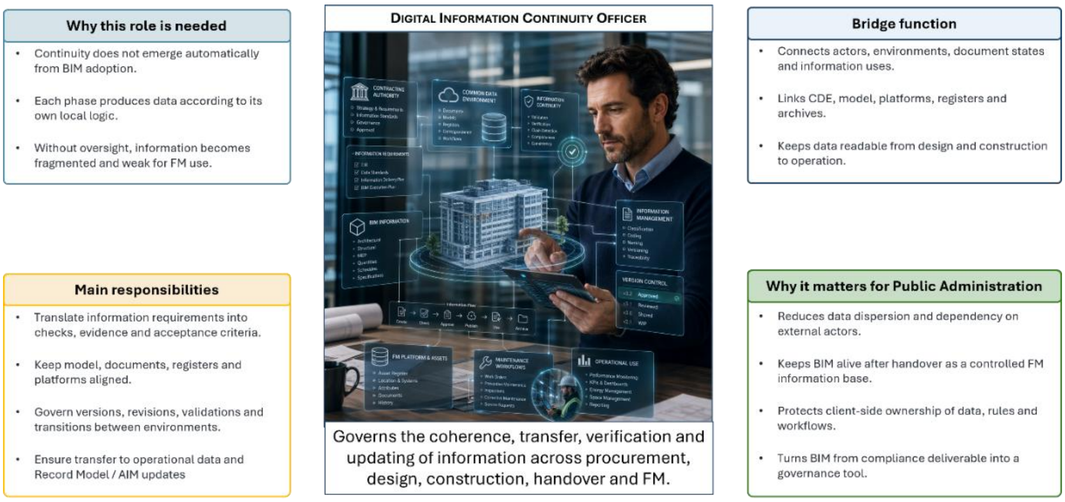


Figure 60 – Digital Information Continuity Officer overview. [Author's elaboration]

The first function to be attributed to this figure is that of a bridge. This definition, however, should not be understood in a weak or merely communicative sense. DICO is not a generic facilitator, but a structural safeguard capable of connecting levels that, in administrative and technical practice, tend to diverge: actors, environments, documentary states, and information uses. At the level of actors, this figure is positioned at the intersection of all those who produce, use, or control data: the RUP, technical offices, any BIM Office, management-FM staff, EO, verification bodies, administrative functions, and, more generally, all the components involved in the life cycle of information. This transversality is not an accessory feature, but a necessary condition: information continuity is interrupted precisely when different actors operate according to partial logics, without a function capable of reassembling their interfaces. At the level of environments, this bridging role concerns the relationship between the CDE, the model, management platforms, registers, and documentary archives. One of the most recurring problems in public-sector processes is not so much the absence of data, but the fact that they reside in different environments, governed by different rules and lacking any clear logic of priority, versioning, and mutual relation. In this sense, the DICO must ensure that data are not dispersed as they move from one environment to another, and that each support maintains a verifiable relationship with the others. At the level of documentary states, this figure also oversees the relationship between drafting, sharing, validation, delivery, acceptance, and subsequent updating. In an FM-oriented BIM-based system, it is not enough for a document to exist or for a model to be formally published; it is necessary to know which state it is in, with what degree of reliability it may be used, and under what responsibilities it may be updated. The bridging figure serves precisely to prevent this sequence from being reduced to mere formalism, thereby losing its relationship with the actual use of information. Finally, its connecting role also concerns the **uses of information**. The same datum may originate in a design phase, be verified during construction, be assumed as a handover basis, and later need to be used within a maintenance context. If no one oversees this transformation of use, the risk is that the information may be correct for one phase but useless for the next. The bridging figure is therefore needed to ensure that data do not remain trapped within the logic of the phase that produced them but can move through the process while preserving **readability and operational value**.

6.4.1. Main Responsibilities

The responsibilities of the Digital Information Continuity Officer are multiple and must be understood in both organizational and operational terms. The first, and most general, consists in translating information requirements into a structure of controls and verifications that can actually be implemented. This means moving from a demand formulated in abstract or documentary terms to a chain of expectations, evidence, checks, and acceptance criteria that Public Administration can genuinely exercise. Without this translation, there is a risk that requirements remain statements of principle rather than actual instruments of governance. A second fundamental responsibility concerns safeguarding the coherence between model, documents, registers, and platform. Such coherence is never automatic: it has to be constructed, verified, and maintained.

The issue is not simply to check that objects are correctly modelled, but to ensure that alphanumeric information, coding systems, documentary relations, operational registers, and management-platform data do not contradict one another. It is here that this figure assumes a decisive role, because it prevents the system from splitting into parallel truths that can no longer be reconciled. A third responsibility lies in governing versions, states, revisions, and validations. In a BIM-based process, data quality depends not only on content, but also on the clarity of its state. The **DICO** must therefore safeguard not only the **"what"** of the data, but also the **"when"** and the **"how"**: when a delivery is to be considered valid, under which revision, under which acceptance conditions, and with what possible transition into the subsequent environment. This function is particularly crucial in the relationship between **procurement, construction, and management**.

Added to this is the responsibility of ensuring the transition from design data to operational data. This is probably the most delicate point, because it coincides with the very core of the thesis: information produced in the early phases of the process must be capable of becoming a useful basis for management. This requires that data be checked, integrated, stabilized, and, where necessary, reinterpreted from a management perspective. This is not an activity that can be left to a simple documentary legacy; it requires a function that assumes it as a specific responsibility. This figure must also oversee the quality of information deliveries, both in terms of completeness and in relation to their coherence with expected uses. This means checking not only whether what was required has been formally delivered, but whether it has been delivered in a form that is genuinely usable by Public Administration.

In this sense, its responsibility also extends to updating the Record Model, that is, ensuring that the transformations occurring during operation do not remain outside the information system. Here, the role becomes essential: if no one oversees the updating of the model and registers, BIM risks coming to an end at the moment of handover, quickly losing its management value. Finally, the DICO is responsible for building, adapting, and improving workflows. It does not merely monitor already established procedures, but intervenes in their very design and refinement.

This aspect is particularly important in the case study, where the transition to BIM–FM required the redesign of maintenance processes and management criteria. The figure is therefore not only a guarantor of continuity, but also an **agent in its construction.**

6.4.2. Relevance for Public Administration

The relevance of this figure is particularly strong in the case of Public Administration, because the public sector cannot simply "receive" information: it must be capable of governing it, controlling it, and retaining ownership of it over time. Public Administration is not merely a client delegating everything to the Economic Operator, but the subject that must remain able to use the data even after the contractual phase has ended. In this sense, information continuity concerns not only the technical efficiency of the process, but also the **administrative capacity of the Contracting Authority**.

The first added value of this figure lies in reducing the **dispersion of data**. In the absence of clear oversight, the information heritage tends to fragment across models, attachments, platforms, folders, registers, and archives, with a consequent loss of traceability and an increased dependence on whoever happened to produce it at any given moment. The DICO, by contrast, serves to maintain a unified logic, preventing Public Administration from having to reconstruct retrospectively the coherence between documents and assets.

The second added value concerns the possibility of genuinely governing BIM–FM. Without such a figure, BIM risks remaining an artefact not fully embedded within the operation of the institution: a file on a server, an outdated model, an information container not integrated into decision-making and maintenance processes. The presence of a function explicitly dedicated to information continuity makes it possible, instead, to treat the model as a living base, subject to control, evolution, and management use.

The third added value lies in strengthening Public Administration's ability not to delegate improperly to external actors decisions that should remain on the client side. In the field of BIM, the temptation to delegate too much to the Economic Operator is strong: not only the production of the model, but also the organization of flows, the interpretation of requirements, the structure of deliveries, and, in some cases, even the management of the data-sharing environment itself. Yet a system built in this way exposes Public Administration to a loss of control. There is therefore a need for someone who, from within or at least from the side of the client, can hold the reins of the entire information process.

For this reason, the *Digital Information Continuity Officer* represents not an organizational luxury, but a condition of maturity for the Contracting Authority. It makes it possible to move from a merely declared BIM to a genuinely governed BIM, from digitalization understood as compliance to digitalization understood as the capacity for public control over data.

In this sense, the figure proposed here constitutes one of the main mechanisms through which Public Administration can avoid leaving the model as a formal object and instead ensure that it becomes an integral part of the building management system.

6.5. Operational Identity of Assets: Coding, Registers, and Updating Rules

If processes are meant to guarantee information continuity, then the objects of management must also be conceived differently. One of the most recurring limits of traditional practices lies in treating the asset as a simple entity to be described or classified, without constructing a genuine operational identity for it. In the context of Facility Management, this is not sufficient. In order to govern maintenance, documentation, work orders, checks, and updates, it is not enough to know that an object belongs to a certain family or is located in a certain environment: it must be possible to recognize it as a stable, traceable, and queryable unit over time.

From this perspective, the issue concerns not only classification, but the construction of a coherent relationship between the physical object, informational object, space, procedure, and maintenance history. This question becomes particularly relevant in the case of Public Administration, where asset management cannot rely on variable identifications, descriptive names used informally, or a memory distributed across documents, platforms, and individuals. In the absence of a univocal logic, the same element may be recognized differently in the model, the FM platform, technical registers, attachments, and maintenance reports, generating what could be described as a genuine identity fracture of the data.

In the case study under consideration, this problem emerges clearly when observing a number of exemplary objects, such as fan coils, rooms, or workstations (PDL). In all these cases, the asset cannot be managed merely as an abstract component or as a modelled object, but must be read as the node of a network of relations that includes at least: its location, its relationship with space, its technical documentation, its maintenance history, the procedures to which it is subject, and the responsibility of the actors intervening on it. Operational identity is therefore the point at which geometric data, informational data, and management data converge.

This shift is important for a broader reason as well. In BIM–FM, it is not enough for the asset to be correctly represented in the model or to possess a set of descriptive parameters; it must also be capable of being integrated into a management logic that makes it recognisable over time, even when the context of use changes, when interventions are carried out, when it is replaced, or when it must be linked back to a work order, procedure, or verification. From this point of view, the theme of operational identity constitutes the real bridge between the Record Model and the FM system: if the object is not identified in a stable way, the process loses continuity; if it is, then the model can genuinely become the information base of management.

For this reason, this section addresses the theme of operational identity in three steps. First, it clarifies the shift from the simple **"name of the object"** to a real unit that can be managed over time. Second, it addresses the issue of coding and operational registers, with particular reference to the relationship between Space_ID, Asset_ID, and procedures. Finally, it connects this structure to the problem of updating the Record Model, showing how information continuity also depends on the ability to keep the system alive after handover.

In the language of modelling, the object is often described as an instance of a family, a technical category, or a disciplinary component. This logic is correct and necessary, but it is not sufficient for management. In an FM environment, the object must cease to be merely a described element and become an entity that can be followed over time as an operational unit. A fan coil, a workstation (PDL), a room, or another element of the building system is useful to management not simply because it exists in the model, but because it can be recognized as an object to which activities, documents, checks, maintenance events, and responsibilities may be associated.

The first step, therefore, consists in moving beyond the level of the simple “name of the object.” The name alone often has a descriptive or catalogue value: it indicates what the object is, but does not yet guarantee its governability. Operational identity, by contrast, implies that the object is embedded within a network of stable relations: it must be possible to know where it is located, to which space it belongs, which documents describe it, which procedures govern it, which interventions it has undergone, and who is responsible for it in terms of management, verification, or updating.

In the case of the *“Torre della Regione”*, this shift is crucial precisely because many of the problems in the traditional process arose from the distance between a generic description of the problem and the difficulty of linking it back to a precise operational element. A report could originate from a perceived discomfort – for instance, inadequate temperature in a certain area – but in order to become manageable it had to be translated into a more precise sequence: building, floor, room, systems category, fault type, equipment involved. It is through this translation that the object begins to lose its character as a simple abstract component and acquires its dimension as an operational entity. This transformation is also important because it introduces the relationship between physical events and informational events. If an object is inspected, replaced, adjusted, or subjected to maintenance, that event must be capable of being recorded unambiguously and linked back to that specific asset. If this connection does not exist, each intervention remains isolated and does not contribute to the construction of a maintenance memory. Operational identity is precisely what prevents data from dissolving into a sequence of disconnected activities, making it possible instead to build a technical and managerial history of the object.

For this reason, within the logic of the thesis, operational identity is not an accessory or purely terminological issue. It represents the point at which the model ceases to be merely a representation and begins to become a management infrastructure. Only when the object is recognized as an operational unit is it possible to construct a system in which maintenance, registers, platform, and documentation are no longer parallel universes, but parts of the same information ecosystem. The construction of operational identity requires a coding system capable of maintaining a stable relationship between space, asset, and, where necessary, procedures. In the case study, this logic was not conceived as a mere assignment of labels, but as a univocal basis for preventing the model, documents, and platform from evolving according to divergent rules. In FM, in fact, a code is valuable not only because it identifies, but because it makes it possible to keep events, records, attachments, checks, and updates coherent over time.

In the system developed, the coding is based on an integrated relationship between the reference to space and the reference to the equipment, to which is added, for objects subject to maintenance, the relationship with the procedure. The logic is neither merely spatial nor merely technical, but structurally hybrid: the object must be capable of being located, recognized as a piece of equipment or management entity, and linked back to a coherent set of activities. It is here that the model-driven dimension becomes decisive, because the model does not simply provide a geometric representation, but feeds the identification system and therefore shapes the way in which the platform can read and manage the asset.

In operational terms, the main registers that derive from this logic are at least three: the space register, the asset/equipment register, and the maintenance history. The first establishes the spatial backbone of the system, that is, the organization of sites, buildings, floors, rooms, and workstations. The second identifies the managed objects, links them to spaces, and enables their functional and maintenance classification. The third records the events: work orders, interventions, evidence, updates, and, more generally, the operational memory of the object. In the case of the experimentation, these registers do not exist as external and separate archives (Figure 61), but as *FactotuM* tables populated according to a model-driven logic from the BIM model.

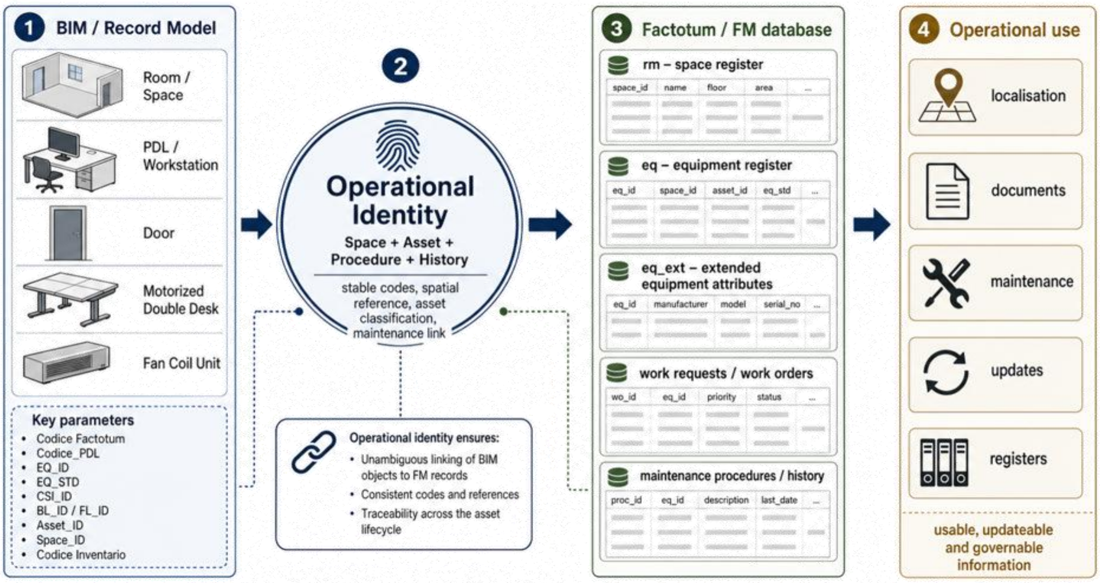


Figure 61 – Operational identity schema linking BIM objects, FM records and operational use. [Author's elaboration]

This aspect is important because it clarifies the relationship between entities and attributes. Entities constitute the "who" of the information system—spaces, equipment, maintenance events—while attributes describe their behaviour, location, standards, codes, and relations. In this way, the model does not merely contain information, but feeds a data structure that can be used directly within the management environment. This shift is far from trivial: it means that the model ceases to be the exclusive place of representation and becomes the first level of organization of a broader information system.

It is precisely here that the issue of double truth emerges with force. In the absence of a univocal logic, the same object may be identified in one way in the model, in another in the documents, in yet another in the platform, and perhaps differently again in the registers or operational practices. The result is not only terminological confusion, but also a loss of control: it is no longer possible to know with certainty which object was actually maintained, which documentation is associated with it, or which version of the data should be considered valid. Coding and registers therefore serve to prevent the system from generating parallel truths. In this sense, they do not represent a secondary technical detail, but one of the principal devices of information continuity.

The issue of coding and registers does not come to an end at the moment of handover. On the contrary, it is precisely after handover that the real robustness of the system is tested. If BIM–FM continuity is to be taken seriously, the identity of the asset cannot stop at the moment when the object formally enters the institution's information heritage: it must be able to continue to exist and evolve over time, within a system in which modifications can be traced, validated, and reintegrated into the information base. It is here that the Record Model takes on a decisive role.

In the context of this thesis, the Record Model is not understood as a simple documentary outcome of handover, but as a part of the as-is model, cleansed of the information that is unnecessary for FM and made coherent with the actual needs of management. It therefore does not coincide with the entire design model, nor with an indiscriminately rich representation, but with that informational and geometric base that is genuinely useful for governing the asset over time. In this sense, the Record Model constitutes the informational input of management, not merely its terminal product. The most delicate issue concerns updating. In the proposed system, this depends on the nature of the modification that has taken place. If the update is purely managerial – for example, the closure of a work order, the recording of an activity, the return of evidence, or the updating of a maintenance attribute – it may occur directly within the FM platform, and may therefore plausibly be carried out by the EO. If, however, the intervention substantially modifies the configuration of the object, its position, its spatial relationship, or even the logic of the system, then managerial updating alone is not enough: the BIM model must also be updated, and this should be overseen by the FM manager or by the institution's BIM Office.

In this scenario, the correct information chain may be read as follows:

intervention → evidence → validation → FM update → possible BIM update → new feeding of the FM database.

The key point is that updating cannot be left to improvisation or to the goodwill of individual actors. It must be governed by a clear procedure capable of distinguishing between cases in which it is sufficient to modify the managerial level and those in which it is also necessary to realign the geometric-informational level of the model. If this distinction does not exist, the system risks splitting in two: on the one hand, an updated operational platform; on the other, a model that grows old and loses value. Or, conversely, a formally rich model that is no longer coherent with operational reality. It must nevertheless be acknowledged that, in the case study, this step is still partly experimental. Some tests have already shown greater operability in the treatment of spaces and workstations (PDL), while on the building services side the issue of scalability remains open. This does not weaken the argument; on the contrary, it confirms its realism. The problem of updating the Record Model cannot be solved simply by declaring it necessary: it must be constructed, tested, and made sustainable over time. It is precisely for this reason that the relationship between the FM platform and the BIM model represents one of the most delicate and strategic points of the entire process. Ultimately, the transition from handover to the Record Model clarifies an essential point for the thesis as a whole: management cannot be limited to receiving a model, but must be able to keep it alive, coherent, and usable.

The quality of the system does not therefore depend only on what is delivered on "day zero," but on the ability to ensure that subsequent interventions, evidence, and modifications do not remain outside the model, but instead feed, in a controlled way, the information base of management. It is precisely on this requirement that the next block of the chapter is built, devoted no longer to processes and assets, but to the documents through which PA should make explicit and govern its own information demand: the Information Requirements and the Information Requirements Document.

6.6. Why Current Information Requirements Are Not Enough

If the first part of the chapter has shown that BIM–FM continuity depends on the ability of the CA to govern processes, roles, registers, updates, and information handovers, the second part addresses the point at which this capacity should find its first documentary formalization: Information Requirements and, in the Italian context, the **Information Requirements Document (*Capitolato Informativo*)**. The CI is therefore the place where the public client sets out, in a clear and intelligible way, what it needs, why it requires it, when it expects it, in what form it should be delivered, and according to which criteria it will be checked. However, it is precisely at this point that one of the most significant weaknesses in the current BIM maturity of PA becomes visible: the gap between the growing reference to BIM in public tenders and the actual ability to translate that reference into a structured information demand.

A first indication of this trend emerges clearly from the 9th OICE Report on Digitalization (2026), which provides a useful introductory framework for understanding the growing role of the *Capitolato Informativo* within public procurement procedures. In the report, the CI is treated as one of the most significant indicators of the progressive structuring of BIM-based tenders, to the point of being described as an "**essential document for the correct implementation of BIM**", rather than as a merely accessory attachment. This statement is methodologically relevant because it assigns to the CI a function that goes beyond the documentary level alone: its presence signals the transition from a generic reference to BIM towards a more structured approach, in which BIM begins to be translated into explicit requirements, expected deliverables, operational rules, and verification criteria.

The data reported (Figure 62) in the dedicated pages of the report confirm this interpretation. In 2025, tenders accompanied by an Information Requirements Document numbered 219, equal to 34.3% of the total, compared to 89 in 2024, corresponding to 25.2%. The increase is clear and shows that public clients are now paying greater attention to the formalisation of information demand. At the same time, however, this very figure also suggests a more cautious observation: if the CI still accompanies only slightly more than one third of procedures, then the documentary maturity of public demand cannot yet be considered either complete or widespread.

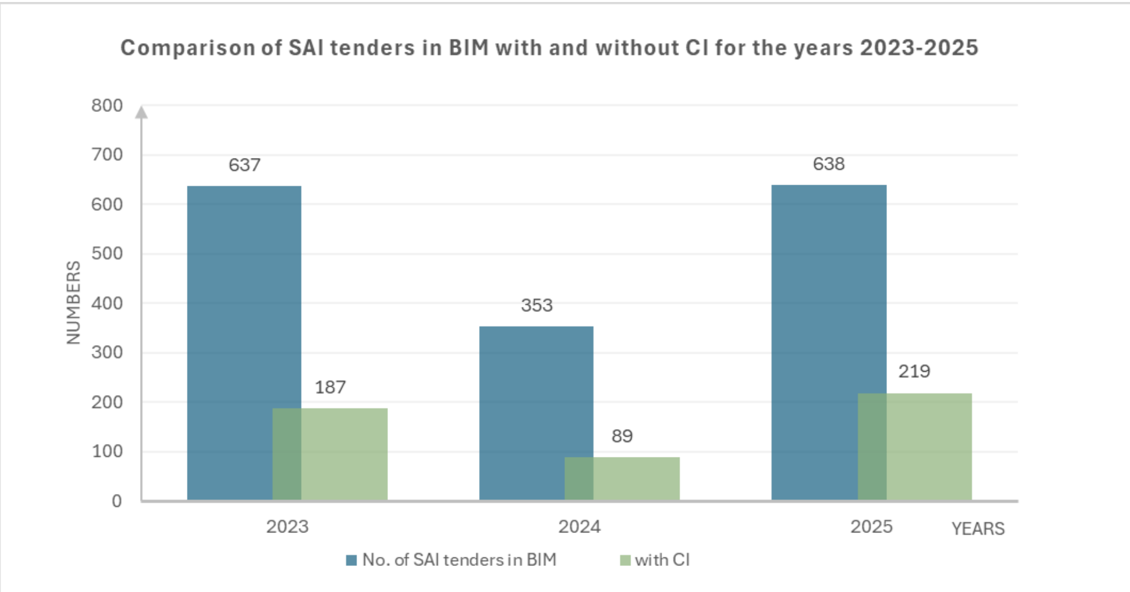


Figure 62 – Distribution of BIM tenders with CI for the years 2023-2026. [Source: 9th OICE Report, Author's elaboration]

This evidence becomes even more significant when read together with the other indicators analysed in the same section of the report. Within the same framework, BIM appears increasingly often both as a professional qualification requirement and as a reward criterion in bid evaluation, while also being associated with growing frequency to the request for specialised figures and certified competences. This leads to a more precise consideration: in Italian public tenders, BIM is growing strongly as an obligation, as an element of award criteria, and as an indicator of qualification, but this growth does not automatically coincide with an equivalent maturation in the ability of PA to formulate a truly governed information demand.

The risk, therefore, is that digitalization may advance more rapidly at the prescriptive level than at the structural level. It is precisely within this gap that the Information Requirements Document becomes a particularly useful object of observation. This is not only because it appears with increasing frequency, but above all because it marks the point at which public demand should cease to rely on a generic invocation of BIM and begin to take the form of a system of expectations that is readable, verifiable, and coherent with the overall process. For this reason, the present study considers the CI not merely as a document to be described, but as an indicator of the informational and organizational maturity of the public client.

From this perspective, the chapter first develops a preliminary comparison with **20 foreign EIRs**, selected through a targeted search of official and publicly accessible sources, with a deliberately restrictive criterion: only documents explicitly identified as Exchange Information Requirements or Employer's Information Requirements, and sufficiently readable to allow direct verification of their main informational contents, were included.

These documents were subsequently excluded from the main comparative analysis, however, because they proved too generic and not fully comparable with the Italian regulatory, procedural, and bureaucratic framework. A corpus of **40 Italian Information Requirements Documents** drawn from public tenders was then assembled and read critically in order to identify where information demand is currently more solidly articulated and where, instead, its main weaknesses still persist.

The assumption guiding this part of the chapter is therefore clear: it is not enough for BIM to appear more frequently in public tenders, nor is it sufficient for the Information Requirements Document to appear more regularly. The crucial point is to understand how it is written, how far it succeeds in being operational, and to what extent it enables Public Administration to govern the relationship between need, requirement, delivery, and verification. It is precisely from this question that the need arises to critically examine current Information Requirements, showing why, in their present form, they still often prove inadequate.

6.6.1. Recurring Limitations of Current EIRs

The analysis of the documents and the comparison with the introductory framework outlined in the OICE Report (2026) make it possible to identify a series of recurring limitations affecting both the documentary maturity of CIs and their actual capacity to support the operational governability of the information process. These limitations should not be read as isolated shortcomings, but as symptoms of a public demand that, while it has progressively incorporated the language of BIM, is not always yet able to translate it into a structure genuinely oriented towards use and management.

The first limitation concerns the weakness of Information Delivery Plan (IDP), milestones, and more generally of control points. Many documents refer to the need for deliveries and checks, but do not clarify with sufficient precision when such deliveries should take place, what content they should have, which phase they relate to, and according to which criteria they should be accepted. In the absence of an informatively robust temporal structure, delivery tends to be reduced to a set of files rather than becoming a true device of transition between phases.

A second limitation, closely connected to the first, concerns the almost total absence of a genuine **RACI logic**. In many documents, roles are named – often also with reference to **UNI 11337-7** – but it is only rarely clarified in precise terms who produces, who verifies, who approves, who updates, and who uses the information. This is one of the weakest points for public clients, because without a clear distribution of responsibilities the information system tends to remain formally supervised but substantively fragile. The absence of a responsibility matrix makes the transition between the production of data and their operational use opaque, and often leaves the EO with excessively wide margins of interpretation on issues that should instead be governed by PA.

A third limitation concerns the weak explicitness of the **CDE dimension**. It is present at the nominal level, but the actual platform, its rules, its states, and its effective governance remain poorly defined. This ambiguity is significant because the CDE is affects traceability, revisions, permissions, approval flows, and the very ability of PA to retain control over its own information heritage.

A fourth limitation is the only partial presence of **actual Information Requirements**. Many documents contain sections, references, prescriptions, and cross-references, but do not always succeed in transforming these contents into requirements that can genuinely be read as **verifiable requests**. This point is decisive: without a clearly formulated information demand, PA can neither govern its relationship with the EO nor build a real chain linking need, delivery, and verification. The result is a demand that appears formally rich but remains substantively difficult to control.

A further limitation concerns the fragility of the **collaborative dimension** of the process. Many documents prescribe checks, clash detection, and controls, but do not explain with equal effectiveness how issues should be shared, traced, returned, and closed. Here again, a gap emerges between the presence of the theme and its translation into an operational device.

Taken together, these limitations converge towards the same conclusion: current CIs are often stronger on the level of formal and declarative elements than on that of operational and governing elements. The index, the glossary, the references to BIM, formats, or roles may all be present, but this does not yet imply that the document can support a real architecture of information demand. For this reason, the problem is not simply that something is missing; it is that what is there is not always structured in such a way as to become genuinely useful to PA.

6.6.2. A Structured Document, Yet One of Limited Usability

The critical point, therefore, is not merely the presence or absence of certain sections, but the fact that many CI, in their current state, **are formally structured yet of limited usability**. The issue is more serious than it may seem. In fact, the PA has demonstrated that it has adopted BIM terminology, often replicates its document structure, and is progressively adopting its standard sections, but it does not always succeed in transforming this framework into a tool truly capable of guiding decisions, deliverables, verifications, and updates. In many cases, the document identifies the fundamental issues but leaves them in a state that is still too abstract or in the hands of the design team. The categories are present, but they are not always translated into actions; the sections exist, but they do not clarify with sufficient precision who uses what, when, for which decision, and according to which acceptance criteria. The result is a document that appears orderly and comprehensive in terms of its editorial structure but remains weak in terms of its actual effectiveness as a governance tool.

This weakness has a very concrete consequence: when the EO must first formulate the **pre-contract BIM execution proposal** (pre-contract BEP, in Italy *offerta per la Gestione Informativa , oGI*) and then the **BIM execution plan** (BEP, in Italy *piano per la Gestione Informativa , pGI*), they often find themselves faced with a public demand that is unclear, only partially defined, or excessively unbalanced towards declarative elements. In such a scenario, the EO is forced to fill gaps, interpret intentions that have not been fully made explicit, and take decisions that should not be left to its discretion. **The problem, therefore, is that PA risks implicitly transferring to external actors strategic and managerial choices that should instead remain on the client side.**

It is here that a more fundamental critical issue emerges: in its attempt to absorb BIM, PA sometimes tends to prescribe a great deal without having fully matured the capacity to govern what it prescribes. This happens for different reasons. In some cases, because the document is built by **accumulation**, reusing formulas already seen elsewhere; in others, because the primary concern is to show that all the "correct" themes have been included; in still others, because the CI is treated as a **formal compliance document** rather than as an instrument for steering **information demand**. In all these cases, however, the result converges: the document grows in length and vocabulary, but not always in **operational precision**.

Therefore, if the public client is not able to formulate its own information demand clearly, then continuity between model, document, delivery, and management remains weak from the very beginning. The critical issue does not manifest itself only at the tender stage, but propagates downstream: in the definition of outputs, in checks, in delivery methods, in the construction of the Record Model, and in the very possibility of updating the system over time. In this sense, the CI is not a secondary or merely documentary problem, but one of the key points at which the real maturity of PA in the transition to a BIM-based process can be measured.

For this reason, the limitation of current CI cannot be addressed simply by calling for greater completeness or greater detail. The issue is not to ask for **"more text,"** but to construct a more rigorous logic. **PA can neither demand everything indiscriminately nor leave the EO full freedom on decisions that affect the governability of data.** What is needed, instead, is a device capable of helping the client formulate a demand that is **clearer, more selective, more verifiable, and more coherent with the aims of the phase**. It is precisely from this need that the necessity emerges to develop a drafting protocol for CIs, starting from a critical analysis of the documents themselves.

6.7. Comparative Analysis of Information Requirements and EIRs

If the previous section has shown why current **Information Requirements** often prove insufficient in terms of the real governability of public demand, the next step is to verify this critical issue through a comparative documentary analysis. In this research, indeed, the problem has not been addressed only in theoretical or regulatory terms, but through the construction of a reasoned corpus of documents, observed as a concrete expression of the way in which PA formulates, structures, and communicates its own information demand in the context of **BIM tenders**.

For this reason, the analysis was structured on two levels. The first concerns the mapping of the corpus and serves to define its scope, composition, and heterogeneity. The second is a proper **comparative matrix** of the CIs, constructed in order to bring out strengths, intermediate areas, and recurring weaknesses.

6.7.1. Corpus and Comparison Criteria

The main corpus of the research consists of 40 Italian *Capitolati Informativi* related to public tenders. These were selected to cover an intentionally heterogeneous set of cases, distributed over a broad time span and referring to very different phases, sectors, and types of intervention, as shown in Table 12 (the complete table is available in *Annex I*). The decision not to restrict the sample to a single type of procurement or to one specific sector stems from a precise need: to observe how the **CI** is used within the actual variety of **Italian public procurement**, rather than only within a particularly homogeneous or already "mature" subset.

Table 12 – Excerpt from the table of the 40 Information Requirements Documents (pt.1) considered in the analysis; the full table is provided in Annex I. [Author's elaboration]

Identification code	Institution	Work phase	Building Typology	Years	Cost
CI01_TO-CarcereMinorile	Ministero delle infrastrutture e dei trasporti - Provveditorato Interregionale OOPP Piemonte Valle d'Aosta e Liguria	PD - PE	Edilizia per la Sicurezza e Custodia	2023	174 016.42 €
CI02_RM-ASL03_GrassiOstia	Azienda Sanitaria Locale ROMA3	PFTE	Edilizia Sanitaria	2025	1 785 692.14 €
CI03-VE-ULSS3_AngelinoMestre	Azienda Sanitaria ULSS 3 Serenissima	PFTE	Edilizia Sanitaria	2025	2 427 152.73 €
CI04-GE-PolisportivoSciorba	Comune di Genova	PD - PE - ESE	Edilizia Sportiva	2023	6 255 888.57 €
CI05-RI-Biblioteca	Comune di Riete - Settore V LL.PP. - UFFICIO IMPIANTI SPORTIVI Ufficio Speciale Ricostruzione Lazio (USR Lazio)	PD - PE - ESE	Edilizia Culturale	2023	731 976.43 €
CI06-TO-ASL05-OspedaleCambiano	Azienda Sanitaria Locale - A.S.L. TO5	PFTE	Edilizia Sanitaria	2023	10 601 596.10 €
CI07-BO-Studentato	Alma Mater Studiorum – Università di Bologna	ESE	Edilizia Residenziale	2024	984 552.52 €
CI08-TA-PortoTaranto	Autorità del Sistema Portuale del Mar Ionio	ESE	Infrastrutture Portuali-Marittime	2023	2 711 011.11 €
CI09-PR-PonteNavetta	MINISTERO INFRASTRUTTURE E TRASPORTI – Provveditorato Interregionale OOPP Lombardia, Emilia Romagna	ESE	Infrastrutture per Mobilità e Accessibilità	2017	1 342 984.46 €
CI10-RM-LaSapienzaMedicina	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA	PD	Edilizia Accademica	2023	489 294.08 €
CI11-TO-RP_PortaMilano	*Regione Piemonte*	PFTE	Edilizia Culturale	2026	1 082 400.00 €
CI12-TO-RP_EdificiRegionali	SCR PIEMONTE SPA - per conto di *Regione Piemonte*	FM	Edilizia Amministrativa	2024	9 181 613.22 €
…	…	...	….	…	…

Alongside this corpus, the research also considered, in a preliminary phase, **20 foreign EIRs** (Table 13). Their examination served an exploratory purpose, useful for understanding how the issue of information requirements is approached beyond the Italian context. However, these documents were subsequently excluded from the main comparative analysis, as they were too generic and not fully comparable with the Italian regulatory, legal, procedural, and bureaucratic framework. The point is not that such EIRs are irrelevant in absolute terms, but that they operate within a different documentary culture, in which the level of detail, the structure of responsibilities, and the relationship between document and procedure do not coincide with the conditions within which Italian PA operates. For this reason, retaining them in the main corpus would have weakened the coherence of the comparison.

Table 13 – Corpus of Exchange Information Requirements (EIR) documents included in the study. [Author's elaboration]

Identification code	State	Institution	Title	Year	Typology
EIR_UK-LboroEstates	United Kingdom	Loughborough University	*Building Information Modelling (BIM) Employer's Information Requirements*	2017	Standalone
EIR_UK-UoMEstates	United Kingdom	University of Manchester	*Employers Information Requirements (where BIM has been agreed)*	2019	Standalone
EIR_PH-MMSP_CP106	Philippines	Metro Manila Subway Project – CP106	*BIM Employer's Information Requirement (Appendix 24 in Employer's Requirements)*	2019	Embedded
EIR_UK-HeritageTemplate	United Kingdom	Historic England	*BIM for Heritage Technical Guidance – Exchange Information Requirements template*	2019	Template
EIR_IE-IrishWater	Ireland	Irish Water / Uisce Éireann	*Information Management using BIM: Exchange Information Requirements (EIR)*	2020	Standalone
EIR_NZ-Watercare	New Zeland	Watercare	*Exchange Information Requirements (EIR)*	2020	Standalone
EIR_PL-BIMPLTemplate	Poland	Ministerstwo Rozwoju BIM dla polskiego budownictwa	*Szablon Wymagań BIM (EIR)*	2020	Template
EIR_PH-MMSP_CP102	Philippines	Metro Manila Subway Project – CP102	*BIM Employer Information Requirement (in bid bulletin)*	2021	Embedded
EIR_PH-MMSP_CP103	Philippines	Metro Manila Subway Project – CP103	*BIM Employer Information Requirement (in bid bulletin)*	2021	Embedded
EIR_PH-MMSP_CP104	Philippines	Metro Manila Subway Project – CP104	*Digital Engineering Employer's Information Requirements (Appendix 8 in bid documents)*	2021	Embedded
EIR_HK-CICTemplate	China	Construction Industry Council (Hong Kong)	*CIC BIM Exchange Information Requirements (EIR) Template (BIM Specifications)*	2021	Template
EIR_UK-UCLEstates	United Kingdom	UCL Estates	*Employer's Information Requirements*	2022	Standalone
EIR_ES-EMVSMadrid	Spain	EMVS Madrid	*BIM-EIR Employer Information Requirements / Requisitos de Información BIM*	2023	Standalone
EIR_RB-RailBaltica	Baltic State	RB Rail	*Building Information Management (BIM) Employer's Information Requirements*	2023	Standalone
EIR_IN-BSRP_C2Stations	India	K-RIDE – Bengaluru Suburban Rail Project C2 Stations	*Employer's Requirements con sezione BIM EIR*	2023	Embedded
EIR_AU-TMRRoads	Australia	Queensland Department of Transport and Main Roads	*Exchange Information Requirements (EIR)*	2024	Standalone
EIR_CA-Metrolinx	Canada	Metrolinx	*Metrolinx Exchange Information Requirements (BIM)*	2025	Standalone
EIR_UK-DfESchemes	United Kingdom	Department for Education	*Exchange Information Requirements*	2026	Standalone
EIR_UK-DoFNI_Template	United Kingdom	Department of Finance Northern Ireland	*Employer's Information Requirements BIM Template*	n.v.	Template
EIR_PE-PlanBIMPeru	Peru	Ministerio de Economía y Finanzas – Plan BIM Perú	*Formato EIR (Anexo E)*	n.v.	Template

Table 12 therefore plays a preliminary role: it is intended to illustrate the structural heterogeneity of the corpus. Indeed, the dataset "speaks", but not with a single voice. It includes tenders concerning design, construction, management, specialist services, major works, healthcare facilities, cultural buildings, schools, administrative buildings, mobility infrastructures, port works, and other types of intervention. This diversity makes the corpus particularly valuable, but it also requires caution in interpretation. It should not be understood as a closed statistical universe or as a perfectly homogeneous series. Rather, it is a documentary set that reflects the actual variety of Italian public procurement in the field of digital information requirements.

From the point of view of **work phases**, for example, the dataset shows a complex composition. If one looks at the combinations as they appear in the documents, the most frequent configurations (Figure 63) are PFTE with **12 cases** (**30.0%**), ESE with **9 cases** (**22.5**%), PD–PE–ESE with **4 cases** (**10.0%**), and PFTE–PE–ESE with **3 cases** (**7.5%**). However, when these configurations are broken down into their individual stages, the picture becomes clearer (Figure 62): ESE appears in **21 tenders** (**52.5%**), PFTE in **19** (**47.5%**), PE in **14** (**35.0%**), PD in **8** (**20.0%**), FM in **3 (7.5%)**, and RIL in **1** (**2.5%**). This suggests two observations. The first is that the sample is strongly oriented towards two poles: the **initial/strategic moment (PFTE)** and the **implementation/executive moment (ESE)**.

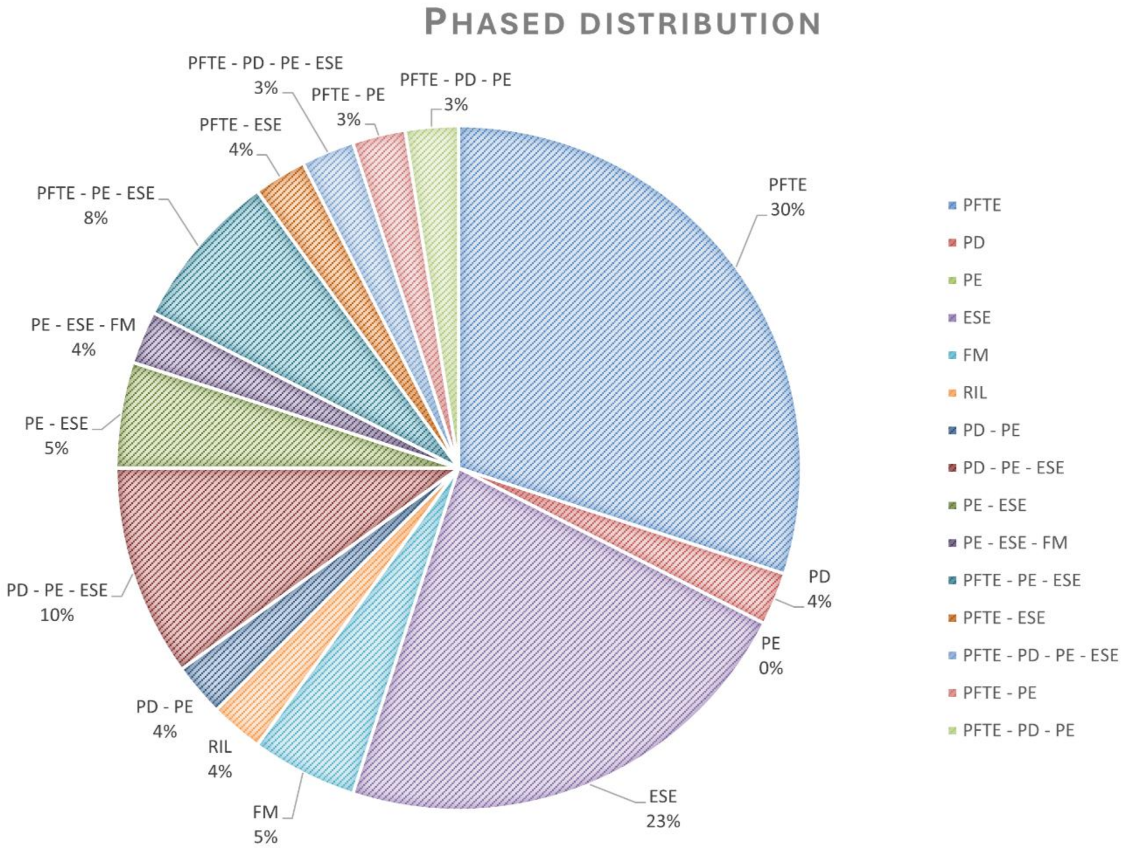


Figure 63 – Distribution of work-phase configurations in the analysed CI corpus. [Author's elaboration]

This observation is reinforced by the presence of a non-negligible share of **multi-phase procurements**. Out of **40 cases**, indeed, **25 tenders** (**62.5%**) present a single phase, while **15** (**37.5%**) articulate the appointment across multiple phases. This is important because it shows that over a third of the sample does not describe isolated services, but rather contractual arrangements that connect different moments of the process. From an analytical point of view, this means that the dataset does not merely tell us "*how many PFTE tenders*" or "*how many executive tenders*" there are, but also how public clients choose to **fragment, concatenate, or integrate control over the process**.

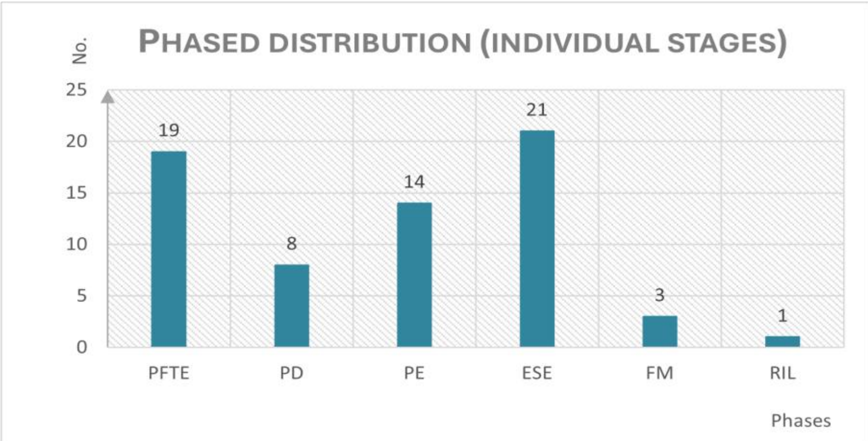


Figure 64 – Distribution of individual work phases after disaggregating combined phase configurations. [Author's elaboration]

A similar caution is also necessary with regard to **building typology**. The frequencies show a broad and diversified corpus: **healthcare buildings** (6 cases; 15.0%), **cultural buildings** (5; 12.5%), **security and custody buildings, academic buildings, administrative buildings, historic buildings, and mobility/accessibility infrastructures** (4 cases each; 10.0%). However, these categories do not all belong to the same logical level. Some define a **function** (healthcare, school, administrative), others a **heritage quality** (historic), and still others describe more the type of intervention or the infrastructural family than a true building typology.

The economic data also confirm this interpretation. The overall value of the sample amounts to **€962,309,796.01**, with an average of **€24,057,744.90** but a much lower median, equal to **€1,892,846.07**. The gap between these two values shows a **strongly asymmetric distribution**, in which a few cases pull the total upward: the highest single record alone accounts for **49.0%** of the total; the top three cases reach **76.5%**; the top five **84.3%**; and the top ten **92.2%** of the overall value. It is therefore clear that **Cost** cannot be read as a uniform and immediately comparable measure, since the corpus includes hospital concessions, FM services, design verifications, PFTE services, competitions, and major infrastructures, that is, very different contractual economies.

From a temporal point of view, the corpus is strongly skewed towards the present: documents dated **2023–2025** amount to **29 out of 40**, equal to **72.5%** of the total. This allows us to say that the sample mainly reflects the most recent phase of the diffusion of BIM in public tenders, but it does not justify reading it as a true **historical series of the national market**.

Overall, Table 12 – Parts 1 and 2 in *Annex I* – therefore makes it possible to define the scope of the corpus, while also immediately highlighting its structurally heterogeneous documentary nature. In this sense, the table helps to capture the complexity and tensions of the Italian context. For this reason, the discussion of the main findings is developed as a critical analysis of the documentary quality and maturity of the CIs.

6.7.2. Main Findings

Table 14 and Table 15, reported in excerpt form in the main text and provided in full in *Annex II*, Parts 1 and 2, constitutes the analytical core of the research. It enables the 40 CIs to be examined comparatively through a set of variables concerning document structure, content, regulatory references, data management, information exchanges, and the degree of maturity of public information demand.

Table 14 – Excerpt from the comparative matrix of the analyzed CI part.1: structure, information exchanges, checks, and qualitative score. [Author's elaboration]

Identification code	Summary	Glossary	oGI pGI	IDP Milestone	IFC	Native formats	Checking	Security	RACI	BCF	I. R. indication	Score
CI01_TO-CarcereMinorile	✓	✓	—	✓	—	—	✓	✓	x	x	x	3
CI02_RM-ASL03_GrassiOstia	✓	✓	—	x	✓	✓	✓	—	x	✓	x	2
CI03-VE-ULSS3_AngelinoMestre	x	✓	—	x	✓	✓	—	—	x	x	x	2
CI04-GE-PolisportivoSciorba	✓	✓	—	x	—	—	—	—	x	x	x	1
CI05-RI-Biblioteca	✓	✓	—	x	✓	✓	✓	—	x	x	—	0
CI06-TO-ASL05-OspedaleCambiano	✓	✓	✓	x	✓	✓	✓	—	x	x	—	3
CI07-BO-Studentato	✓	✓	✓	✓	✓	✓	✓	—	✓	✓	✓	4
CI08-TA-PortoTaranto	✓	✓	—	x	✓	✓	✓	—	x	x	x	3
CI09-PR-PonteNavetta	✓	✓	✓	x	✓	✓	✓	✓	✓	x	x	4
…	…	…	…	…	…	…	…	…	…	…	…	…

Table 15 – Excerpt from the comparative matrix of the analyzed CI part.2: technical, managerial, and data-governance requirements. [Author's elaboration]

Identification code	Pages	LOIN - LOD	Naming	Delivery format	CDE	Work scheme	Roles	Data ownershp	File size
CI01_TO-CarcereMinorile	38	Specific LOD	Omniclass	Digital + hard copy	Managed by the EO	Discipline-based coordination	Roles under UNI 11337-7	Explicitly assigned to the CA	300 MB
CI02_RM-ASL03_GrassiOstia	19	Not specified	Uniclass	Not specified	Not specified	Discipline-based coordination	Roles under UNI 11337-7	Not specified	Not specified
CI03-VE-ULSS3_AngelinoMestre	16	Specific LOD	Specific coding	Digital	Managed by the EO	Discipline-based coordination	Not specified	Not specified	150 MB
CI04-GE-PolisportivoSciorba	15	LOD according to project phase	Not specified	Hard copy + PDF/A	Managed by the EO	Not specified	Roles under UNI 11337-7	Explicitly assigned to the CA	Not specified
CI05-RI-Biblioteca	13	Specific LOD	Not specified	Digital + hard copy	Not specified	Not specified	Not specified	Not specified	500 MB
CI06-TO-ASL05-OspedaleCambiano	37	LOD according to project phase	Specific coding	Hard copy + PDF/A	Not specified	Discipline-based coordination	Roles under UNI 11337-7 + BIM certification (PdR 28:2020)	Explicitly assigned to the CA	500 MB
CI07-BO-Studentato	37	LOIN approach	Specific coding	Digital + hard copy	Internal to the CA	Discipline-based coordination	Roles under UNI 11337-7	Explicitly assigned to the CA	400 MB
CI08-TA-PortoTaranto	21	LOD according to project phase	Uniclass	Digital + hard copy	Internal to the CA	Discipline-based coordination	Roles under UNI 11337-7	Explicitly assigned to the CA	Not specified
CI09-PR-PonteNavetta	31	LOD according to project phase	Specific coding	Digital + PDF/A	Managed by the EO	Discipline-based coordination	Roles under UNI 11337-7	Explicitly assigned to the CA	Not specified
…	…	…	…	…	…	…	…	…	…

A first group of findings concerns the **strong elements** of the corpus, that is, those dimensions in which the CIs now show a certain degree of stability. At the editorial level, almost all documents include an **index** (38 cases; 95.0%) and a **glossary** (37; 92.5%), which suggests that the minimum documentary form of **the CI is now well** consolidated. Similarly, the **IFC + native format** pair is almost structural: the request for IFC appears in 38 cases (95.0%), and that for native formats in 37 (92.5%). The theme of **verification / clash / LC** also shows a high presence (35 cases; 87.5%), as does the definition of roles with reference, in whatever form, to **UNI 11337-7** (35 cases; 87.5%). To this may be added a significant figure concerning **data ownership**, explicitly attributed to the CA in 31 cases (77.5%). These percentages indicate that, at the level of formal and declarative elements, and of the major BIM categories, the corpus shows a relatively high threshold of maturity.

A second group of findings concerns intermediate elements, that is, contents that appear to a non-marginal extent but are not yet fully consolidated. This is the case of **oGI/pGI/BEP**, present in 23 cases (57.5%); of information uses and, more generally, of the presence of actual Information Requirements, explicitly stated or referred to in a dedicated document, in 22 cases (55.0%); of **security** (22; 55.0%); and of the logic of **LOD by phase** (22; 55.0%). These figures show that many documents are beginning to translate BIM demand into **process organization**, but are still doing so in a partial, non-uniform way and not always coherently with a logic of full **controllability**. In other words, the presence of the theme does not yet automatically coincide with its full **operational maturity**.

The third group, and the most important from a critical point of view, concerns the **weak elements**, namely those that should indicate a more advanced degree of operational, collaborative, and lifecycle-oriented governance of information demand. Here, the figures are very clear. **IDPs/milestones** are present in only 12 cases (30.0%); **BCF** appears in 10 cases (25.0%); a **RACI logic** appears in only 7 cases (17.5%); the **LOIN approach** in 7 cases (17.5%); and the **CDE platform** is explicitly identified in only 5 cases overall (12.5%), whereas in the remaining documents the theme of the **CDE** is invoked but not translated into a precise technological infrastructure.

Finally, at the end of the analysis, each document was assigned a qualitative **score** from 0 to 5 (Table 16). This score was not conceived as a strictly mathematical value, but as a synthetic interpretative assessment based on the critical reading of each CI. It takes into account the degree of completeness of the document, its internal coherence, and the clarity of its overall structure and operational setting. In this sense, the score helps to compare the documents not only in terms of the presence or absence of specific sections, but also in terms of their actual capacity to organize a clear, consistent, and usable information demand.

Table 16 – Qualitative scoring scale used to assess the documentary maturity of the analysed CIs. [Author's elaborations]

SCORE	QUALITATIVE INTERPRETATION	DESCRIPTION
0	Not assessable / absent	The document does not provide relevant information, or cannot be effectively considered a usable CI.
1	Very weak	The CI is largely generic, poorly structured, and provides limited support for information governance.
2	Partially structured	The document includes some relevant sections, but with significant gaps in completeness, coherence, or operational clarity.
3	Intermediate	The CI is sufficiently structured and covers several key aspects, but remains limited in terms of depth, consistency, or usability.
4	Well structured	The document is generally complete, coherent, and clearly organized, although some aspects could be further specified or made more operational.
5	Highly mature	The CI is complete, internally coherent, well structured, and capable of clearly guiding requirements, deliverables, responsibilities, checks, and information exchanges.

From a synthetic point of view, the distribution of scores shows a corpus that is on average intermediate but still includes a significant share of weak documents. In detail: 1 case falls into **band 0** (2.5%), **5 cases** into **band 1** (12.5%), **10 cases** into **band 2** (25.0%), 10 cases into **band 3** (25.0%), 11 cases into **band 4** (27.5%), and only 3 cases reach **score 5** (7.5%). Aggregating the data, the **low-band documents** (0–2) amount to **16** (40.0%), the **medium-band documents** (3) to 10 (25.0%), and the **high-band documents** (4–5) to 14 (35.0%). The average is **2.85/5**, with a median of **3/5**. This means that the corpus, taken as a whole, is neither poor nor immature in absolute terms, but neither can it be considered fully mature: rather, it expresses a transitional condition, in which rather well-structured documents coexist with documents that remain partial or weak.

This percentage-based reading reveals an extremely clear structure of the corpus. The CIs are generally **strong** on the **formal and declarative elements of BIM** – index, glossary, IFC, native formats, roles, coordination, verification—i**ntermediate** on those elements that begin to transform BIM into process organization – oGI, security, Information Requirements, LOD by phase – and still **weak** on the more mature elements of operational, collaborative, and operation-oriented governance – milestones, RACI, BCF, CDE platform, LOIN, FM. This tripartition is not merely descriptive: it shows that Italian PA has become relatively capable of prescribing BIM, but not yet equally capable of turning it into a truly governed information demand.

This argument must, however, be further refined in light of the **building typology** and the nature of the cases analyzed. Not all **CIs** can be read as if they belonged to the same context. In Italy, indeed, the degree of detail and certain prescriptions also depend on the sector: a healthcare intervention, a major mobility infrastructure, a historic building, or an FM service do not require exactly the same documentary articulation. This means that part of the differences does not depend solely on the editorial quality of the document, but also on the specificity of the administrative object to which it refers. Yet this observation actually reinforces the underlying problem: if the CI must adapt to different cases, it cannot do so in a casual or implicit way, but should be constructed according to a logic consciously related to phase, sector, intervention type, and objective.

It is at this level that the critique takes on a broader meaning. Public Administration, precisely because it is strongly bureaucratic, often succeeds in producing documents that are formally ordered and rich in prescriptions; however, this very tendency may produce a paradoxical effect: the level of prescription grows, but the capacity to manage it does not always grow at the same pace. In some cases, the document appears as the outcome of a process of **adaptation** or **accumulation of references**; in others, as a device that "copies" the form of BIM without having fully matured its logic. The result is that the public client prescribes a great deal, but does not always yet know exactly **what it wants, why it wants it, and how it intends to verify it**.

Ultimately, the main finding emerging from the analysis is that the examined *Capitolati Informativi* are, in most cases, no longer embryonic or unstructured documents. At the same time, however, they cannot yet be considered fully mature instruments for governing public information demand. They occupy an intermediate stage: BIM is now widely present as a language, as a documentary framework, and as a prescriptive apparatus, but it does not always translate into an operational architecture capable of ensuring continuity between phases, decisions, deliverables, checks, and use in operation.

It is precisely from this diagnosis that the next step of the chapter emerges: the need to move beyond critique alone and propose a drafting protocol capable of supporting Public Administrations in producing Information Requirements Documents that are clearer, more selective, more verifiable, and ultimately more governable.

6.8. From the operational analysis to the proposal of a CI prototype

The evidence emerging from the analysis of the corpus shows quite clearly that the problem of *Capitolati Informativi* does not concern only the presence or absence of specific sections, but rather their capacity to become a device genuinely able to govern public information demand. The proposed CI prototype is situated precisely within this gap: the gap between a document that is formally correct and a document that is actually operational. This proposal also stems from the intention to take up the logic of UNI 11337 and make it more governable, more readable, and more useful for Public Administration, by offering a more explicit and more controllable translation of that logic in the drafting of the CI.

The nature of the proposal is deliberately hybrid. On the one hand, it relies on the regulatory structure and on established references; on the other, it also takes the form of an operational tool – checklist – capable of helping those who draft the CI not to overlook essential elements, not to become lost in documentary proliferation, and not to improperly delegate to the Economic Operator decisions that should instead be clarified by the client. In this sense, the protocol is not conceived as a rigid formula or as a model to be applied mechanically, but as a supporting structure that helps bring the CI back to its primary function: to express a clear, selective, verifiable information demand, coherent with the phase, the objective, and the intended use of the data.

The operational analysis therefore leads to the identification of **seven fundamental cores** – phase, information uses, roles and responsibilities, information exchanges, verifiable requirements, CDE, and data ownership – which constitute the essential points around which a truly governable CI can be built. These cores, however, should not be understood as isolated sections or as a simple list of requirements to be fulfilled, but as interdependent components of the same information governance architecture. The point, in fact, is not to add further prescriptions, but to construct a CI in which phase, objective, request, deliverable, verification, update, and responsibility for data are clearly connected and mutually coherent.

On this basis, the proposal takes on a more concrete form: that of a **prototype *Capitolato Informativo*** designed for PA and developed with particular reference to the case of *Regione Piemonte.* Its objective is not to build a new documentary framework as an alternative to UNI 11337-6, nor to superimpose an additional regulatory grid onto those already in place, but rather to offer a possible operational translation of its structure, making it more explicit, more selective, and less exposed to the risks identified through the comparative analysis: genericity, documentary proliferation, and the omission of essential content.

From this perspective, the prototype is intended as an **operational support** for both drafting and reading the CI. On the one hand, it helps the Contracting Authority organize its information demand in a clearer and more controllable way; on the other, it helps the Economic Operator identify more immediately the elements that are truly relevant within the document. For this reason, it takes the form of a document structured through sections, tables, summary frameworks, and checklists.

6.8.1. The fundamental cores of the protocol

To make this logic more explicit, the proposed protocol is based on seven cores that represent the essential points around which an effectively governable *Capitolato Informativo* can be built. Their relevance does not lie simply in their presence within the document, but in the way they are able to connect the process, the information demand, and the conditions for its verification. If considered in isolation, they risk being reduced to a list of topics to be addressed; if read through their mutual relationships, however, they define the structure through which the CI gains coherence and the capacity to guide the process. From this perspective, phase, uses, roles, information exchanges, verifiable requirements, CDE, and data ownership are the points through which the client can clarify what is being requested, at which moment in the process, for what purpose, through which responsibilities, and according to which control criteria.

The first step of the protocol consists in defining the phase, and this is neither a marginal nor a merely introductory element. On the contrary, it is one of the most delicate points, because the phase determines the nature of the requirements, the expected level of detail, the type of deliverables, the depth of verification, and, ultimately, the overall coherence of the CI. For this reason, the reference to the target phases of UNI 11337 should be understood as an ordering principle for the document, not as a simple formal label.

Table 17 – Fundamental cores of the CI drafting protocol. [Author's elaboration]

Core	Function	Effect on the CI
Definition of the phase	To specify the stage and phase of the construction information process in which the CI applies	Makes requirements, information level, deliverables, uses, and checks coherent with the declared phase
Information uses	To clarify the decisions, activities, or controls for which the information is required	Links data to an actual use and reduces merely nominal uses
Roles and responsibilities	To clarify who produces, checks, accepts, updates, and uses the information	Strengthens process governability and reduces organizational ambiguity
Information exchanges	To define milestones, containers, formats, expected contents, verification criteria, and evidence	Turns delivery into a structured and controllable information step
Verifiable requirements	To make explicit what must be checked, when, and through which evidence	Improves the precision of the demand and the controllability of requirements
CDE	To define the regulated environment in which data are shared, managed, approved, and traced	Ensures continuity, versioning, workflows, permissions, and audit trail
Data ownership	make explicit title, availability, reuse, and control over the information patrimony	Strengthens the CA’s control over data and models and reduces dependence on external actors

The first core concerns the **definition of the phase**, which acts as one of the main filters of governability within the document. Here, the phase is not intended to provide a generic introduction to the context, but to establish the stage and moment of the construction information process in which the CI applies. This positioning determines the nature of the requirements, the expected level of detail, the type of deliverables, the depth of verification, and, ultimately, the overall coherence of the document.

For this reason, the reference to the target phases of **UNI 11337** (Figure 65) should be used as an ordering criterion for the CI, rather than as a simple opening label. A CI oriented towards O&M, for example, requires a profoundly different structure from one referring to the **Technological Design** phase: the uses of data change, the required outputs change, the checks change, and the expected relationships between model, documents, and management platforms change as well.

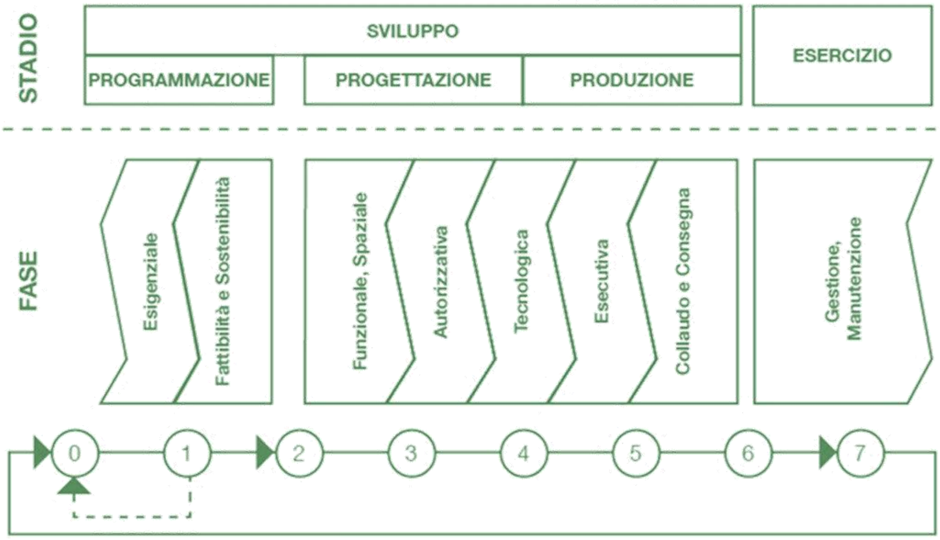


Figure 65 – UNI 11337 target phases used as an ordering criterion for the definition of Information Requirements. [source: adapted from UNI 11337 series; Author's elaboration]

Alongside the phase, the protocol assigns a central role to **information uses**, since this is precisely where many CIs reveal a recurring weakness. Information uses often appear as formally correct expressions within BIM terminology, yet they are not always firmly connected to a concrete decision or action. The protocol therefore suggests a more demanding formulation: each use should be described as an explicit relationship between actor, decision, control, and expected output. This clarification has important organizational implications, because it makes more legible who is expected to produce the information, who is expected to verify it, and who is expected to use it in practice.

This issue is closely connected to **roles and responsibilities**. Here too, the point is not simply to name BIM roles or to refer formally to **UNI 11337-7**, but to clarify who does what within the information demand. In many of the documents analyzed, roles are present at a declarative level, while actual responsibilities remain weakly defined. For Public Administration, this is a particularly sensitive issue, because clarity cannot concern only the Economic Operator: the internal organization of the Contracting Authority also needs to be made more explicit, especially with regard to who oversees the demand, who verifies, who accepts, who updates, and who uses the data over time. In this sense, the reference to the **OIR**, or more broadly to the organizational act of the client, helps situate the CI within a wider administrative framework. The relationship between certification and competence also deserves some caution. Formal qualifications may have a role, but they can hardly replace, on their own, a more substantive assessment of the experience, knowledge, and capabilities actually required by the process.

The same need for clarity becomes even more concrete in the case of **information exchanges**. This is the point at which the relationship between phase, content, control, and acceptance takes operational form. Many documents refer to deliverables and outputs, yet often without fully building the chain that links phase, use, delivery, verification, and evidence. The protocol therefore treats each exchange as a structured information step and suggests clarifying, at a minimum, the reference milestone, the container, the required format, the expected content, the verification criterion, and the evidence that allows acceptance. Within this same logic, the **Specialist Modelling Report** becomes particularly relevant, since, together with the model, it can provide the Contracting Authority with a key support for verification.

This leads directly to the issue of **verifiable requirements**, which is perhaps the most operational core of the entire protocol. A requirement becomes meaningful when it places the client in a position to understand what has to be checked, at which moment, and through which evidence. From this point of view, overly generic formulations – such as requesting a "complete" model or a "guaranteed" level of quality – offer only an apparent point of reference, because they do not clarify the object of the check or the criterion through which it should be assessed. The protocol therefore proposes a minimum structure composed of an identifier, a priority, a required action, an object, a phase or milestone, a verification criterion, and an expected piece of evidence. This does not necessarily make the CI rigid; rather, it helps make the transition from information need to control more legible.

A particularly sensitive role is played by the **CDE**. For a Public Administration, the data-sharing environment can hardly be considered an accessory issue or a merely technical option. The CDE affects information continuity because it governs document states, workflows, permissions, versioning, and audit trails. Although, in a transitional phase, some responsibilities may still be entrusted externally, in the medium to long term the availability of an internally controlled and regulated environment appears increasingly to be a condition of maturity for the client. This question is closely tied to the even more delicate issue of **data ownership**. Within the perspective adopted in this thesis, the data and models produced in a public process should remain under the control of the Contracting Authority, also in order to preserve reuse capacity, information continuity, and strategic autonomy. Making this point explicit within the protocol helps prevent it from remaining implicit or dispersed among other prescriptions.

Taken together, these seven cores do not add unnecessary complexity to the *Capitolato Informativo*. Their value becomes clearer when they are understood as parts of the same structure, capable of connecting phase, use, responsibility, delivery, verification, management environment, and data governance. In this continuity, the CI begins to move away from the logic of juxtaposed requests and becomes more capable of functioning as a real instrument of public clientship.

6.8.2. Structure of the CI prototype

The prototype developed in this research is not intended to replace **UNI 11337-6**, nor to construct a documentary framework alternative to the one provided by the current regulatory context. Its purpose is rather to offer a more governable translation of the standard in terms of the drafting of the *Capitolato Informativo,* making it clearer how the contents required by the regulation can be selected, organized, and articulated according to the phase, the objective, the type of intervention, and the reference sector. In this sense, the value of the prototype does not lie in adding further chapters or prescriptions, but in showing how the normative structure can be used in a more explicit, coherent, and controllable way.

From this perspective, **UNI 11337-6** acts as the ordering matrix of the document, while the proposed protocol guides its interpretation and use. The prototype is therefore organized into three main blocks (Figure 66) – **common core**, **technical section**, and **management section** – which make it possible to distribute the contents of the CI more clearly and to connect them more explicitly to the fundamental cores discussed above. This articulation preserves close adherence to the normative framework, while strengthening its operational function: it helps those who draft the CI avoid dispersing essential information, and it helps those who read it identify more immediately what is actually required.

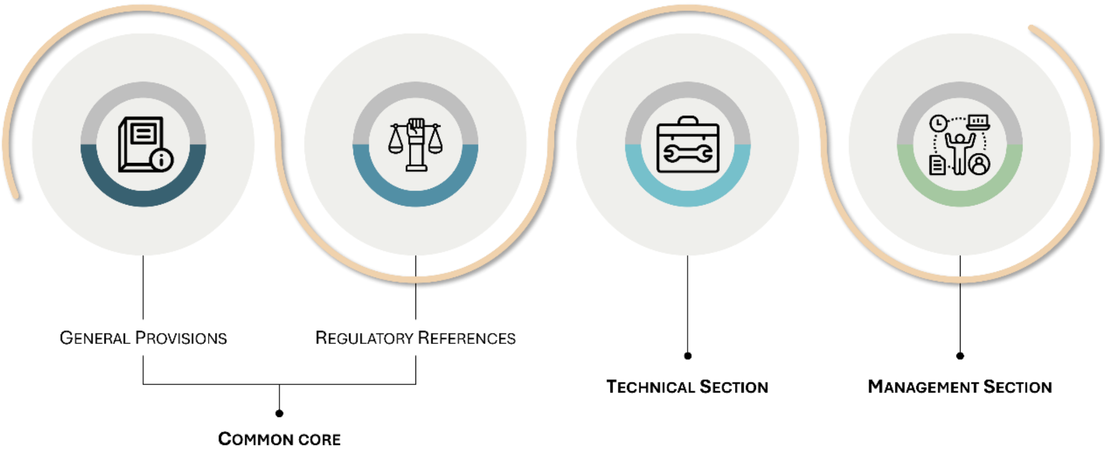


Figure 66 – Schematic representation of the structure of the CI prototype. [Autor's elaboration]

The first block is the **common core**, which brings together the introductory information, the contextual framing of the document, and the relevant legal and regulatory framework. It includes the identification of the CI, the identification of the project or intervention, the introduction, the purpose of the document, the reference phase, the type of intervention, the location, the glossary, and the The first block is the **c**ommon core, which gathers the introductory information, the contextual framing of the document, and the relevant legal and regulatory references. It includes the identification of the CI, the identification of the project or intervention, the introduction, the purpose of the document, the reference phase, the type of intervention, the location, the glossary, and the regulatory framework.

The role of this block goes beyond a simple formal opening. It acts as the first orientation device of the document, since it clarifies from the outset which process the CI refers to, what kind of information demand it is intended to construct, and within which application context the subsequent contents should be read.

For this reason, in the prototype the common core is reinforced by an initial summary framework, designed to condense the main data of the document into tabular form and to make its purpose, focus, required information basis, supported processes, and data ownership immediately readable.

The second block is the **technical section**, which is the part of the document where the client defines the technical requirements of the information management system. This section (Figure 67) includes contents related to hardware and software infrastructure, interoperability conditions, delivery formats, the structure of the **CDE**, naming and coding criteria, information parameters, the possible logic of model federation, reference systems, the technical organization of data, and the requirements for technical and informational verification.

The technical section, therefore, should not be understood as a generic "more BIM-oriented" part of the CI, but as the framework within which data must be produced, exchanged, checked, and kept coherent. In the prototype, this section takes a strongly structured form, also through summary tables, in order to make the minimum requirements more readable and to reduce the risk of omissions or excessively generic formulations.

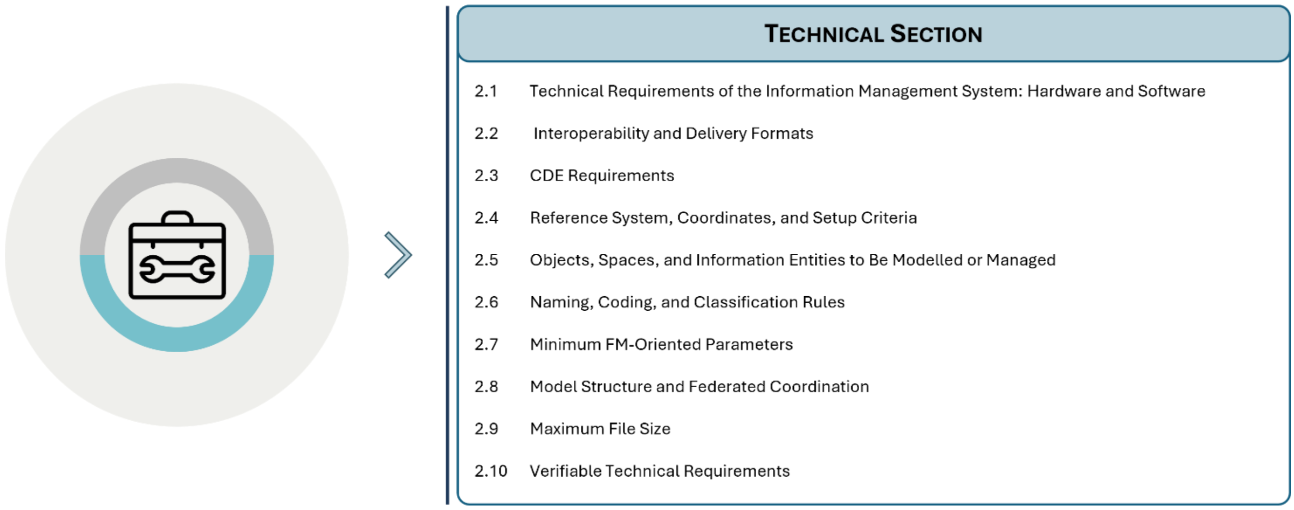


Figure 67 – Schematic representation of the contents of the technical section of the CI prototype. [Author's elaboration]

The third block is the **management section**, which assumes a particularly important role in the prototype, especially in light of the thesis's BIM–FM orientation.

This is the part of the document where it becomes clear why information is required, by whom it will be used, in support of which decisions, through which exchanges, and according to which verification and acceptance criteria. It includes information objectives, model and data uses, roles and responsibilities, the **RACI** matrix, information exchanges, deliverables, the **IDP**, verification criteria, non-conformity management, updating rules, and, in the specific case of the prototype developed here, the relationship between the model, the Record Model, registers, and the FM platform.

The management section is therefore the point at which the CI begins to function less as a container of BIM-related topics and more as a document capable of clarifying the relationship between phase, use, requirement, delivery, verification, and update (Figure 68).

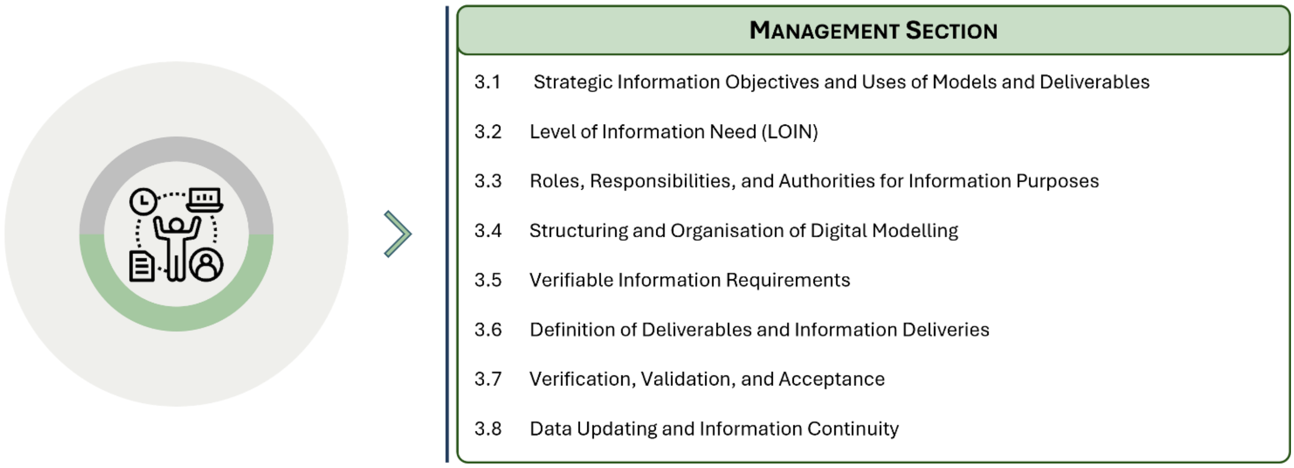


Figure 68 – Schematic representation of the contents of the management section of the CI prototype. [Author's elaboraion]

The transition from protocol to prototype lies precisely in this articulation. The protocol identifies the logic through which the document should be constructed and the cores that should not be overlooked; the prototype, in turn, represents one possible documentary translation of that logic, organized so as to support both the drafting and the reading of the CI within a public client organization. From this point of view, the reference to **UNI 11337-6** is not weakened, but made more operational: the standard continues to provide the ordering framework, while the prototype helps transform it into a structure that is more readable, more selective, and more easily governable.

On this basis, the **prototype *Capitolato Informativo*** included in the annex was developed. It represents one possible documentary translation of the proposed protocol and makes its application explicit in the form of a single document organized into a **common core**, a **technical section**, and a **management section** *(see Annex III)*.

6.8.3. Modularity, tables, and operational checklists

One of the qualifying elements of the proposal lies in its **modularity**. The prototype is not conceived as a document to be reproduced identically in every circumstance, nor as a fragmented system made up of multiple texts, annexes, and autonomous cross-references. Its aim is instead to construct a single document, based on a stable core and a recognizable structure, while still being capable of adapting in a controlled way to the specific conditions of the intervention. In this sense, modularity does not mean unrestricted freedom to add or remove contents, but rather a criterion for calibrating the CI according to the phase, the objective, and the application context.

In the proposed prototype, this adaptability is mainly based on three variables: **phase**, **type of intervention**, and **sector or building typology**. The phase affects the type of information required, the expected level of detail, the nature of the deliverables, and the system of checks. The type of intervention influences the structure of the requests, the relative weight of the technical components, and the relationship between survey, representation, updating, and management. The sector or building typology, in turn, affects the specificity of the contents, the degree of prescription, and the most relevant uses of the model. From this perspective, modularity helps reduce two opposite but equally problematic risks: on the one hand, excessive genericity, which makes the document only weakly operative; on the other, documentary proliferation, which makes the CI more difficult to read, interpret, and govern. This same logic also explains the decision to structure the prototype through **tables**, **summary frameworks**, **matrices**, and a **final verification checklist**. These devices are not introduced as a merely graphic expedient or as a formal burden added to the document. Their function is more substantive: they help make the information demand more legible and its drafting more controllable. The initial tables, for example, condense the essential data of the CI and clarify at once its focus, objectives, required information basis, and data ownership. Matrices help make explicit relationships that often remain partially implicit in continuous prose, such as those between roles, responsibilities, uses, deliverables, and checks. The final checklist, in turn, acts as a drafting support, helping the author of the document verify that the fundamental contents have actually been addressed and that no significant omissions or inconsistencies remain.

In this sense, the prototype is designed to be readable in **two directions**. On the one hand, it supports the **Contracting Authority** in drafting the CI, helping it avoid omissions, limit generic formulations, and retain control over decisions that should remain within the sphere of the client. On the other hand, it also supports the **Economic Operator** in reading the document, because it makes the main requirements, levels of responsibility, expected deliverables, verification points, and acceptance criteria more immediately identifiable. The tabular and modular structure, therefore, does not simply simplify the document; rather, it makes its internal logic more transparent.

The **checklis**t, in particular, performs a role that goes beyond that of a simple drafting reminder. It condenses, in a more concise form, the same logic that underpins the protocol: helping Public Administration construct a *Capitolato Informativo* that is less implicit, less dispersed, and more effectively governable. In this sense, the checklist does not merely verify the presence of sections; it draws attention to the points that more directly affect the substantive quality of the document, such as the coherence between phase and requirements, the clarity of information uses, the distribution of responsibilities, the legibility of information exchanges, the verifiability of requirements, the governance of the CDE, and the explicit treatment of data ownership.

6.8.4 The prototype as an operational support

Considered as a whole, the proposed prototype should not be read as a rigid model to be applied mechanically, nor as a merely formal exercise developed alongside the thesis. It represents, rather, the operational translation of the logic developed in the previous sections: a support for both drafting and reading the *Capitolato Informativo*, designed to help Public Administration structure its information demand more consciously and, at the same time, to allow the Economic Operator to identify the essential elements of the document more clearly.

The modularity of the prototype is therefore not only a formal property of the document, but one of the conditions of its effectiveness. It makes it possible to preserve a common, recognisable, and stable core, while calibrating the CI to the actual needs of the specific case, without reducing it either to a rigid grid or to an indistinct sequence of prescriptions. A significant part of the prototype's operational value lies precisely in this ability to hold together stability and adaptation, synthesis and control.

From this point of view, the annex to the thesis should not be understood as an exhaustive scheme, nor as a model that can be directly transferred to every context. It should instead be read as one possible formalization of the proposed protocol, developed to show how the principles discussed in the chapter may be translated into a documentary structure that is more readable, more selective, and more governable. Its value lies above all in making explicit one possible way of constructing the CI, capable of linking phase, uses, responsibilities, exchanges, requirements, checks, and data governance more clearly.

6.9. From Processes to the CI: Towards BIM–FM Continuity

The path developed in this chapter has made it possible to connect levels that, in the transition towards BIM–FM in the public sector, often tend to remain separate: the level of processes, the level of organizational responsibilities, and the level of documentary formalization of information demand. Read together, these levels show that continuity does not depend only on the availability of data, but on the way in which data are requested, structured, verified, accepted, and updated over time. In this sense, the chapter has not treated processes and documents as parallel themes, but as two forms through which the CA either builds, or fails to build, the conditions for making BIM genuinely useful for management.

On the one hand, the reinterpretation of the public construction process from an FM perspective has shown that information loss does not correspond to a single point of rupture, but accumulates progressively throughout the life cycle, becoming particularly evident in the transition between handover and the start of operation.

The so-called *handover gap* has therefore emerged not as a simple lack of documents, but as the effect of a broader weakness in governance: unstable rules, inconsistent coding systems, fragile relationships between physical assets and information objects, discontinuous archiving, weak updating procedures, and limited oversight of the transition from one phase to another. On this basis, the shift from **as-is** to **as-FM** has shown that information continuity can only be strengthened when processes are redesigned in a model-driven form, oriented towards the Record Model, and structured in such a way as to make requests, procedures, work orders, evidence, and updates readable and traceable.

Two further outcomes of the chapter move in the same direction. The first concerns the proposal of the ***Digital Information Continuity Officer*** (DICO), understood as an overseeing function capable of holding together actors, environments, documentary states, checks, and updates, preventing data from remaining correct only locally while losing coherence in the transition between design, construction, and operation.

The second concerns the construction of the operational identity of assets, based on coding, registers, and updating rules. In both cases, the point that emerges is that the transition towards BIM-based management does not simply coincide with the addition of digital tools, but with a different capacity of the client to recognize, organize, and maintain its information objects over time.

The same issue reappears at the documentary level. The *Capitolato Informativo*, in fact, is not a separate theme from processes, but the place where that same need for continuity should find a clear formulation. The introductory framework provided by the OICE Report (2026) and the comparative analysis of the corpus have revealed a transitional situation: public demand appears increasingly capable of absorbing BIM terminology and formal apparatuses but often remains more fragile precisely in those aspects that should ensure its operational governability.

The CIs examined are generally stronger in their formal and declarative components than in those related to operational, collaborative, and operation-oriented governance. In other words, PA shows a growing capacity to prescribe BIM but does not yet always succeed in translating it into a fully mature, clear, and controllable information demand.

This is the rationale behind the drafting protocol and the CI prototype proposed in the second part of the chapter. Their contribution does not consist in introducing a further documentary apparatus or in replacing UNI 11337-6 with a parallel scheme, but in making the relationship between process and document more legible and more governable.

The prototype annexed (*annex III*) to the thesis should be read precisely in this way: as one possible formalization of a logic in which phase, information uses, roles, exchanges, verifiable requirements, CDE, and data ownership are made explicit and kept in mutual relation. Its value, therefore, is not only editorial, but methodological, because it attempts to show how the information demand of the public client can be constructed in a form that is more selective, more verifiable, and more coherent with the processes it is intended to support.

In this sense, the contents of the chapter converge around the same logic. The process does not precede the document as a separate plan, and the document does not merely describe the process from the outside. Rather, the two are constructed reciprocally, because it is precisely in their relationship that the information demand of the Contracting Authority either **gains or loses governability**.

Chapter 7

People: training strategies and BIM office in PA

7.1 People as an enabling condition for BIM–FM integration in PA

The previous chapters have shown that BIM–FM integration within a Public Administration cannot be reduced either to the technical quality of models or to the formal correctness of documents and procedures. Models developed according to coherent criteria, readable disciplinary rules, and information levels compatible with management uses are a necessary condition.

The same applies to processes and documents capable of translating an often-generic demand into verifiable requirements, controllable deliverables, and explicit acceptance criteria. However, the experience developed through the case study of the *Torre della Regione Piemonte* reveals a further step: even when models and documents are available, BIM becomes genuinely useful for Facility Management only if the organization has the internal capacity to govern its own information demand and sustain it over time.

In this context, ***"governing"*** means translating operational needs – maintenance, traceability, information retrieval, updating - into clear and realistically controllable requirements. It means being able to read and verify deliverables without depending entirely on external actors. It means maintaining continuity between what is required in one phase and what will actually be used during operation.

When this capacity is missing, BIM risks being reduced to a set of files and formal obligations that struggle to enter everyday routines and therefore fail to generate stable value for the operational phase. Within public client organizations, two opposite risks emerge.

On the one hand, there is the tendency to ask for ***"everything"*** as a precaution, overloading the information demand and the documents with requirements that cannot then be verified, organized, or maintained. On the other hand, there is the opposite tendency: asking for "too little" and delegating crucial choices to the Economic Operator, eventually receiving outputs that are formally delivered but difficult to integrate into internal procedures and FM needs. In both cases, what becomes weaker is the link between demand, verification, and use, which is the point through which the real quality of BIM–FM integration can be assessed.

For this reason, the **People pillar** is understood here as an enabling condition, not as an additional topic. In this case, training is not treated as generic BIM familiarization, but as the construction of operational capacities that make models, requirements, and processes governable: formulating minimum and manageable requirements, recognizing recurring critical issues, setting up sustainable checks, verifying deliverables, and using structured information within maintenance processes.

In a complex and strategic building such as the regional skyscraper, these capacities cannot remain episodic or depend on a few motivated individuals. They must be designed, measured, and made repeatable.

The chapter therefore develops a single argumentative path with a precise aim: to define and validate a BIM–FM Training Framework for Public Administration which, starting from needs, roles, and maturity levels, makes it possible to identify a minimum effective pathway for building usable and verifiable competences.

The work proceeds from the reconstruction and prioritization of training demand to the description of the proposed training pathway and its expected outputs, up to the assessment evidence and the connection with the operational establishment of the BIM Office in *Regione Piemonte*. In this way, training is understood as a lever for transforming individual capacities into a stable organizational safeguard, capable of supporting BIM–FM continuity over time.

7.2 Constructing the training demand: needs, priorities, and conditions for transferability

The construction of the training demand was approached as a genuine design step, because in the public sector training can easily be reduced to a sequence of *"supporting"* contents if it is not anchored to explicit operational needs and realistic priorities. To avoid this, the starting point was not a catalogue of courses, but a structured discussion held directly within the context of the case study. Its aim was to bring concrete critical issues to the surface: where information is lost, which activities become fragile due to the lack of reliable data, which steps generate systematic dependence on external actors, and which deliverables are difficult to check or maintain over time.

The initial meeting (Figure 69) therefore served an elicitation function: it transformed needs that were often implicit or fragmented into material that could be discussed, shared, and later translated into training objectives and verifiable outputs.

Figure 69 – Kick-off meeting for the elicitation of training needs and the definition of workshop objectives within the case study context, the Regione Piemonte skyscraper. [Author's photo].

To prevent the discussion from remaining merely descriptive, participants were asked to take a further step: to translate needs and expectations into a to-do list of activities and objectives that each of them recognized as relevant to their own operational work. In this chapter, the to-do list is not treated as a simple list, because its value lies in making manageable a demand that, in many public-sector contexts, tends to expand by accumulation: when it is not clear what can actually be controlled, everything risks appearing equally important.

The **to-do list** (Figure 70) therefore acted as a focusing device. It required participants to name concrete activities – such as inspections, maintenance planning, updating and recording data in the model, inventories, coordination, and revisions – and made it possible to bring together, within the same representation, immediate operational needs and medium-term structuring objectives.

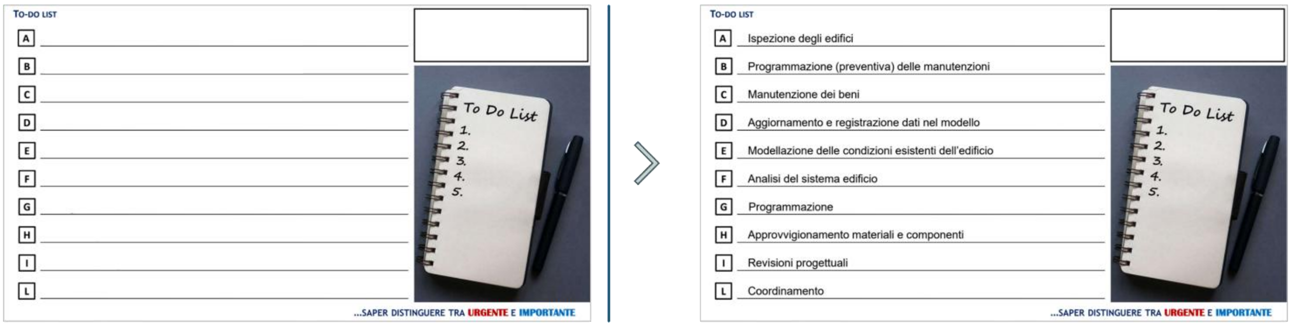


Figure 70 – To-do list of activities: empty template and completed example. [Author's elaboration]

The decisive step occurred when the to-do list was placed within the **Eisenhower matrix** (Figure 71), transforming the list into a map of priorities. This is where the first element of methodological robustness emerges: prioritisation was not left to individual impressions or to the "urgencies of the moment", but was made visible through a simple and shared criterion: urgent/important. The matrix requires a choice and, above all, implicitly requires that choice to be justified. To declare that something is urgent means recognising that it blocks or slows down current activities; to declare that something is important means recognising that it affects the organization's capacity to govern information over time.

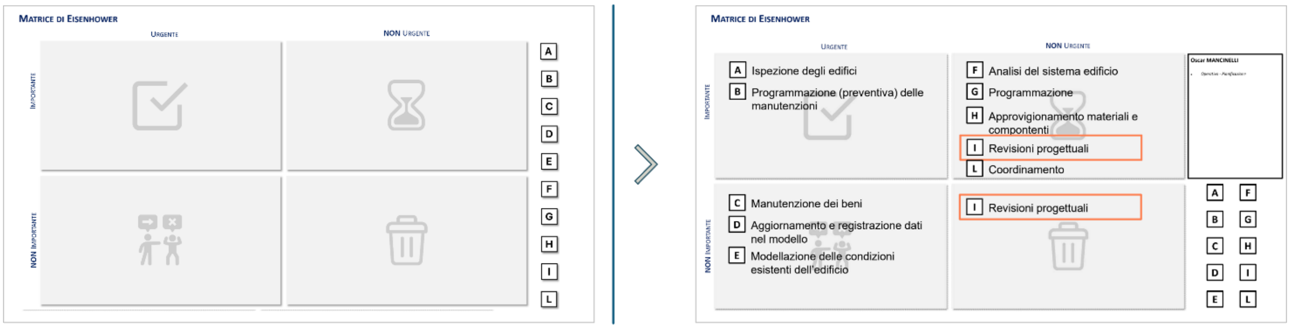


Figure 71 – Eisenhower matrix for activity prioritization: empty template and completed example. [Author's elaboration]

Applied to BIM–FM, this device works as a filter of governability: it brings out what staff perceive as a prerequisite for being able to operate, and what can instead be planned as progressive consolidation.

For *Regione Piemonte,* the outcome of this phase is summarized in the completed matrix (Figure 72).

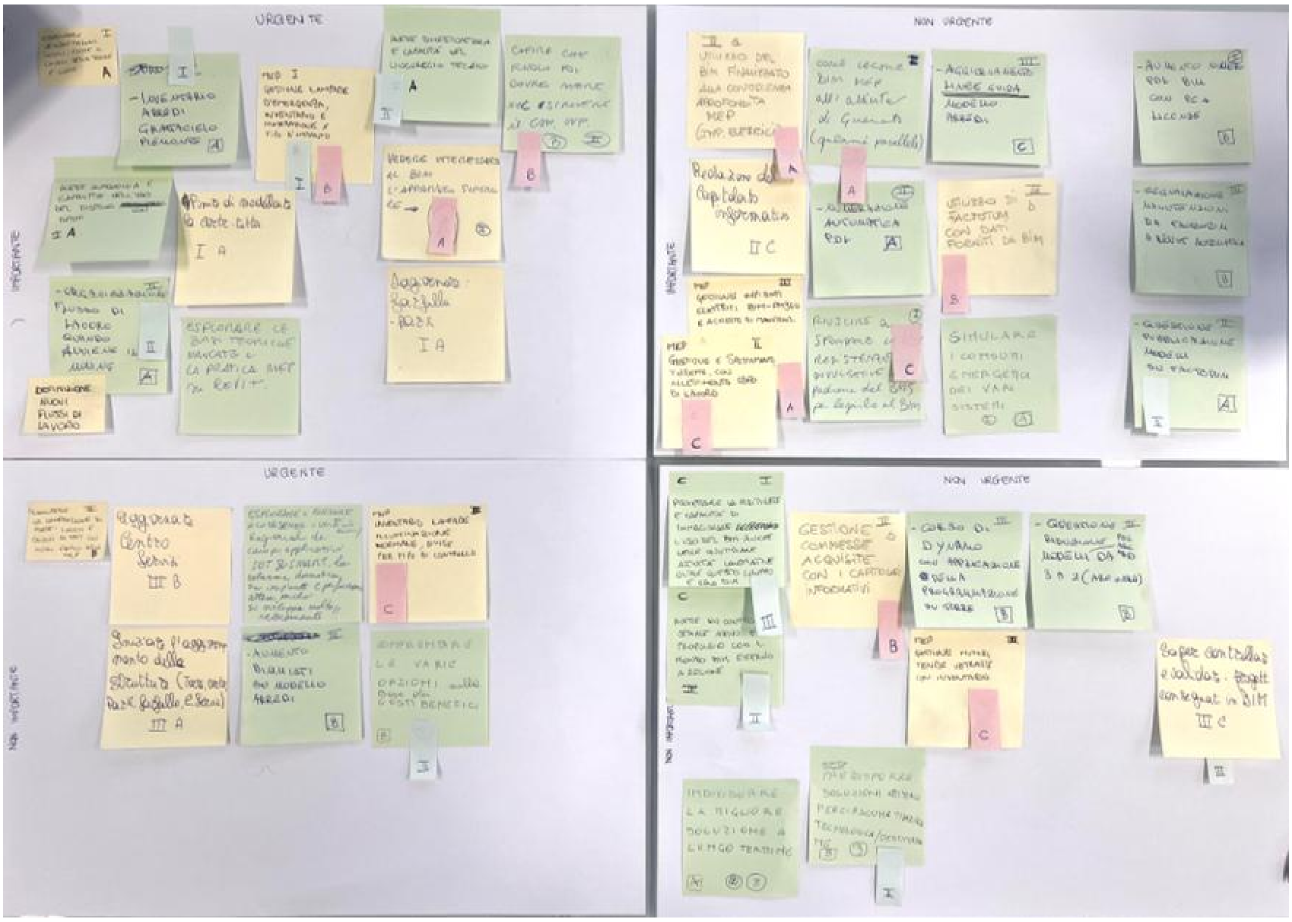


Figure 72 – Eisenhower matrix completed by Regione Piemonte participants. [Author's elaboration].

A first interpretative finding is the high density of the *Urgent–Important* quadrant, which includes a significant share of the issues raised. This concentration should not be read as an individual error or as a lack of ability on the part of the participants, but rather as an indicator of a context in which many needs are perceived as both decisive and immediate.

Foundational needs emerge – technical language, operational autonomy, applied practice, and clarification of roles – together with needs related to the governance of documentary demand, such as the drafting of the *Capitolato Informativo*. In an organization that builds internal capacity, these elements tend to be perceived as urgent because they affect the entire adoption pathway.

At the same time, the presence of contents placed in the *Not Urgent-Important* quadrant indicates a second level of maturation: specialist and structuring topics – such as BIM for MEP, building systems management, updating guidelines, publication on the management tool, and maintenance reporting – are recognized as relevant, while also requiring planning that goes beyond an immediate response.

To strengthen the transferability of the framework and reduce the risk that the training demand would be entirely dependent on the regional case alone, the same device was also applied in comparison with **other Public Administrations**, in this case with officials from the *Municipalities of Orbassano and Beinasco* (Figure 73).

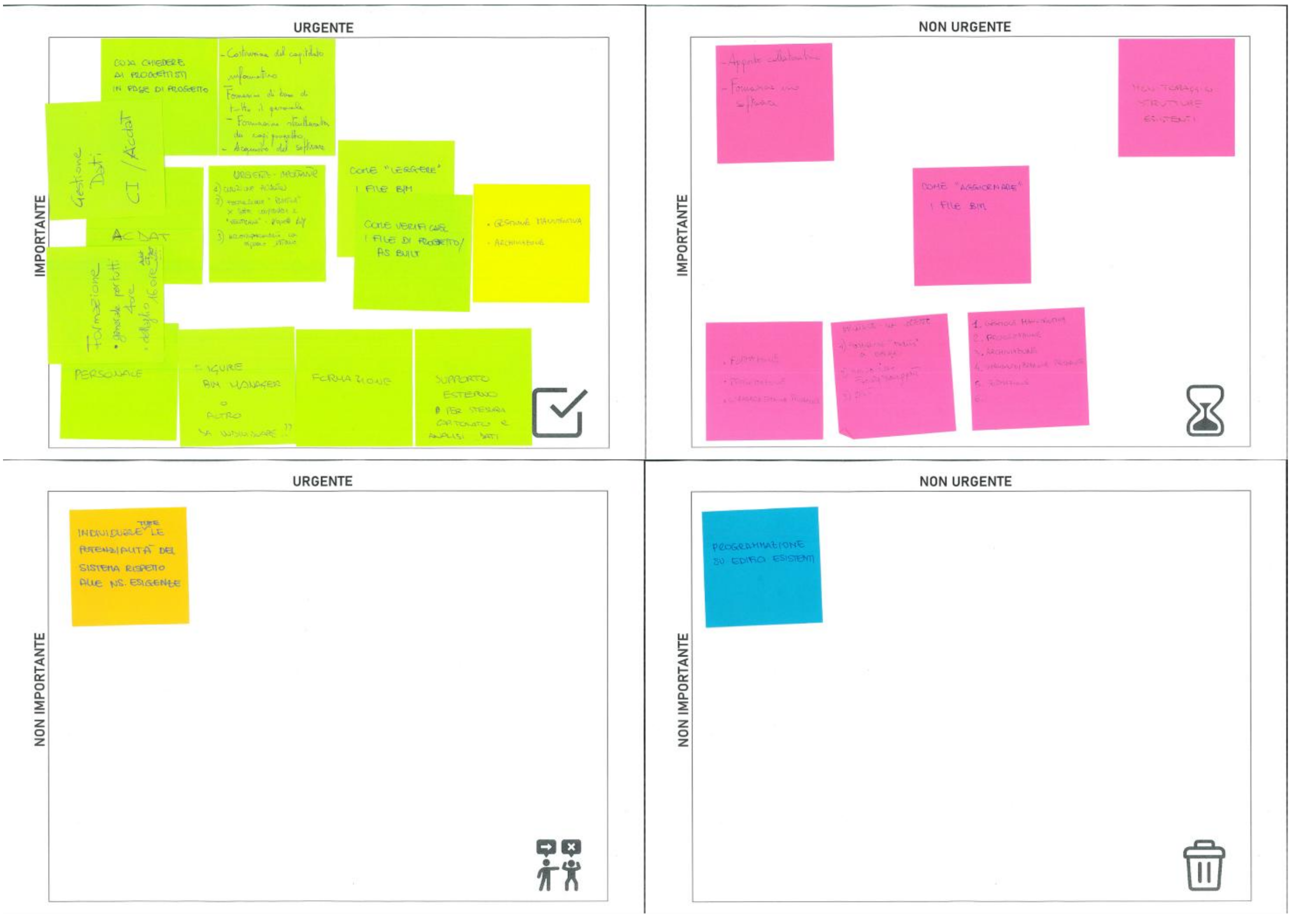


Figure 73 – Eisenhower matrix completed by other PA participants. [Author's elaboration]

Here, the content of the *Urgent–Important* quadrant shows a different emphasis: many priorities are concentrated on the governance of the client role and on the controllability of the information chain, including the CDE, what to ask from designers, the drafting of the *Capitolato Informativo*, and the reading and checking of BIM files. These priorities are accompanied by the need for differentiated training, combining a broad basic level with more structured training for coordination roles.

In this case too, the ***"inflation of urgency"*** is a relevant result, because it highlights a transversal need: prioritization itself becomes an object of training and governance. In other words, the exercise shows that information demand tends to expand and concentrate around urgency when shared criteria are lacking to distinguish prerequisites, operational activities, and structuring objectives. The Training Framework therefore becomes a tool for making this selection explicit and sustainable, avoiding overly ambitious training pathways while, at the same time, preventing postponements that shift structural decisions outside the organization.

The comparative matrix (Table 18) makes it possible to read convergences and differences without forcing a statistical generalisation. The most evident convergence concerns the emergence of issues which, although expressed in different terms, systematically relate to questions of governability: control of the data-sharing environment (CDE), construction and management of information demand (*Capitolato Informativo*), ability to read and verify deliverables, connection between information and maintenance needs, and clarification of operational roles and responsibilities.

Table 18 – Comparative matrix (*Regione Piemonte* vs Orbassano–Beinasco): convergences, differences, and implications for the Training Framework. [Author's elaboration].

COMPARISON AXIS	*REGIONE PIEMONTE*	ORBASSANO–BEINASCO	IMPLICATION FOR THE FRAMEWORK
URGENT–IMPORTANT QUADRANT	Operational autonomy, shared language, practice and application to a real case; clarification of roles; CI.	Client-side governance and controllability: CDE, what to ask for, CI, reading and checking BIM files; differentiated training.	Differentiated training responses are needed: RP points towards operational integration and method applied to the case study, while other PAs emphasise information demand, verification, and control of the information chain.
NOT URGENT–IMPORTANT QUADRANT	Specialisation and structuring: BIM for MEP, building systems management, guidelines, management tool, maintenance reporting.	Monitoring of existing assets, file updates, collaborative procurement, FM, and training.	Planning should address "structuring conditions" - standards, procedures, integrations - beyond immediate urgency.
COMMON SIGNAL	Concentration of priorities in the Urgent–Important quadrant.	Concentration of priorities in the Urgent–Important quadrant.	Prioritisation itself becomes an object of governance: criteria and rules are needed to delimit the demand and construct a minimum effective pathway.
NATURE OF THE "TRAINING" NEED	Strongly linked to operational method and the individual capacity to act on the case study.	Strongly linked to client-side capacity, control, and verification.	The L0–L3 pathway should remain modular and combinable: not all needs require the same level or the same output.

The differences do not contradict this convergence but specify its point of pressure. In the regional case, urgency is described above all as the construction of operational autonomy, a shared language, and the ability to apply knowledge to a real case. In comparison with Orbassano and Beinasco, urgency is framed mainly as the capacity to govern the documentary chain and to control what is requested and verified in relation to designers and operators.

This reading has two methodological implications. The first is that the training demand that emerges does not correspond to a ***"software need",*** but rather to a need for oversight: the priority is the possibility of turning information into an object that can be controlled, verified, and used within the organization's processes. The second is that the concentration of many issues in the Urgent–Important quadrant reveals a structural difficulty in distinguishing between prerequisites, operational urgencies, and consolidation objectives. Urgency tends to expand when shared criteria for delimiting the demand are missing and when initial maturity levels are uneven. In this sense, the exercise does not simply provide a snapshot of priorities. It constructs an explicit, organized, and comparable training demand, making the transition from needs to priorities traceable and offering a solid basis for designing the training actions.

7.3 The BIM–FM Training Framework for PA

The transition from the training demand previously reconstructed and prioritised to a replicable training structure requires a specific design operation: transforming a heterogeneous demand – one that cuts across different roles, processes, and maturity levels – into differentiated pathways, each defined by a clear scope, a coherent level of intensity, and explicit, readable expected outcomes.In the public sector, where time and resources are limited and training demand tends progressively to expand, training becomes effective when it generates capacities and abilities that can be concretely used within operational processes.

The objective, therefore, is not to ***"train everyone on everything"***, but to build distributed capacities that are coherent with the different functions of Public Administration and with the initial maturity level of the groups involved. The sustainability of a BIM–FM strategy thus depends on the ability to identify what truly needs to be governed, distribute it across different roles and responsibilities, and develop competences with operational, not merely cognitive, effects.

To make this translation controllable, the framework adopts an operational distinction between Knowledge (K), Abilities (A), and Competences (C). The **K–A–C triad**, summarized in Figure 7.6 as a device for interpreting BIM learning oriented towards FM, is not used as an abstract taxonomy, but as a design lens. It makes it possible to connect the demand that emerged from the analysis to the type of capacity to be built and to the most appropriate training level.

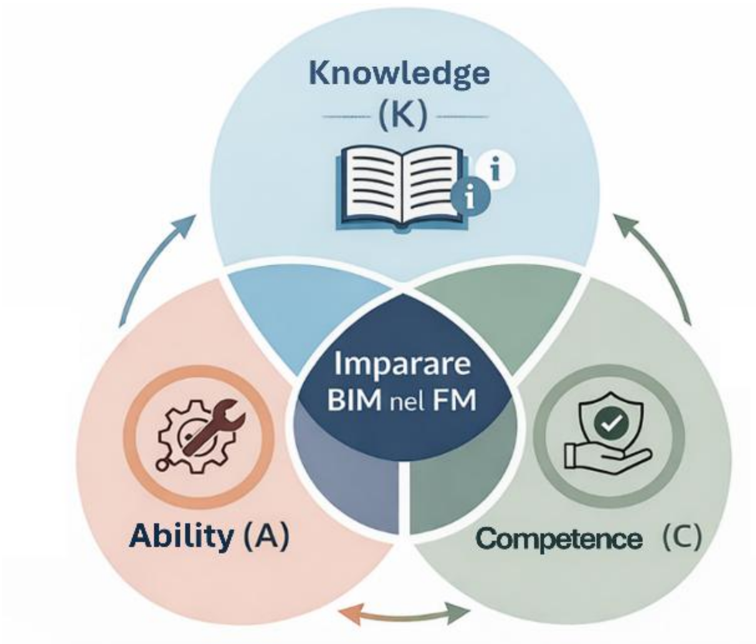


Figure 74 – Knowledge–Abilities–Competences (K–A–C) triad as an interpretative device for BIM training oriented towards Facility Management. [Author's elaboration]

In the BIM–FM domain, **knowledge** refers to the understanding of concepts and criteria that make it possible to correctly interpret information demand, deliverables, and checks. **Abilities** refer to repeatable actions that make information readable, searchable, and controllable, such as reading files and models, querying properties, using parameters and schedules, and applying checklists. **Competences**, finally, refer to the capacity to oversee responsibilities over time, integrating knowledge and abilities within processes, routines, and checks – for example, maintaining coherence between what is requested and what is actually used in management.

On this basis, the Training Framework is organized into a **four-level pathway** (L0–L3), summarizedin the infographic in Figure 75, which makes it possible to compare the duration, intensity, target groups, and theory-to-practice ratio of the four training paths. The pathway does not describe a mandatory sequence; rather, it identifies different training functions, which can be activated in different combinations according to priority needs and the profiles involved.

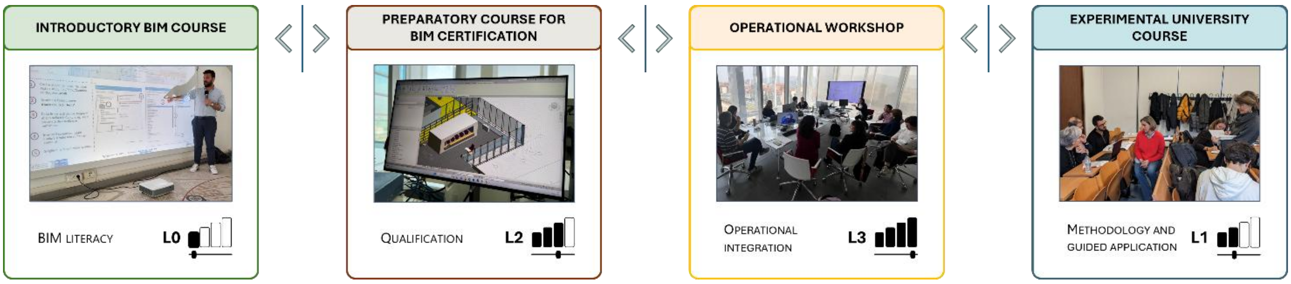


Figure 75 – Scheme of the BIM–FM training pathway for Public Administration (L0–L3). [Author's elaboration].

7.3.1 From demand to training requirements

The design of the Training Framework starts from an operational assumption: in a Public Administration, learning becomes useful when it translates into capacities that affect the way the organization formulates its demand, checks deliverables, and uses information in management.

For this reason, the framework treats training as the construction of differentiated training requirements, linked to different functions and, above all, to observable outcomes. From a design perspective, the idea of a "training requirement" shifts the focus from the course programme to the expected performance: what a person must be able to understand, do, and oversee consistently within processes. This makes it possible to avoid training based on the uniform transfer of content.

The evidence that emerged from the matrix exercise – CDE, *Capitolato Informativo*, reading and checking deliverables, maintenance management, operational autonomy, and shared language – shows that public demand is concentrated on issues of governability before it concerns isolated skills. These issues share a common feature: they cannot be solved through single, punctual competence, because they require different combinations of knowledge, abilities, and competences depending on the role involved. The same need – for example, *"checking a BIM file"* – takes on different meanings if it concerns the client who must accept a deliverable, the FM staff who must query data for a maintenance activity, or an information governance function that must ensure coherence, traceability, and publication. The training pathway responds to this complexity by distributing the K–A–C components in a differentiated way and by making explicit what each path enables.

Within this logic, the pathways are defined through three stable criteria that make the proposal readable and assessable: (i) a declared scope, namely which problems the pathway addresses and which it does not; (ii) a coherent level of intensity, in terms of duration, theory-to-practice ratio, and continuity or episodic nature; and (iii) a set of expected outcomes expressed in a controllable form. This last point is central: training cannot be assessed only in terms of hours delivered or participant satisfaction, because the aim of the chapter is to build internal capacity. For this reason, even when a pathway does not produce formal deliverables in the strict sense, it should still generate minimum evidence: guided exercises, assessable outputs, progress reports, traceability of activities, or applied criteria. These forms of evidence make it possible to distinguish generic familiarity from the actual acquisition of operational capacity.

It follows that the L0–L3 pathway should not be read as a linear sequence, but as a response structure for different training requirements. Some levels — as discussed in the following sections — are designed to build common prerequisites and reduce asymmetries; others are intended to stabilise rules and checks; others, finally, aim to transform learning into continuous practice, making the acquisition of competences coincide with real and traceable activities.

7.3.2 Architecture of the L0–L3 pathway

he entire L0–L3 pathway was structured to make training **selectable, sustainable**, and **verifiable** within the public sector and beyond. For this reason, the four levels are not conceived as ***"courses in sequence"*** in the traditional sense, but as distinct training functions that respond to different needs and distribute knowledge, abilities, and competences in different ways.

Figure 76 – BIM-FM training pathway for Public Administration (L0–L3): duration, intensity, target groups, and theory-to-practice ratio of the four paths. [Author's elaboration]

The overall architecture is summarized in Figure 76, which provides an immediate reading of duration, intensity, target groups, and the theory-to-practice ratio. What matters, however, is not only the quantitative description, but the way in which each level defines its own scope and produces recognisable minimum outputs.

The first structural element of the pathway is the progression of intensity.

L0 is a short and concentrated path, designed to build a shared vocabulary and minimum criteria.

L1 unfolds over a longer period and introduces a guided and assessable operational methodology.

L2 consolidates control and standardization capacities through structured exercises.

L3 takes the form of a continuous laboratory, close to real work, in which learning is linked to tasks and milestones and produces recurring operational traces.

This progression should not be read as ***"more difficult means better",*** but as a gradual shift from understanding and method towards continuity and oversight.

The second element is the theory-to-practice ratio, which in this pathway is not merely a didactic indicator, but a signal of the function of the course. A theory-oriented level such as L0 does not indicate lower relevance. Rather, it means that its task is to reduce ambiguity, build criteria, and make the information chain readable, preventing participants from working *"by imitation"* without understanding. By contrast, practice-oriented levels, especially L2 and L3, are designed to make the methodology applicable and repeatable, testing not only the execution of individual actions, but also the coherence of the process and the capacity to produce controllable outputs.

The third element, which is decisive for the robustness of the framework, is the definition of expected minimum outputs. In a structure oriented towards governability, each level must clarify what remains from the training and through which evidence it can be assessed.

Outputs are not intended as additional bureaucracy, but as minimum conditions for distinguishing between declarative learning and the real acquisition of operational capacities. L0, although it does not produce project deliverables, should at least generate guided exercises and shared criteria that make the information demand more controllable. L1 should produce assessable outputs and a structured restitution of the method. L2 should consolidate standards and checks through practical exercises and comparable results. L3 should produce process traceability and recurring artefacts, such as periodic reports, documenting progress and making decisions and critical issues visible.

These three elements – **intensity, theory-to-practice ratio**, and **minimum outputs** – make it possible to read the pathway as a design structure rather than as a list of courses. In this way, training becomes a selectable and combinable system: the organization can activate different levels according to the function to be overseen and the initial maturity level, without losing overall coherence. In the following subsections, the four paths are described individually, using the same argumentative grid for each: operational purpose, format, characteristic activities, and expected minimum outputs.

7.3.3 L0 – Introductory BIM course

Level **L0** (*BIM literacy*) was designed to address a recurring condition in Public Administrations that begin BIM–FM pathways: the absence of a shared vocabulary and of minimum criteria for correctly interpreting information demand, reading deliverables, and assessing their controllability.

At this stage, it is not realistic to expect staff to become autonomous in modelling or in the advanced management of files within a short time. It is instead strategic to build a common basis that reduces asymmetry in relation to external actors and enables a more informed internal discussion on requirements, checks, and priorities. For this reason, L0 has a limited duration of approximately 20 hours, organized as a **full immersion course** in **five 4-hour slots**, with a **predominantly theoretical theory-to-practice ratio** of 80/20, consistent with its function: consolidating criteria before specialised abilities.

The content of L0 is built around an operational objective: **making the information demand governable** before it turns into either an unmanageable accumulation or an implicit delegation to the Economic Operator.

The course therefore works on steps that, in practice, recur as prerequisites: understanding the difference between need, requirement, deliverable, and acceptance criterion; recognising what is verifiable as opposed to what remains merely declarative; distinguishing between manageable minimum requirements and "maximalist" requests that the organization would not be able to check and maintain; and building a shared technical language that makes the information chain legible even to non-specialist profiles. In this sense, L0 is not an ***"introductory***" course in a generic sense, but a level of literacy specifically oriented towards the client organization: it aims to create the conditions for actively participating in the definition and control of information demand.

Although limited, the practical component has a precise function: not to train participants in modelling, but to make the criteria concrete. The guided exercises are intended to show how an operational objective can be translated into a controllable requirement, how a request can be associated with a minimum deliverable, and how an acceptance criterion can be formulated clearly. It is in this dimension that L0 produces its minimum outputs: not project deliverables, but learning traces useful for building a common language and grammar within the organization. In terms of K–A–C, L0 works mainly on **knowledge** (K) and introduces elementary abilities (A) in a guided form, creating the necessary basis for the subsequent levels to be sustained without sudden leaps in difficulty and without relying exclusively on isolated individual competences.

Finally, L0 has a **transversal value** across roles. Its function does not concern only those who will work directly on models and data, but also those who must make decisions on the sustainability of information demand, such as managers and heads of units; those who oversee procedures and the acceptance of deliverables, such as client-side and procedural figures; and those who will use structured information in management. In this sense, L0 represents the first level of **internal alignment**: it stabilizes dialogue between different functions and reduces the risk of interpreting the BIM–FM chain as an exclusively technical issue.

7.3.4 L1 – Experimental PA–Students university course

Within this research, level **L1** (*Methodology and guided application*) was developed as an experimental **PA–Students university course** of approximately **6 CFU**, corresponding to about 60 hours, with an **indicative theory-to-practice ratio of 60/40**. It was conceived as a context in which training does not remain at the level of general criteria but is translated into a guided operational methodology. Compared with L0, the aim is no longer only to build a shared vocabulary or minimum criteria of governability, but to accompany participants through a progressive applied pathway, capable of producing comparable and, above all, assessable outputs. The university framework allows for two elements that, within the framework, have methodological value: the possibility of structuring a continuous pathway, rather than isolated events, and the presence of a formal assessment, through an exam, which makes learning observable and discussable beyond subjective impressions.

Within the Training Framework, the function of L1 is to consolidate a delicate transition: from the understanding of criteria to the ability to apply them within a workflow. In a BIM–FM context, many weaknesses do not derive from the absence of tools, but from the difficulty of translating objectives and needs into a coherent chain of choices: what should be modelled and what should not, which information fields are actually necessary, how an output can be made searchable, and how sustainable checks can be constructed. L1 works precisely on this transition area, because it combines theoretical moments, needed to establish language and criteria, with progressive exercises that require participants to produce outputs that can be communicated and checked. In terms of the K–A–C framework, L1 still places significant emphasis on knowledge and abilities, but it introduces the competence dimension more explicitly: the capacity to make coherent decisions and document them.

A distinctive aspect of L1 is its hybrid target and its role as a course. The fact that the pathway was conceived as a PA–Students experiment has not only didactic value, but also organizational relevance. It brings academic training into contact with public-sector operational needs, making the distance between "school-like" exercises and outputs that an organization can actually reuse more evident. This setting reinforces the applied nature of the course: the aim is not to train participants on a single platform, but to build a method that makes it possible to produce and verify information oriented towards management.

In terms of outputs, L1 aims to generate materials and deliverables that can be discussed and compared, accompanied by an evaluative restitution. Assessment through the final exam constitutes the first level of formal evidence within the framework, while the tools for feedback and restitution – the **final questionnaire** (*Annex IV*) and the workshop evidence – will be discussed later in the validation section. It is important to underline that, within the chapter, L1 is presented as one of the experimental devices that make it possible to construct a guided and measurable operational method, capable of producing outputs that may also support the internal standardization of the organization, rather than as a "university course" in a self-referential sense.

7.3.5 L2 – Qualification pathway preparatory to certification

Level **L2** (*Qualification*) is conceived as a qualification pathway preparatory to certification, with an indicative duration of approximately **60 hours**, structured into **fifteen 4-hour slots**, and with a theory-to-practice ratio weighted towards the **applied component (40/60).** Within the Training Framework, L2 performs a function that is distinct from the previous levels: it does not focus on basic literacy, nor on guided methodology in an introductory sense, but on the stabilisation of rules, standards, and checks that make information reliable and governable over time.

This point is central in the BIM–FM context: the quality that is useful to Public Administration does not coincide with indiscriminate completeness, but with the coherence and repeatability of checks, the continuity of coding systems, and the capacity to produce controllable and interoperable information outputs.

L2 is therefore the level at which the focus shifts ***from "doing" to "doing consistently"***. In a Public Administration seeking to integrate BIM and management, the most frequent weakness is not the lack of data, but their heterogeneity: fields that are not populated, criteria applied inconsistently, outputs that are difficult to compare, and checks that are not repeatable.

Qualification thus becomes a step in organizational maturation. It consolidates a culture of information quality that does not depend solely on individual experience and that can be supported by internal procedures and routines. For this reason, L2 is particularly coherent with functions responsible for quality, consistency, and verification, and with profiles expected to act as internal reference points in the definition and application of standards.

From a didactic point of view, the greater weight given to practice is consistent with the function of this level. Activities are not aimed at "learning a tool" in a generic sense, but at exercising the application of criteria and rules through controllable outputs.

In terms of K–A–C, L2 mainly strengthens abilities and competences: abilities in producing and checking coherent outputs, for example through the organization, consistency, and verifiability of information; and competences in maintaining standards and managing checks in a repeatable way. It is here that the framework consolidates a decisive capacity for BIM–FM integration: making the information chain verifiable not by exception, but by method.

An important aspect for the coherence of the chapter is that L2 is defined as ***"preparatory to certification"*** even when it is not directly delivered as a certifying pathway.

Within the framework, certification is not the objective in itself, but rather an indicator of a certain level of structuring. What matters is that this level builds competences that can be used to oversee standards, checks, and information quality. In other words, L2 represents the component of "internal qualification" that enables Public Administration to reduce the risk of depending entirely on external expertise and to make the adoption of BIM–FM information management more stable over time.

7.3.6 L3 – Continuous operational workshop "Objective: BIM4FM for PA"

Level **L3** (*Operational integration*) represents the most distinctive component of the Training Framework, because it understands training as a continuous process closely connected to real work activities. The operational workshop "***Obiettivo BIM4FM per PA***" was organized on an almost weekly basis: **4 hours per week**, with an indicative **theory-to-practice ratio of 20/80**. It was explicitly designed to integrate BIM methodology into the organization's working routines, with particular attention to its usefulness for management and maintenance activities. At this level, training is not conceived as an isolated event, but as a pathway built through direct experience. Figure 77 summarizes the overall central role of learning through practical activities, operational experimentation, and the progressive transformation of tasks into shared procedures.

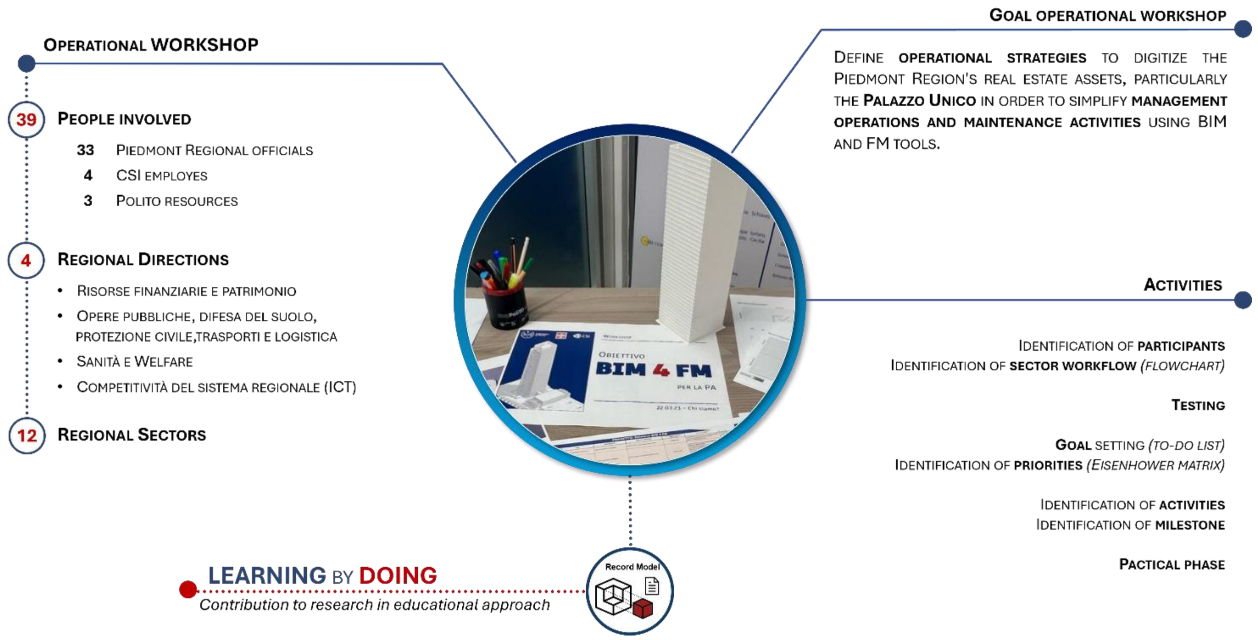


Figure 77 – Structure of the course according to a learning-by-doing approach. [Author's elaboration]

A useful empirical element, which clarifies the operational nature of the workshop, concerns participation dynamics. In the initial phase, the workshop involved a heterogeneous group of about **40 people**, coming from **12 sectors** and **4 directorates**. As the activities progressed, participation gradually consolidated into a more stable core of about **15 participants**, in addition to the research team. This trajectory is significant because it reflects a typical phenomenon in operational training pathways within Public Administration: when training progressively enters the sphere of actual work, continuity becomes a selective factor, and the group tends to stabilize around those who are able to sustain responsibility and presence on the task.

From a methodological point of view, L3 does not correspond to "generic practice", but to a pipeline that structures learning into recognizable and traceable phases. The **initial phase**, dedicated to onboarding and cognitive framing, builds the conditions for operational work: it presents the scope of the workshop, collects expectations, makes sector-specific workflows explicit also through diagrams, defines objectives and activities, identifies priorities and milestones, and verifies participants' prior knowledge.

The **theoretical phase** performs a function of alignment around criteria, language, and operational references. It does not aim to “cover everything”, but to provide the elements needed to guide decisions during practice, distinguishing what is essential, verifiable, and sustainable.

The **practical phase** constitutes the core of the workshop and adopts a learning-by-doing logic. Participants work on concrete activities, coordinate contributions across sectors, retrieve and verify available information, reconstruct the existing condition, model targeted objects, simplify the as-built model where necessary to make it searchable and manageable, and progressively update the information content.

The **verification phase**, finally, introduces a measurement of the competences acquired. Its structure will be discussed in greater detail in the following sections.

Within this structure, one element plays a central role: the **weekly progress report** (Figure 78). The report is not a mere organizational detail, but the artefact that makes visible what, in traditional training pathways, often remains implicit: progress, choices, critical issues, decisions, and their consequences. The progress report introduces a form of traceability on two levels. On the training level, it makes it possible to monitor whether and how the methodology is actually being acquired, because it documents which tasks have been addressed and with what outcomes. On the organizational level, it builds an operational memory that can be discussed and reused: it makes it easier to identify recurring problems, transform them into rules or standards, and redirect activities and training in a more targeted way.


REPORT SETTIMANALE DELLE ATTIVITÀ

Nome del progetto	Data del Report
BIM 4 FM – TRP_TO_ARC	25/01/2024

SINTESI

Componenti Gruppo	N. Gruppo
Morra – Torrengo	2

Sintesi puntuale delle attività svolte

Riunione di aggiornamento e confronto con Zucco, Del Giudice e Ceroni sull'interfaccia Revit-Factotum:

- gestione flusso di lavoro per primo popolamento Palazzo
- gestione flusso di lavoro per aggiornamento collocamento PDL (rif. Attività Leanza)
- gestione flusso di lavoro per aggiornamento interventi / sostituzioni beni mobili inventariati (rif. Attività Scoffone)

Si discute come gestire le funzionalità su Factotum, per coinvolgere l'Ufficio BIM nel flusso di lavoro quando le attività rendono necessario un aggiornamento del modello e di conseguenza di Factotum in modalità model-driven.
RP verificherà le attività da tenere in considerazione
CSI verificherà le opzioni compatibili con factotum
Politecnico coordinerà l'attività

Figure 78 – Example of weekly progress report. [Author's elaboration]

In terms of K–A–C, L3 works mainly on the competence dimension. It does not aim only to ensure that individual operations are carried out correctly, but to build the capacity to oversee a process over time, coordinating information, checks, and updates in line with management needs.

L3 therefore represents the point at which **training and operation enter into continuity**. Its expected outcome is not an abstract “improvement of the model”, but the conscious acquisition of a BIM methodology oriented towards FM: the ability to define contents according to uses, manage graphic and alphanumeric information coherently, recognize typical critical issues, and produce traceable evidence supporting information continuity.

7.3.7 Combinable pathways: from the training chain to the selection logic

The L0–L3 pathway was designed as a combinable structure, because in a Public Administration needs do not emerge uniformly, and the capacity to sustain intensive training varies according to roles and the initial maturity of the groups involved. Combinability is not merely an organizational detail, but a methodological choice. It makes it possible to avoid two recurrent and fragile outcomes: on the one hand, a maximalist approach, in which extensive and undifferentiated pathways are activated, often unsustainable over time and likely to be interrupted; on the other, a de facto minimalism, in which training is reduced to short interventions that do not produce verifiable capacities and do not affect routines. Combinable architecture instead makes it possible to modulate intensity and objectives while maintaining coherence between what the organization intends to oversee and what it can realistically sustain.

The **decision rule** adopted in the framework is based on three factors, understood as essential criteria for guiding the choice without turning it into an overly complex process.

The first is function/role, understood as the set of information-related responsibilities to be overseen: governance of demand and checks, operational use of information in management, oversight of standards and quality, and continuity of information flows.

The second is operational priority, which distinguishes between needs that block current activities and therefore require short-term responses, and more structuring needs that require planning and progressive consolidation.

The third is the initial maturity of the group: the presence or absence of minimum prerequisites – shared vocabulary, familiarity with criteria and checks, ability to read deliverables – conditions the effectiveness of the more operational levels. Without these prerequisites, highly practical pathways risk producing mechanical execution and dependence on tutoring; for groups that are already more mature, overly long introductory pathways generate friction and reduce sustainability.

The output of this rule is defined here as the **Training Toolkit**. The term is used in an operational sense: it indicates a set of reusable artefacts and materials developed during the experimentation and usable to replicate the selection, delivery, and assessment of the pathways, even when these materials have not yet been collected into a single editorial product.

In the case examined, the Toolkit includes the structure of the pathway and its synthetic representations, the materials used to construct and discuss the demand – to-do lists and priority matrices – and the tools for assessing and tracing activities, such as the practical test outline, questionnaires, measures, and restitution tools. What makes this set a "*toolkit*" is not its format, but its possibility of reuse: it guides the coherent selection of pathways and documents their outcomes through comparable evidence.

To make this logic of combinability operational also at a synthetic level, Table 19 compares the four levels in terms of duration, intensity, K–A–C balance, and expected minimum outputs. The table provides a synthetic-comparative matrix useful for guiding the choice and clarifying what each level enables and what type of evidence it produces. It is therefore possible to state that the decision rule and the Training Toolkit allow the L0–L3 pathway to be treated as a system that can be activated coherently with functions, priorities, and initial maturity.

Table 19 – Comparative matrix of the L0–L3 pathway: duration, intensity, and K–A–C balance, with minimum outputs. [Author's elaboration

LEVEL	DURATION / FORMAT	THEORY / PRACTICE	PREVAILING K–A–C	FUNCTION IN THE FRAMEWORK	EXPECTED MINIMUM OUTPUTS / EVIDENCE
L0	20 h, 5 × 4 h, full immersion	80/20	K↑, with A introduced in guided form	Shared vocabulary and minimum criteria for interpreting demand, deliverables, and checks	Guided exercises on needs → requirements; minimum controllability criteria; examples of requirements and acceptance criteria
L1	~60 h, 6 ECTS; semester, 3 h + 1.5 h/week	60/40	K/A, with initial C	Guided operational method: translating criteria into workflows and assessable deliverables	Structured outputs and deliverables; process documentation; assessment evidence through exam and feedback through final questionnaire and restitution
L2	~60 h, 15 × 4 h	40/60	A/C↑	Qualification: standards, information quality, and repeatable checks	Structured exercises on standards and checks; coherent and comparable information outputs; application of quality and consistency criteria
L3	4 h/week, continuous workshop	20/80	C↑, with A in context	Operational integration: continuity, tasks/milestones, transformation into routines	Tasks and milestones on a real case; weekly progress report; traceability of progress, choices, and critical issues; evidence of continuity and updating

7.4 Validation of the Training Framework: protocol, tools, and evidence

7.4.1 Validation logic

A BIM–FM training proposal for Public Administration risks being assessed weakly if it is described only through generic satisfaction measures or "*delivery*" indicators, such as the number of hours delivered, the number of participants, or the continuity of meetings. In a public-sector context, these elements are certainly relevant for organizational sustainability, but they are not sufficient to demonstrate that training has actually built internal capacities that can be used within processes and management activities. In BIM–FM, the critical issue is not simply learning a vocabulary or becoming familiar with a software environment, but making a more demanding transition possible: turning information into a governable object, that is, something that can be translated into controllable requirements, verifiable deliverables, updating routines, and coherent use within maintenance processes. For this reason, the **validation of the Training Framework** is conceived as a methodological device aimed at making learning both observable and discussable. It must be observable because it should produce verifiable traces that make it possible to distinguish between declared understanding and enacted capacity. It must be discussable because it should allow for a critical reading of the results: identifying where recurring difficulties emerge, which steps generate the greatest cognitive load, which competences appear more fragile, and, above all, to what extent these weaknesses depend on the participants' initial profiles rather than only on the intrinsic complexity of the tasks. In other words, this chapter assumes that a framework can be **considered "validated"** when it produces evidence that makes it possible to discuss whether, and how, the expected capacities have actually been built. This approach leads to a methodological choice consistent with the overall structure of the framework: validation is placed within the training framework itself and accompanies the construction of the L0–L3 pathways. Since it is intended to measure coherence, effects, and applicability, it cannot be conceived as a separate and subsequent phase, but must be integrated into the design of the training. Its function is to verify whether the articulation of the training levels can be connected to ***assessment tools*** capable of capturing three complementary dimensions: (i) **profiling and self-declared competences**, useful for contextualising the results obtained; (ii) **operational performance on structured tasks**, aimed at producing observable and comparable evidence; (iii) **perceived complexity and structured feedback**, necessary to understand where difficulties are concentrated and how they are distributed across activities, roles, and participant profiles.

This logic does not assume that all participants must reach the same outcome, nor that the test should "certify" competences in a rigid sense. Rather, it assumes that the framework should be able to provide a minimum set of evidence consistent with its declared purpose: to show that BIM–FM training, when designed as a structured device, can generate measurable and replicable results, rather than simply producing unverified training moments. In this sense, the survey tools and operational traces are part of the framework itself. To ensure transparency and traceability, the tools adopted are made available as annexes and are referenced in the text whenever they are used as a basis for measurement or comparison: the **cognitive questionnaire** administered through *LimeSurvey* (*Annex IV*), the **practical exercise brief** *"Obiettivo: BIM4FM per PA",* with its sequential structure and saving/assessment rules (*Annex V*), and the **end-of-course questionnaire** for "*Modellazione digitale di impianti*", administered through Google Forms (*Annex VI*).

7.4.2 Common multi-cohort exercise

The validation of the Training Framework is based, as a first line of evidence, **on a common practical exercise** administered to **different cohorts**. The choice of a single test responds to a precise methodological need: to build a stable and observable reference through which learning can be read not as a declaration – ***"I know how to use BIM"*** – but as the ability to move through a set of activities consistent with information management oriented towards FM. Without a common task, assessment tends to depend too heavily on the specific features of each course, and it becomes difficult to distinguish what is an effect of the training pathway from what is an effect of the context.

The exercise was applied to groups with different backgrounds: PA employees involved in the operational workshop, a university class, a class from a professional training pathway (CEFS), and a group composed of researchers, research fellows, and PhD candidates. The comparison between cohorts is not used to produce a ranking between categories, nor to infer differences in "value" between profiles. Rather, it serves to observe, in a controlled way, two aspects that are often confused in BIM–FM training: (i) which steps are structurally critical, namely difficult regardless of the profile, and (ii) which steps become critical mainly in relation to initial maturity and previous experience. This distinction is important because it shifts the interpretation from the individual to the device: if a difficulty recurs across different cohorts, it is plausible that it concerns the nature of the task or the way in which it is organized; if a difficulty emerges mainly within a specific profile, it becomes useful information for calibrating prerequisites, support tools, and the teaching sequence, without altering the substantive content of the test.

To make the comparison genuinely interpretable, the common exercise is not only *"the same brief"*, but a system of comparability built on four operational choices. First, a **mandatory sequence of activities**, which prevents participants from skipping steps and makes it possible to identify where performance stops or slows down. Second, the **requirement to save the file progressively** at the end of each activity, using a dedicated naming system, which transforms the exercise into a process trace rather than only a final result; in this way, each step produces an identifiable and verifiable artefact. Third, the systematic recording of the ***Perceived Activity Complexity Level*** (LCAP) for each task, which introduces a punctual and comparable perceptual measure along the sequence, useful for identifying where cognitive load is concentrated even when the output is formally correct. Fourth, the use of **uniform materials and instructions**, so that the observed differences can be attributed as far as possible to performance rather than to variations in the setting. From the perspective of the Training Framework, the common exercise therefore performs a dual function. On the one hand, it provides an empirical basis for verifying whether certain minimum operational abilities – related to the controlled management of information, data structuring, and the production of searchable outputs – can actually be acquired and measured. On the other hand, it generates reusable evidence for improving the training design: identifying the steps where difficulties are concentrated, understanding whether cognitive load accumulates around specific activities, and recognising which elements require greater scaffolding – for example, closer guidance, examples, or preparatory exercises – for certain cohorts. In this sense, comparability is the condition that allows the test to become a tool for interpreting the learning process, rather than an isolated event.

The complete exercise brief, including the twelve sequential activities and the rules for completion and saving, including LCAP recording, is provided in ***Annex V***, "*Practical Exercise — Obiettivo BIM4FM per la Pubblica Amministrazione*".

7.4.3 Assessment protocol

The practical exercise was administered through a protocol structured into four consecutive moments (Figure 79): pre-test, cognitive questionnaire, practical test, and post-test.

Figure 79 – Four-step assessment protocol: pre-test, cognitive questionnaire, practical test, and post-test. [Author's elaboration]

These moments were designed to collect complementary evidence and make the assessment more interpretable. The underlying logic is straightforward: if technical performance is observed on its own, it risks being read in an opaque way, because it is not clear how much depends on ambiguities in the task brief, differences in previous experience, or the cognitive load of individual steps. The four-step sequence reduces this opacity by separating: (i) the clarification of the procedure and rules, (ii) the construction of a minimum participant profile, (iii) performance on structured tasks with verifiable outputs, and (iv) a controlled restitution of perceived complexity.

The **pre-test** has the function of reducing procedural ambiguity and making the test conditions comparable. Before the exercise begins, the brief is presented and read cooperatively, clarifying objectives, the sequence of activities, saving rules, and the indicators collected during the exercise. This step, with an indicative duration of about twenty minutes, helps to limit two frequent distortions. The first is the effect of misunderstandings about the task, which would turn the exercise into a test of interpretation of the brief. The second is the variability caused by divergent readings of the same activity.

The aim is therefore to establish an explicit and shared framework of expectations, so that what is observed is mainly linked to execution capacity rather than to uncertainty about the rules of the exercise.

The second moment is the **cognitive questionnaire**, administered through *LimeSurvey* and provided in *Annex IV*. The questionnaire has a contextualizing function: it collects targeted information on participants' profiles and declares experience within the domain of interest, building a useful reference for interpreting the practical test. In other words, performance is read in relation to minimum background elements, such as previous experience, familiarity with tools and procedures, and certain self-declared competences.

Even when the aim is not to "*explain*" performance statistically, this contextualization is crucial: it prevents simplistic interpretations and makes it possible to distinguish between difficulties linked to the structure of the tasks and difficulties linked to the participant's initial maturity.

The structure of the questionnaire, organized into sections and logical sub-sequences, is summarized and graphically represented in Figure 80, which shows how the tool was designed to support the interpretation of the practical test.

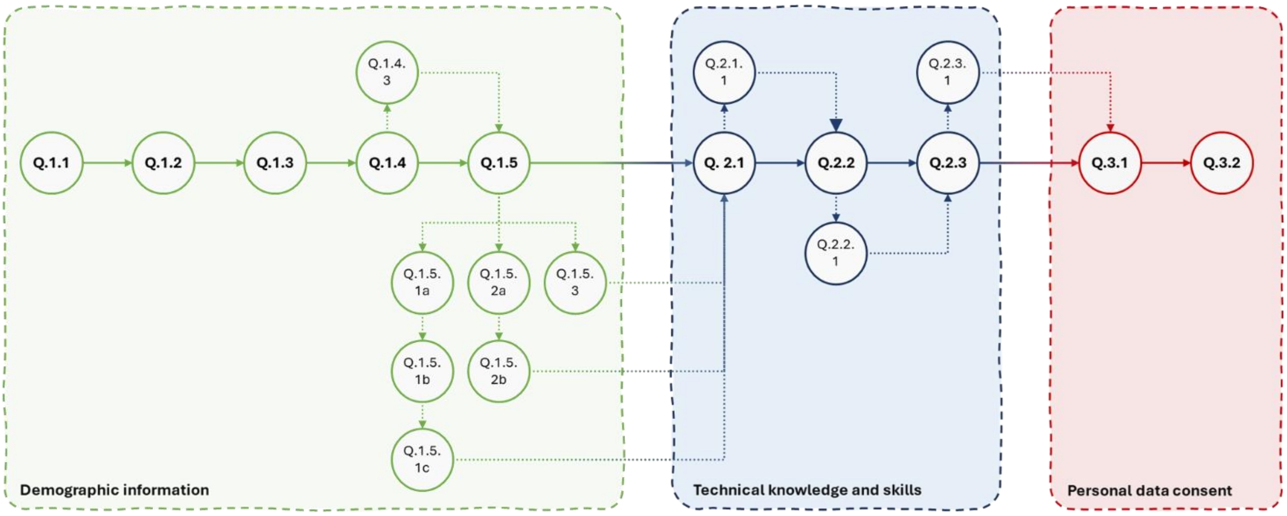


Figure 80 – Structure of the cognitive questionnaire administered through *LimeSurvey*: articulation into sections — profile information, technical competences/abilities, consent, and saving code — and logic of the question flow. [Author's elaboration]

The core of the protocol is the **practical test** on *Autodesk Revit,* structured as a sequential exercise consisting of twelve activities (AT00–AT12). Each activity must be completed in order, without the possibility of skipping steps. At the end of each step, participants are required to save the file with progressive naming and to record the Perceived Activity Complexity Level (LCAP) on a 1–5 scale.

This structure produces two types of evidence: on the one hand, a technical trace of the process, consisting of intermediate files and outputs associated with the activities; on the other, a punctual perceptual trace associated with each task, namely the LCAP score. The complete exercise brief and delivery rules are provided in *Annex V*, making the entire structure of the test verifiable, together with the coherence between required activities, expected outputs, and collected indicators.

The protocol concludes with the post-test, designed to integrate the individual measure with a controlled and documentable restitution. In this phase, participants collaboratively complete the **Activity Perception Table**, which makes the assessments of perceived complexity comparable and allows significant variations to be discussed. This step completes the performance observed during the practical test by making it possible to identify recurring patterns of difficulty and to highlight activities which, although formally "simple", are perceived as cognitively demanding, or vice versa.

7.4.4 Revit practical test (AT00–AT12)

The practical test constitutes the performance-based core of the assessment protocol, as it makes it possible to observe the acquisition of operational abilities through a set of structured activities, carried out under controlled conditions and with verifiable outputs. The exercise is designed as a constrained sequence of **twelve activities** (AT00–AT12), to be completed in order, without skipping any step, using unambiguous instructions, provided materials, and explicit execution criteria. This choice responds to a criterion of measurement governability: a mandatory sequence makes execution comparable across participants and cohorts, and allows difficulties, slowdowns, or errors to be located along the process.

The overall structure of the test is summarized in Table 20, which reports, for each activity, the operational objective, the expected observable output, and the request to record the Perceived Activity Complexity Level (LCAP).

A distinctive element of the test is the requirement to **save the file progressively** at the end of each activity, using a dedicated naming convention according to the scheme "TRP_ESE_COGN-ATxx". This procedure does not only have an organizational function; it also makes it possible to build a versioned trace of the execution and to check the temporal sequence through which the activities are performed. Reading the different saved files makes it possible to observe the time difference (Figure 81), in minutes and seconds, required for each step, providing useful information not only on the final result but also on the process followed.

Regional employes

Partecipants	START	ΔT_0	ΔT_1	ΔT_2	ΔT_3	ΔT_4	ΔT_5	ΔT_6	$\Delta T_{7.1}$	$\Delta T_{7.2}$	ΔT_8	ΔT_9	ΔT_{10}	ΔT_{11}	ΔT_{12}	da sottrarre	Tempo Impiegato
A M	10:03	00:05	00:04	00:11	00:22	00:06	00:04	00:08	00:06	00:29	00:02	00:10	00:03	00:02	00:03	00:00	01:55
B C	10:03	00:03	00:07	00:05	00:21	00:05	00:04	00:12	00:14	00:17	00:03	00:09	00:07	00:02	00:04	00:00	01:53
DC S	10:15	00:05	00:03	00:12	00:22	00:05	00:08	00:16	00:11	00:19	00:01	00:10	00:03	00:02	00:05	00:00	02:02
M GR	10:03	00:05	00:01	00:04	00:10	00:04	00:03	00:06	00:07	00:08	00:01	00:12	00:07	00:02	00:06	00:00	01:16
T A	10:03	00:07	00:03	00:04	00:31	00:04	00:10	00:04	00:09	00:23	00:02	00:03	00:09	00:01	00:02	00:16	01:36
V P	10:03	00:05	00:05	00:10	00:16	00:05	00:07	00:13	00:10	00:27	00:04	00:03	00:10	00:01	00:03	00:00	01:59
Average Value																	**01:46**

Figure 81 – Extraction of selected time values from the exercise. [Author's elaboration]

Each step therefore produces an identifiable artefact, which can be analyzed to reconstruct where the sequence stops, where recurring errors emerge, and which activities require more time, intervention, or support. In a BIM–FM context, this approach is consistent with the general aim of the framework: to read the quality of performance in relation to process controllability, the traceability of transformations, and the ability to interpret execution as a sequence of verifiable actions.

The twelve activities are organized as an operational progression consistent with the use of BIM for information management. The sequence guides the participant from (i) the preparation of the working environment, to (ii) the management of external references, from (iii) the selective modelling of elements and spaces, to (iv) the semantic structuring of the model, and finally to (v) the production of searchable, verifiable, and exchangeable outputs.

Table 20 – Structure of the Revit practical test (AT00–AT12): activities and observable output for each task [Author's elaboration]

TASK	REQUIRED ACTIVITY	EXPECTED OBSERVABLE OUTPUT
AT00	Open Revit 2019, create a new project from the template "Template_Esercitazione.rte", and save the file for the first time using the required naming convention (TRP_ESE_COGN-AT00).	Project file correctly created from the provided template and saved with compliant naming.
AT01	Open the floor plan view "ARC_LF05-PiantaEsercitazione" and correctly link the structural file "TRP_TO_STR.rvt" to the project. Save progressively as TRP_ESE_COGN-AT01.	Structural model correctly linked to the project and visible in the required working view.
AT02	Import, correctly position, and pin the CAD file "TRP_PiantaEsercitazione" within the project. Save progressively as TRP_ESE_COGN-AT02.	CAD file correctly imported, positioned, and pinned as a reference base for the following activities.
AT03	Insert doors based on the imported CAD plan, limited to elements with a red identifier and excluding the core doors, according to the criteria specified in the brief. Save progressively as TRP_ESE_COGN-AT03.	Door objects correctly modelled and positioned in plan, consistently with the CAD reference and assigned criteria.
AT04	Create rooms for the individual spaces based on the imported CAD plan, excluding the core rooms. Save progressively as TRP_ESE_COGN-AT04.	Rooms correctly generated and associated with the expected spaces in the plan view.
AT05	Link to the project the TXT shared-parameter file named "TRP_ESE_ParametriCondivisi" and create the shared parameters required by the brief. Save progressively as TRP_ESE_COGN-AT05.	Shared-parameter file correctly linked and required parameters created in the project.
AT06	Load into the project the shared parameters contained in the TXT file and those created in the previous activity as project parameters, according to the required settings. Save progressively as TRP_ESE_COGN-AT06.	Project parameters correctly set and associated with the categories/conditions required by the brief.
AT07	Create a category schedule named "TRP_ABC_ESE-Porte", with the required fields (Level, Family, Type, *FactotuM* Code, Door Code, Unit Cost, Electric Lock, Count), ordered as specified, filtered on level LF05, and with totals enabled. Save progressively as TRP_ESE_COGN-AT07.	Door schedule correctly configured, ordered, filtered, and prepared for counting/totals.
AT08	Export the schedule to Excel through the BIMOne plug-in, fill in the fields based on the values reported in the CAD file and in the table included in the brief, and then re-import it into Revit. Save progressively as TRP_ESE_COGN-AT08.	Door schedule correctly exported, filled in Excel, and re-imported into Revit with updated data.
AT09	Tag the doors using the tag family "TRP_ET-Porta". Save progressively as TRP_ESE_COGN-AT09.	Doors correctly tagged in the plan view using the assigned family.
AT10	Create a room schedule named "TRP_ABC_ESE-Locali", with the fields Level, *FactotuM* Code, and Electric Lock, ordered as specified, filtered on level LF05, and filled in. Save progressively as TRP_ESE_COGN-AT10.	Room schedule correctly created, filtered, and filled in.
AT11	Tag the rooms in plan using the tag family "TRP_ET-CF_Locali". Save progressively as TRP_ESE_COGN-AT11.	Rooms correctly tagged in the plan view using the indicated family.
AT12	Modify the door schedule in order to display the total cost of the doors. Save the final file as TRP_ESE_COGN-AT12.	Final door schedule updated with the total cost calculation.

In the first activities, AT00–AT02, attention is focused on **setup** and **context control**. The test begins with the creation of the project from a dedicated template and continues with the controlled insertion of external sources: linking a model, importing and positioning a CAD file, and subsequently pinning the reference. At this stage, the capacity to prepare an orderly, coherent, and unambiguous working environment is observed, as this is a necessary condition for ensuring the reliability of subsequent operations.

With AT03–AT04, the exercise moves into **targeted** and **delimited modelling**. The insertion of doors according to predefined criteria and the creation of rooms, with the exclusion of certain portions, introduce a central principle for BIM–FM: modelling must be guided by the information objective. Elements are represented when they are meaningful for the process and according to explicit rules. Selectivity therefore becomes a condition for model governability, because it allows data to remain legible, controllable, and coherent with the intended uses.

Activities AT05–AT06 concern the **semantic structuring of the model** through shared parameters and project parameters. The creation and loading of parameters constitute a key step, because they connect the modelled objects to information fields that are useful for management. At this stage, the transition from geometric element to information object becomes visible: an object gains operational value when the information associated with it is structured, coherent, and searchable.

The final activities, AT07–AT12, lead to the **production of information outputs** and to the **verification of operational interoperability**. The creation of door and room schedules, the export and re-import through Excel using the *BIMOne* plug-in, tagging, and the calculation of the total cost make visible the chain that connects data, output, and control. The export/import workflow towards Excel reproduces a frequent condition in real processes, where BIM information is extracted, filled in, checked, and reinserted into the model while maintaining coherence. Tagging finally translates the information content into a legible form within the graphical view, making the data controllable both through schedules and through the representation of the model.

Alongside technical traceability, the test also introduces a systematic measure of pe**rceived complexity**: at the end of each activity, the participant records an LCAP value on a 1–5 scale. This measure is intended to make the assessment of performance more interpretable. It identifies where cognitive load accumulates along the sequence and makes it possible to distinguish between activities that are technically simple but perceived as complex — particularly because they require reasoning or choices — and activities that are technically articulated but perceived as manageable because they are guided or repetitive.

The restitution of these values, aggregated in the **Activity Perception Table**, makes patterns of difficulty comparable by activity and across participants.

An example of the table and its synthetic reading is reported in Figure 82, where it is possible to observe the distribution of LCAP values and the mean values for each task. This type of evidence is particularly useful in a framework that aims to be replicable: it makes it possible to justify, in a non-impressionistic way, where a pathway requires greater scaffolding, where the sequence can be recalibrated, and which activities represent recurring critical steps.

Regional employees - Activity Perception Table

Partecipant	AT00	AT01	AT02	AT03	AT04	AT05	AT06	AT07	AT08	AT09	AT10	AT11	AT12	Average value	LCAP Total
A M	2	1	2	1	1	1	1	1	3	1	1	1	3	1,5	1
B C	1	4	3	3	1	2	3	1	1	1	1	1	5	2,1	3
DC S	1	1	2	3	2	3	3	4	1	3	3	1	5	2,5	4
M GR	5	1	2	4	1	3	3	1	1	3	1	1	3	2,2	3
T A	3	2	2	3	2	4	4	4	2	2	2	2	4	2,8	3
V P	1	3	2	3	1	3	3	2	1	1	1	1	5	2,1	3
V V	1	2	1	3	2	3	4	4	5	1	2	2	3	2,5	3
S R	1	1	1	3	1	3	4	4	4	1	2	2	3	2,3	3
Average value	1,88	1,88	1,88	2,88	1,38	2,75	3,13	2,63	2,25	1,63	1,63	1,38	3,88	**2,24**	**2,88**

Figure 82 – Activity Perception Table: recording of LCAP for activities AT00–AT12 and synthesis of mean values. [Author's elaboration]

Overall, the test produces a set of observable evidence that makes performance verifiable on several levels: (i) the versioned files for each activity, which document the process; (ii) the intermediate information outputs – schedules, tags, export/import – which show whether the data have been structured and made searchable; and (iii) the LCAP measure for each activity and its restitution in the Activity Perception Table, which provide an interpretation of cognitive load along the sequence.

It is this combination, rather than any single element, that makes the test coherent with the logic of the Training Framework: observing not only whether the participant completes the exercise, but how they move through the steps that transform a model into controllable and reusable information.

7.4.5 Post-test: from the individual measure (LCAP) to the activity-based reading

The **post-test** was designed to transform the individual measure of the LCAP into a structured and comparable restitution. The objective is to produce additional, controlled, and documentable evidence, useful for identifying where difficulty is concentrated along the sequence of activities and how participants perceive it. Within a training framework oriented towards process governability, this information makes it possible to recognize the activities perceived as more linear and those that generate a higher cognitive load. This load may depend on the density of the required operation, the need to verify data coherence, the semantic structuring of the model, or the interpretation of the task briefly.

The restitution is organized through the **Activity Perception Table** (APT), completed in such a way as to reconstruct, for each participant, the sequence of LCAP values associated with activities AT00–AT12. The table is deliberately simple: for each task, the score from 1 to 5 assigned by the participant is reported; afterwards, mean values are calculated for each activity, together with synthetic indicators for each participant, such as the individual mean and the overall index. The structure has an interpretative and operational function: it constructs a map of perceived complexity, useful for reading the practical test and identifying the steps that require greater didactic support or a different calibration of the sequence.

In the case analyzed, Figure 83 makes it possible to observe the behaviour of the group of regional employees and, at the same time, to introduce a first comparison with the other profiles involved in the test. The table reports the individual scores of the regional employees and, in the lower part, the synthetic mean values for the other groups. This organization allows for a two-level reading: on the one hand, the internal variability within the group of officials; on the other, the positioning of this group in relation to the other participants.

Regional employees - Activity Perception Table

Partecipant	AT00	AT01	AT02	AT03	AT04	AT05	AT06	AT07	AT08	AT09	AT10	AT11	AT12	Average value	LCAP Total
A M	2	1	2	1	1	1	1	1	3	1	1	1	3	1,5	1
B C	1	4	3	3	1	2	3	1	1	1	1	1	5	2,1	3
DC S	1	1	2	3	2	3	3	4	1	3	3	1	5	2,5	4
M GR	5	1	2	4	1	3	3	1	1	3	1	1	3	2,2	3
T A	3	2	2	3	2	4	4	4	2	2	2	2	4	2,8	3
V P	1	3	2	3	1	3	3	2	1	1	1	1	5	2,1	3
V V	1	2	1	3	2	3	4	4	5	1	2	2	3	2,5	3
S R	1	1	1	3	1	3	4	4	4	1	2	2	3	2,3	3
Average value	1,88	1,88	1,88	2,88	1,38	2,75	3,13	2,63	2,25	1,63	1,63	1,38	3,88	**2,24**	**2,88**

Ragazzi CEFS 24

Partecipant	AT00	AT01	AT02	AT03	AT04	AT05	AT06	AT07	AT08	AT09	AT10	AT11	AT12	Average value	LCAP Total
9	1,33	1,67	1,44	2,44	1,33	2,22	2,11	1,89	2,22	1,56	1,56	1,67	1,89	**1,79**	**3,11**

Studenti BIM (III anno)

Partecipanti	AT00	AT01	AT02	AT03	AT04	AT05	AT06	AT07	AT08	AT09	AT10	AT11	AT12	Average value	LCAP Total
31	1,16	1,19	1,13	2,58	1,19	1,84	2,10	1,94	3,13	1,81	1,42	1,16	1,90	**1,73**	**2,58**

Dottorandi - Assegnisti - Ricercatori

Partecipanti	AT00	AT01	AT02	AT03	AT04	AT05	AT06	AT07	AT08	AT09	AT10	AT11	AT12	Average value	LCAP Total
12	1,33	1,08	1,17	2,42	1,00	1,58	1,83	2,00	2,25	1,58	1,58	1,17	2,00	**1,62**	**2,58**

Figure 83 – APT: regional employees' individual scores and summary values for the other groups. [Author's elaboration].

For the regional employees, the highest mean value is recorded in AT12, equal to 3.88, which emerges as the most critical step in the sequence. This is followed by AT06, with 3.13, AT03, with 2.88, AT05, with 2.75, and AT07, with 2.63. The lowest values are instead recorded for AT04 and AT11, both equal to 1.38, followed by AT09 and AT10, both equal to 1.63. The overall group mean, equal to 2.24, indicates a moderate perception of the test, but the distribution of values shows recognizable peaks in relation to specific tasks.

The reading of Figure 83 suggests that the difficulty perceived by regional employees is concentrated above all in the steps where the activity requires the connection of technical operations, information logic, and output verification.

The peak in AT12 is particularly significant, because it concerns a final phase of the test in which the participant must recombine what was carried out in the previous steps and transform it into a controllable result. In this sense, perceived complexity seems to be linked to the need to verify data coherence, understand the correctness of the processing, and produce a legible final output. AT06 and AT03 also show high values, confirming the greater exposure of participants in tasks connected to information structuring, parameterisation, and the management of less automatic operational steps.

Figure 84 makes the comparison between the four groups more explicit: regional employees, CEFS 24, BIM&CM Students 24, and doctoral students/research fellows/researchers.

Total Activity Perception Table

Partecipant	N.	AT00	AT01	AT02	AT03	AT04	AT05	AT06	AT07	AT08	AT09	AT10	AT11	AT12	Average value	LCAP Total
Regional employees	**8**	1,88	1,88	1,88	2,88	1,38	2,75	3,13	2,63	2,25	1,63	1,63	1,38	3,88	**2,24**	2,88
CEFS 24	**9**	1,33	1,67	1,44	2,44	1,33	2,22	2,11	1,89	2,22	1,56	1,56	1,67	1,89	**1,79**	3,11
BIM&CM Sudents 24	**31**	1,16	1,19	1,13	2,58	1,19	1,84	2,10	1,94	3,13	1,81	1,42	1,16	1,90	**1,73**	2,58
DttF	**12**	1,33	1,08	1,17	2,42	1,00	1,58	1,83	2,00	2,25	1,58	1,58	1,17	2,00	**1,62**	2,58
TOTAL Average value		1,43	1,45	1,40	2,58	1,23	2,10	2,29	2,11	2,46	1,64	1,55	1,34	2,42	**1,85**	**2,79**

Figure 84 – Comparative synthesis of mean LCAP values by task and participant group. [Author's elaboration]

This synthesis shows that the regional employees present the highest mean LCAP value, equal to 2.24. The other groups are positioned at lower values: 1.79 for CEFS 24, 1.73 for BIM&CM students, and 1.62 for doctoral students, research fellows, and researchers. This result indicates that the group of officials perceived the exercise as more demanding than the other profiles, probably due to a lower daily familiarity with the Revit environment and with the information modelling operations required by the test.

The comparison between groups makes it possible to distinguish tasks that are critical mainly for regional employees from those that generate more transversal difficulty. AT12 is the clearest case of a PA-specific criticality: regional employees reach a mean value of 3.88, while the other groups remain at lower values, between 1.89 and 2.00.

This difference indicates that the final activity produced a particularly marked cognitive load for the administrative-technical profile of Public Administration, which had to manage a step in which the use of the tool had to be accompanied by a more conscious reading of the data produced.

A different behavior can be observed for AT03, which maintains relatively high values across all groups: 2.88 for regional employees, 2.44 for CEFS 24, 2.58 for BIM&CM students, and 2.42 for doctoral students, research fellows, and researchers. This pattern makes AT03 a more general cognitive node of the test, capable of generating complexity even in groups with greater familiarity with digital tools, modelling, or technical procedures. A similar consideration can be extended to AT08, which reaches the highest value among BIM&CM students, equal to 3.13, and contributes significantly to the overall mean of the comparative table, where it reaches 2.46. The presence of high values across diverse groups suggests that some activities present a complexity linked to the nature of the required operation and to the need to correctly read, transform, or verify information.

Overall, the results appear coherent with the nature of the activities considered. Perceived complexity increases in tasks that require information structuring, control of data coherence, parameter management, and the transformation of information into a verifiable output. The creation of shared parameters, their implementation as project parameters, and the calculation of the total cost are steps in which the technical operation also assumes an interpretative dimension. The participant must understand what is being produced, where the data are located, how they are retrieved from the model, and how they become readable through schedules, tables, or final results.

Tasks with lower mean values, such as AT04, AT09, AT10, and AT11, seem to correspond to more guided, linear, or procedural steps. In these cases, the perceived cognitive load is lower because the activity requires the execution of circumscribed operations, with a lower level of integration between concepts, checks, and data restitution. The difference between these tasks and the more critical ones confirms that, within the same exercise, perceived difficulty varies according to the information density of the required action.

This evidence plays a key role in validating the training framework. The Activity Perception Table makes it possible to identify the points in the sequence where participants may encounter greater difficulty, slow down, make mistakes, or require support. The perceptual data therefore complement the assessment of the practical test, offering a useful key for understanding the relationship between operational activities, learning, and cognitive load. For a pathway addressed to Public Administration, this reading is particularly relevant, because it shows that the most delicate activities are those in which BIM is used as a tool for organizing, controlling, and restituting information.

The training consequence is the need to strengthen, in a targeted way, the steps with higher LCAP values. This can be done through guided examples, preparatory exercises, intermediate procedural checks, moments of progressive verification, and a more careful distribution of support during the test. In particular, for regional employees, the data suggest focusing attention on the tasks related to parameterization, information coherence, and the production of the final output. These are the moments in which the exercise most clearly reveals the transition from the operational use of software to the understanding of BIM as a tool for governing information for Facility Management.

7.4.6 End-of-course questionnaire for the university course

Alongside the evidence produced by the practical test and the post-test restitution, the validation of the Training Framework includes a second channel of observation, used specifically within the experimental university course ***"Modellazione Digitale di Impianti"***. This consists of the **end-of-course questionnaire** administered through *Google Forms*, designed to collect evidence on the perceived effectiveness of the training, the usefulness of the contents addressed, and the coherence of the teaching experience with the objectives of the course. The full questionnaire is provided in *Annex VI,* in order to make the structure of the tool and the questions submitted to participants transparent.

The decision to limit its use to the experimental university course depends on the specific nature of this training activity. Unlike the common practical test, which was designed to be comparable across different groups through operational tasks and LCAP values, the final questionnaire was developed to read the overall experience of a longer pathway, structured through lectures, exercises, applied moments, and progressive activities. For this reason, the responses collected are not used as a direct measure of acquired competence, but as complementary evidence of the perceived quality of the training structure.

Within the validation process, the questionnaire therefore plays an interpretative role. It makes it possible to understand how participants assessed the course in terms of usefulness, clarity, transferability, and capacity to connect digital modelling with operational objectives typical of BIM oriented towards control, data structuring, and output verifiability. In this sense, the tool complements the observable performance produced in the practical test, offering a broader reading of the training experience and of the way in which students perceived the value of the pathway in relation to competences applicable in real contexts.

The questionnaire was organized as a guided sequence of sections. A summary of its architecture is shown in Figure 85, which makes the logical flow visible: consent, participant profile, engagement, effectiveness of the mixed learning setting, perceived competences, perceived impact, and finally a differentiated branch according to the participant's role, whether public official or university student. This aspect is methodologically relevant because it avoids a single undifferentiated grid and makes it possible to collect specific elements in relation to two profiles which, although sharing the same teaching pathway, have different expectations and criteria of usefulness.

Among the synthetic results reported, some evidence is particularly useful because it directly relates to the objective of training governability. First, a significant share of responses assigns high values, 4–5, to the statement concerning the acquisition of the ability to verify the coherence/information quality of the model (Figure 86). This point is crucial because it shifts the focus of training from "knowing how to use Revit" to "***knowing how to check an output***", that is, to the kind of capacity that a Public Administration must build in order to reduce external dependence and make the verification of deliverables sustainable.

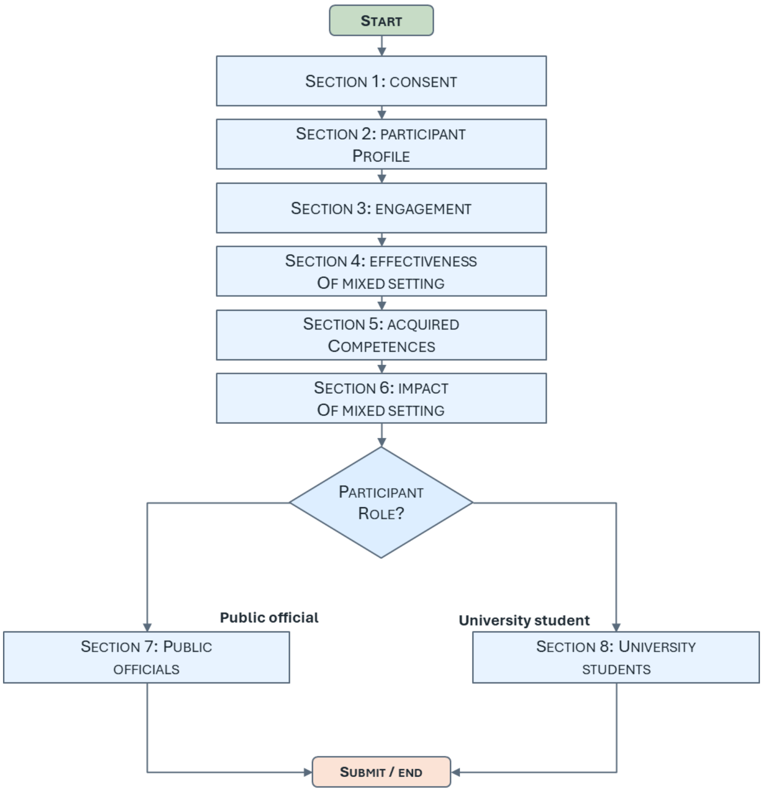


Figure 85 – Structure of the end-of-course questionnaire "Modellazione digitale d'impianti": sections and conditional path according to the participant's role. [Author's elabortion]

A second set of evidence concerns the perceived ability to interpret the existing condition and translate it into an information model (Figure 87). Here too, the item is relevant because it captures a typical step in management: the need to transform real data or problems – space, asset, configuration – into structured, coherent, and therefore usable information.

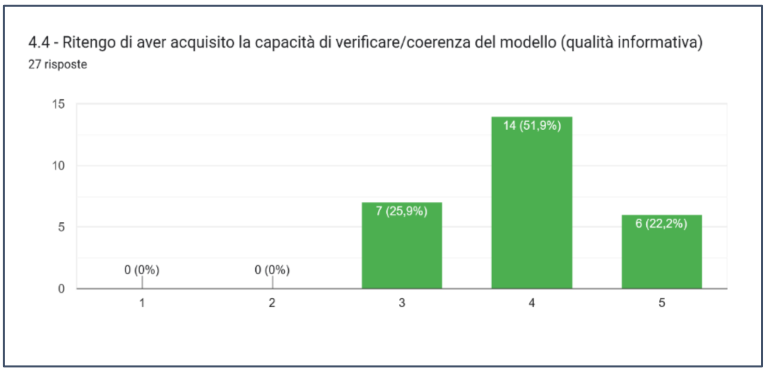


Figure 86 – Result for the item: "*I believe I have acquired the ability to verify the coherence of the model (information quality).*" Response distribution on the rating scale, where 0 = not at all and 5 = very much. [Source: Google Forms results; Author's elaboration].

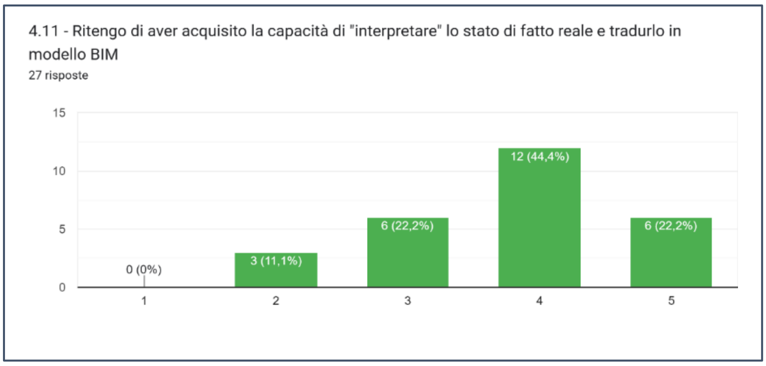


Figure 88 – Result for the item*: "I believe I have acquired the ability to 'interpret' the real existing condition and translate it into a BIM model."* Response distribution on the rating scale, where 0 = not at all and 5 = very much. [Source: Google Forms results; Author's elaboration]

A further useful element, especially in relation to the logic of the mixed class and the collaboration between different profiles, concerns the perception that the presence of both students and public officials improved the quality of the experience (Figure 88). This evidence is not presented as causal proof, but as an indicator of coherence between the teaching structure and the training objective: if the mixed setting is perceived as improving the experience, then the methodological choice to integrate different profiles appears at least compatible with the participants' experience.

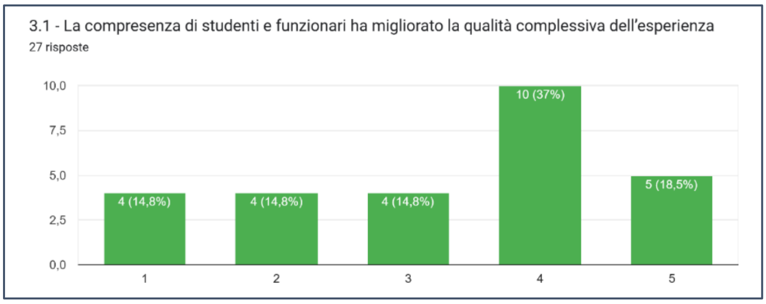


Figure 87 – Result for the item: *"The co-presence of students and public officials improved the overall quality of the experience."* Response distribution on the rating scale, where 0 = not at all and 5 = very much. [Source: Google Forms results; Author's elaboration[

A fourth result of interest concerns the perceived usefulness of the experience for future professional development (Figure 89) and the willingness to recommend this training approach (Figure 90). Although these indicators are perceptual, they are relevant because they touch on two dimensions that directly affect the sustainability of a framework: perceived usefulness, which supports motivation to use what has been learned, and recommendability, which signals the credibility of the structure in the eyes of those who experienced it.

Finally, the questionnaire includes an open or multiple-choice item concerning the most valuable aspects of the mixed class (Figure 91). This evidence is useful because it makes it possible to understand which components are recognized as most significant: not only the technical dimension, but also aspects such as work organization, communication and collaboration, awareness of constraints and needs, and greater attention to quality. This type of evidence is coherent with the overall approach of the chapter, in which training is understood as the construction of operational capacities and control criteria, rather than as the mere transmission of content.

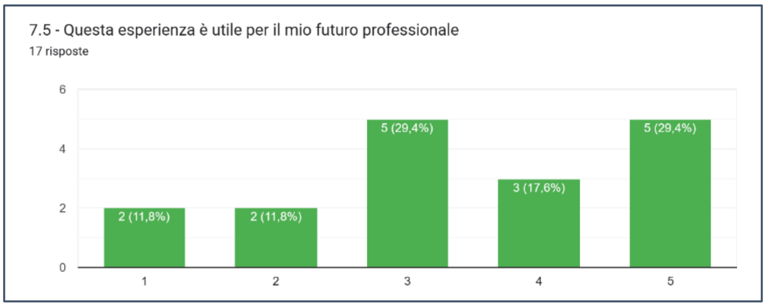


Figure 90 – Result for the item: *"This experience is useful for my future professional career."* Response distribution on the rating scale, where 0 = not at all and 5 = very much. [Source: Google Forms results; Author's elaboration].

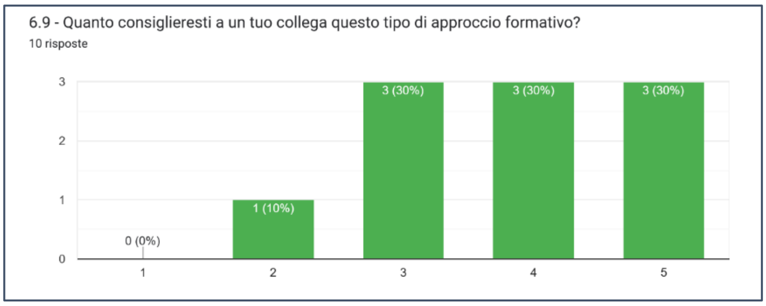


Figure 89 – Result for the item: *"How much would you recommend this type of training approach to a colleague*?" Response distribution on the rating scale, where 0 = not at all and 5 = very much. [Source: Google Forms results; Author's elaboration].

Overall, the end-of-course questionnaire helped to integrate the validation process with a reading of perceived effectiveness: capacity for control and verification, interpretation of the existing condition, usefulness of the mixed setting, and perceived transferability of the experience. Within this chapter, its function is to strengthen the argument that training does not produce participation alone, but also awareness and orientation towards control – dimensions which, in a Public Administration, directly affect the possibility of making models and deliverables governable.

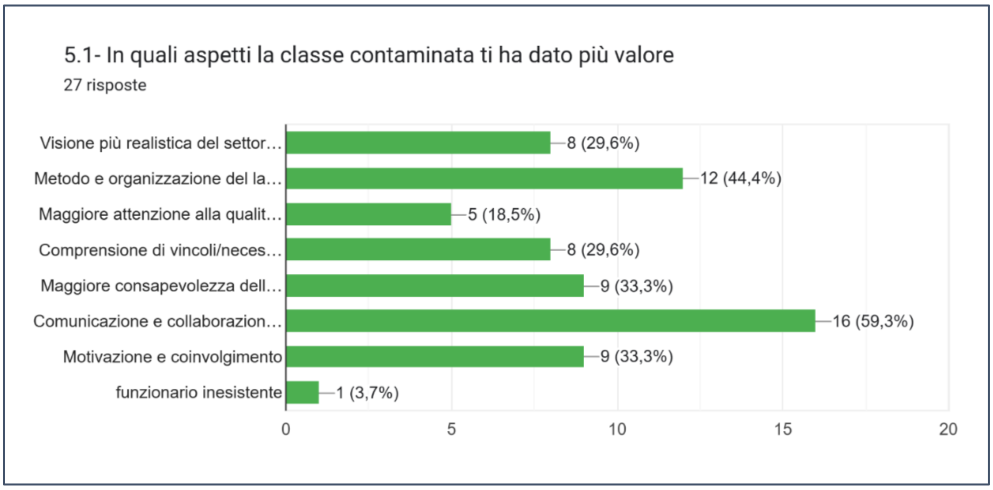


Figure 91 – Result for the item: *"In which aspects did the mixed class provide you with the most value?"* Response distribution by category. [Source: Google Forms results; Author's elaboration].

7.4.7 Three dimensions, three traces, one logic of comparability

The evidence collected is distributed across three dimensions coherent with the declared approach**: profiling, operational performance**, and **perception of complexity**. Their usefulness derives from the fact that each dimension leaves verifiable and, above all, comparable traces across participants and cohorts. This tripartition makes it possible to read validation as a unified device: each tool contributes to reducing interpretative ambiguity and to making the relationship between learning and enacted capacities discussable.

Profiling provides a minimum reference for contextualizing the test. It makes the declared starting point explicit and allows the results to be interpreted in light of the heterogeneity of the groups involved. In a framework oriented towards comparability, this initial reference is essential: it makes the test readable as a performance situated within a profile, rather than as an isolated result.

Operational performance produces an observable trace along a constrained sequence. Comparability is built through intermediate outputs and through a structure that makes the key steps of the process recognizable in a stable way across participants. The mandatory sequence and the production of artefacts for each step make it possible to read execution along the pathway, identifying where slowdowns, uncertainties, and errors are concentrated, and linking them to specific and verifiable tasks.

The **perception of complexity**, collected punctually and then returned in a structured form, introduces an activity-based reading. It makes it possible to identify where cognitive load tends to accumulate along the sequence and to distinguish differences between tasks. The value of this dimension lies in its interpretative function: it complements the performance-based reading by highlighting the steps perceived as more demanding, without shifting the focus of validation away from observable performance.

The coherence of the protocol emerges from the possibility of reading these three dimensions together. Validation is therefore based on a set of evidence that makes learning interpretable along the sequence and, consequently, improvable. Here, the chapter consolidates its main argument: a training framework is defensible when it makes traceable the relationship between what participants declare, what they are able to do under comparable conditions, and where they perceive difficulty along the pathway. This logic, made explicit and documented in the annexes, closes the validation section and prepares the overall synthesis of the Training Framework.

7.5 Comparison with UNI 11337 roles

7.5.1 Roles provided by UNI 11337

To strengthen the transferability of the Training Framework and move the discussion on roles beyond the scale of the regional case alone, the chapter introduces a comparison with the roles referred to by UNI 11337 in BIM processes. This reference is useful because it provides a recognizable and shared vocabulary through which responsibilities and areas of oversight can be described without relying on ad hoc definitions. The comparison is therefore concerned with the clarity of functions: which responsibilities must be overseen in order for BIM–FM information continuity to be maintained over time, and which operational traces make it possible to recognize that such oversight actually exists.

In the public-sector context, the existence of a formally appointed role does not in itself guarantee that the corresponding function is covered, just as the coverage of a function may exist even when the role is not explicitly named. Responsibilities tend to be distributed across several actors and to intersect different areas: client-side governance and procedures, management/FM, technical offices, procurement and legal support, information systems, and security.

This distribution is physiological, but it generates a typical problem of governability: when responsibilities remain implicit, or are exercised discontinuously, the information demand tends to expand without a stable criterion, checks become inconsistent, and operational use loses continuity. The reference to UNI roles makes it possible to read this risk in a more controlled way, because it focuses attention on a precise point: the presence of effective and verifiable responsibilities, regardless of how the organization allocates them in terms of people or offices.

The comparison is particularly useful because it also clarifies the center of gravity of BIM when read from a BIM-FM perspective. Information continuity is not played out only in the production of the model, but in the capacity to keep four steps coherent: demand, delivery, verification, and use. At this level, the UNI roles become an ordering tool, because they make it possible to relate different responsibilities to four macro-areas that a Public Administration must oversee in a recognizable way.

The first macro-area concerns the **governance of information demand and acceptance rules**: what is required, with which operational motivation, according to which verifiability criteria, and under which minimum conditions a delivery can be accepted and made usable. This is where decisions that affect the entire process are located: the selection of controllable requirements, the definition of outputs coherent with the intended uses, and the sustainability of checks in relation to internal resources.

The second macro-area concerns **coordination and quality control**: coherence between information contents, repeatable checks, management of non-conformities, and the capacity to maintain a stable level of reliability in deliverables. This oversight becomes decisive when models and outputs are produced in complex and distributed contexts, because BIM–FM continuity is weakened above all when quality is treated as an episodic control rather than as a procedure that can be applied consistently.

The third macro-area concerns the **production and disciplinary structuring of information**: coherent population of data and information contents according to the intended uses. Here, the point is not to "model more", but to structure what is needed in a legible and searchable way, while respecting shared coding and parameter rules. This is the level at which the object shifts from a geometric element to an information unit that can be extracted, checked, and transferred along the chain.

The fourth macro-area concerns the management of the sharing environment and information flows, namely the CDE: versioning, access, publication, traceability, and preservation of evidence. In a public-sector context, this oversight has particular weight, because traceability affects the ability to reconstruct decisions, checks, delivery states, and responsibilities, especially when information must remain usable during operation and across subsequent cycles.

Within this framework, the *BIM Manager*, *BIM Coordinator*, *BIM Specialist*, and *CDE Manager*, as referred to by UNI 11337, are understood as a system of functions that explicit the location of decisions, checks, and responsibilities along the information chain. Alongside this system, there is also a transversal oversight of information continuity, which is particularly sensitive in Public Administration because it operates at the point of contact between requirements, checks, updating, and operational use. This oversight helps to maintain coherence over time, especially when responsibilities are distributed across different offices and when activities risk fragmenting into separate tasks without stable coordination.

7.5.2 Functional map for PA: from BIM roles to verifiable responsibilities

Interpreting UNI roles as **functional categories** makes it possible to perform a simple but relevant methodological operation: moving from a list of ***"nominal"* roles** to a **map of responsibilities** that can be verified through traces and outputs. In a PA, the issue is not whether a *BIM Manager* or a *CDE Manager* formally exists, but whether the corresponding functions – governance of demand, coordination and quality, production/structuring of information, and management of CDE flows – are effectively overseen and made observable. In this sense, the standard provides a useful vocabulary as a control framework (UNI 11337), while the Training Framework makes it possible to connect these functions to capacities and evidence – artefacts, tests, traces – that make coverage less dependent on a single person and more sustainable over time.

This step is directly connected to the discussion developed in the previous chapters on the figure of the **Digital Information Continuity Officer**, introduced as a function for overseeing information continuity along the chain of request, delivery, acceptance, and updating. Here, the DICO is taken up again with a specific function: making explicit the need for a transversal oversight that cuts across the UNI categories without overlapping with them. Its usefulness, in comparison with the BIM roles provided by the standard, lies in its capacity to occupy the connecting space between responsibilities that often remain separate: governance of demand, checks, management of documentary flows, and updating during operation.

The map proposed in Table 21 summarizes this logic in operational form. For each functional category, the table indicates three elements: (i) the core responsibility that must be overseen in a BIM–FM-oriented Public Administration; (ii) the prevailing K–A–C component required, used as a design criterion to connect functions and training pathways; and (iii) examples of evidence coherent with the tools actually used in the chapter and with the materials collected in the Training Toolkit. Here, the K–A–C triad maintains an operational meaning: it helps distinguish functions that mainly require knowledge and governance capacity, functions that require observable abilities in production and control, and functions that require continuity of oversight as an organizational competence.

This map performs two functions. The first concerns the legibility of responsibilities: it offers an ordering criterion for recognizing which forms of oversight must be covered for BIM to become usable in FM, even in the absence of an organizational chart with dedicated roles. The second concerns the connection with training: the map makes explicit the link between the function to be overseen, the capacity to be built, and the traces that make that capacity verifiable. This step consolidates the central argument of the chapter: training produces value when it builds internal capacities that remain observable and sustainable over time, through outputs and control tools.

Table 21 – Comparative matrix between UNI 11337 functional role categories and the DICO profile in the Public Administration BIM–FM context [Author's elaboration].

Functional category	Key responsibility in the PA context (BIM-FM)	Prevailing component	Verifiable evidence
Governance of demand, *BIM Manager*	Define controllable requirements and clear acceptance criteria, keeping the information demand sustainable over time.	K + C	Elicitation and prioritization outputs, including to-do lists, Eisenhower matrices, *LimeSurvey* cognitive questionnaire results, and pathway deliverables showing controllability and acceptance criteria.
Coordination and quality control *BIM Coordinator*	Check deliverable coherence, apply repeatable controls, identify critical issues, and manage information quality.	A + C	Versioned Revit test files and intermediate outputs from AT00–AT12, combined with LCAP scores and the Activity Perception Table to identify critical tasks and support needs.
Production and disciplinary structuring of information BIM Specialist	Structure data according to intended uses, turning spaces and elements into searchable and verifiable information.	A, with a K basis	Revit test outputs on parameterization, schedules, tagging and export/import, with data-to-output traceability and Google Forms feedback on model verification and interpretation.
Management of the sharing environment and flows *CDE Manager*	Govern versions, access, publications, traceability, and organization of deliverables within the CDE.	K + C	Evidence from prioritization matrices and *LimeSurvey* responses on CDE awareness, supported by progressive task-based file versioning during the practical test.
Oversight of information continuity, *DICO*	Maintain continuity across request, delivery, verification and use, coordinating actors, routines and update cycles.	C	Integrated evidence from *LimeSurvey* profiling, versioned practical-test outputs, LCAP activity perception data, Google Forms feedback, and prioritization tools such as to-do lists and Eisenhower matrices.

7.6 Operational launch of the BIM Office in Regione Piemonte

The operational launch of the **BIM Office** in *Regione Piemonte* (Figure 91) represents a decisive step in the pathway reconstructed in this chapter, because it translates the work developed at the training, experimental, and methodological levels into a stable organizational form. The trajectory outlined in the previous sections has shown that BIM–FM continuity requires trained people, verification tools, the ability to read models, and awareness of the relationship between data, processes, and managerial use.

At a certain point, however, these conditions must find a clear institutional location, capable of giving operational continuity to the competences that have been built. It is precisely within this transition that the activation of the regional BIM Office is situated.

Figure 92 – Official opening day of the BIM Office of *Regione Piemonte*. [Author's photo and elaboration].

The official press release, also published by *Piemonte Informa* on 15 March 2024 (Figure 92), makes it possible to locate this moment precisely, presenting it as the ***"official baptism"*** of a project launched about a year earlier in collaboration with *Politecnico di Torino* (Regione Piemonte, 2024).

The press release also specifies an organizational and material aspect of particular relevance: the office was inaugurated in a room inside the *Grattacielo Piemonte*, with dedicated workstations. This makes it explicit that BIM is being adopted by the Region as an internal operational practice, and not as an episodic initiative or one external to the administration.

This step is also significant in the way it is publicly described. The press release presents *Regione Piemonte* as one of the first Public Administrations in Italy to activate an office specifically dedicated to BIM, assigning this choice a pioneering character and a clear institutional positioning (Regione Piemonte, 2024).

However, the relevance of this information does not concern only its communicative value. The institutional text highlights several aspects that directly correspond to the logic developed in this thesis: BIM is described as a system capable of coordinating graphic and alphanumeric information; it is linked to the management of a complex building; and it is presented as a support for maintenance planning, systems management, and the activities carried out within the building.

The statement by the Regional Director of Heritage, is particularly relevant in this sense, because it explicitly connects the usefulness of BIM to the **Operation and Maintenance phase**, recognising the value of updated information for building management (Regione Piemonte, 2024).

Figure 93 – Social media post by *Alberto Cirio*, President of *Regione Piemonte*, on the inauguration of the BIM Office within the regional administration, showing the use of digital modelling and immersive technologies for building information management. [Source: Alberto Cirio's social media profile]

The opening of the BIM Office therefore constitutes a coherent outcome of the pathway illustrated in this chapter. The training described in the previous sections worked on the construction of internal capacities: understanding processes, reading information demand, using tools in a guided way, managing structured tasks, and checking outputs.

With the establishment of the office, these capacities enter a more stable organizational dimension and become part of an internal safeguard. This is the deeper meaning of the operation: giving continuity to a function that concerns the quality of information, its verifiability, and its usability over time.

In the case of *Grattacielo Piemonte*, this need is particularly pressing. It is a complex building, with a high density of building systems, articulated uses, and a strong need for coordination between building components, systems, spaces, activities, and the actors involved in management. In this configuration, data quality does not have merely descriptive value; it has a direct impact on the possibility of planning interventions, quickly retrieving reliable information, tracking modifications, and linking models, documents, and management activities.

The BIM Office is therefore established as a place for overseeing this operational chain: an internal point within the administration where information demand can be formulated with greater awareness, deliverables can be read and checked, and information can be kept coherent with management uses.

For this reason, the opening of the **BIM Office** can be read as the point at which the **People pillar** acquires a recognizable organizational form. Training remains essential, because it builds vocabulary, method, capacity, and awareness. The office allows these acquisitions to take root within an administrative device, to be translated into repeatable practices, and to feed an internal memory of the organization. In more concrete terms, this means maintaining and updating control criteria, supporting the information quality of models, fostering the connection between BIM and management, interacting with directorates and external actors, and accompanying the progressive structuring of routines and responsibilities.

The opening of the BIM Office in *Regione Piemonte* should therefore be interpreted as a threshold in the maturation of the BIM–FM pathway: **a threshold at which experimentation is consolidated into an internal safeguard, and investment in people begins to translate into durable administrative capacity**.

7.7 From training as an event to capacity as organizational infrastructure

The pathway developed in this chapter has connected three levels that, in the transition towards BIM–FM in the public sector, often tend to follow separate trajectories: people and competences, the design of training pathways, and organizational stabilization. Read together, these levels show that the issue concerns the construction of the conditions through which models, requirements, and processes can be governed over time by an internal capacity of the organization.

The outputs produced are: (i) a validated Training Toolkit, (ii) a decision tree for selecting training pathways and expectations according to roles, and (iii) the operational launch of the BIM Office of *Regione Piemonte* as an organizational safeguard. The coherence between these elements is the point that closes the chapter: each output performs a distinct function, and their combination provides a proposal that can also be used beyond the single experimentation.

The **Training Toolkit** represents the operational repository of the work carried out: tools, briefs, and materials that make it possible to replicate the framework while maintaining transparency and verifiability. The Toolkit corresponds to the structured set of annexes and artefacts made available precisely to prevent the proposal from remaining tied only to a narrative account. Validation gives the Toolkit a methodological anchor: the tools used produce comparable evidence, and therefore evidence that can be discussed and improved. The output, in this case, concerns practical transferability: an organization adopting the framework has access to a set of materials that makes it possible to structure activities, collect evidence, and maintain coherence between objectives and checks without having to reconstruct the entire structure from scratch.

The **decision tree** (Figure 94) constitutes the most operational synthesis of the entire chapter. Its role is to transform the framework into a rule for selection: it makes explicit which pathway should be activated according to prevailing responsibilities and needs, together with a set of expected outcomes and coherent evidence. This element is central because it responds to a typical constraint of Public Administration: time and resources are limited, and training requires a justifiable selection. The tree makes it possible to connect roles and responsibilities to a minimum effective pathway, avoiding random choices and making the link between "who must oversee what" and "which capacity must be verified" legible. The figure summarises this logic as an applicative device.

The **operational launch of the BIM Office** completes the picture because it transfers training capacity onto a stable organizational level. The chapter has shown that, in a public organization, BIM–FM continuity depends on the possibility of maintaining coherence over time between information demand, checks, and operational use. The office constitutes the place where this coherence can be overseen as a routine: criteria, controls, traceability, updates, connections between offices, and external interfaces. The opening event represents an important institutional threshold; full operability requires an internal structure made up of trained people and assigned responsibilities. On this point, the national regulatory framework explicitly recalls the need for an organizational act defining structures and safeguards for the adoption of digital information management methods and tools (D.Lgs. 36/2023, art. 43; Annex I.9). Within this logic, the BIM Office acquires value when it is established as a stable function, with adequate competences and repeatable working mechanisms.

Read together, the three outputs describe a clear chain: the Toolkit makes the structure replicable and the evidence explicit; the decision tree makes the pathway selectable and the choice governable; the BIM Office makes the oversight of continuity sustainable over time. This set therefore produces a unified outcome: training is treated as an infrastructure of internal capacity, capable of supporting the governability of BIM–FM over time and reducing dependence on episodic initiatives.

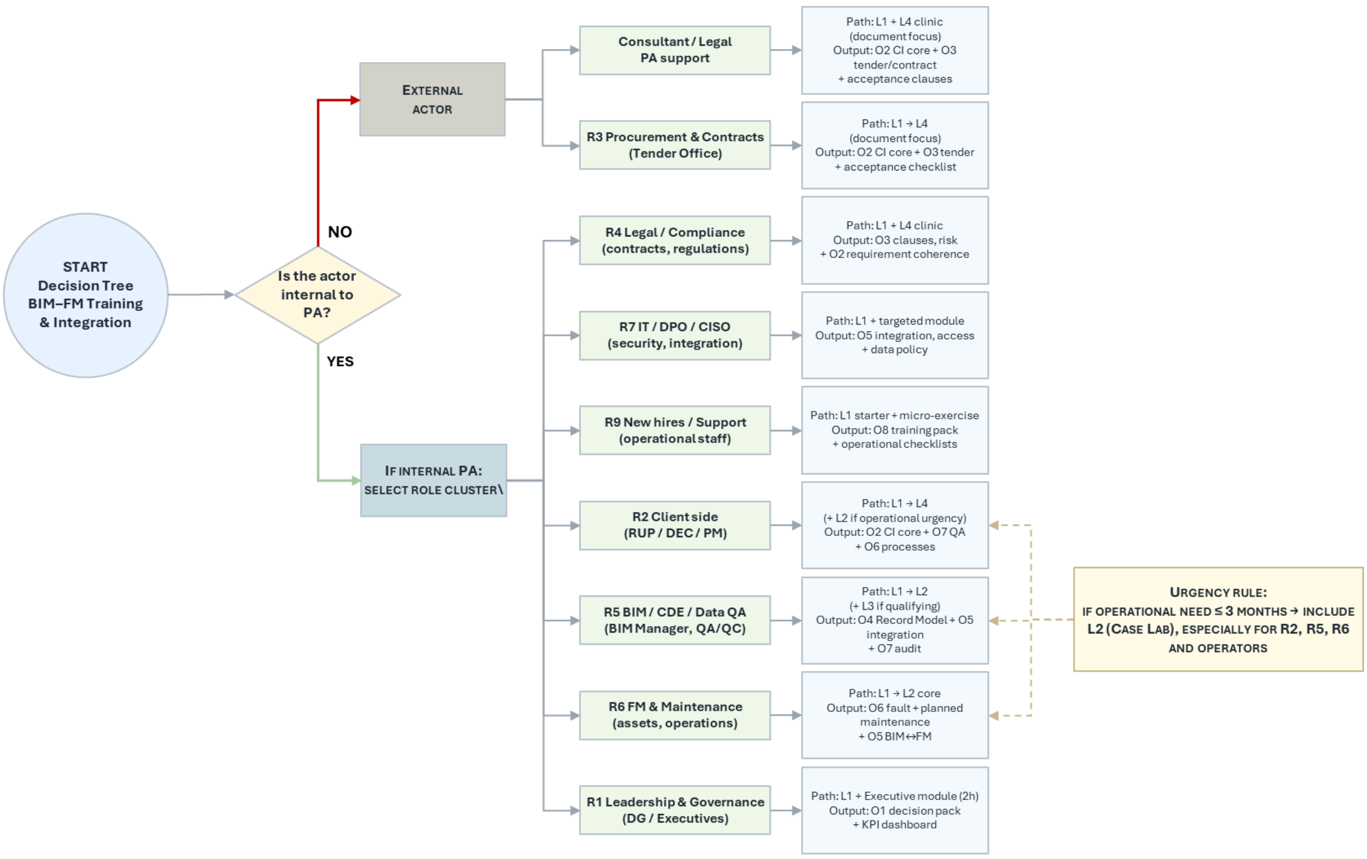


Figure 94 – Decision tree for selecting the BIM–FM training pathway: role clusters and prevailing needs as inputs for defining pathway, expected outputs, and associated evidence. [Author's elaboration]

Chapter 8

Drawing for FM 5.0: Human-Centerd Visualization and FM in PA

8.1 FM 5.0 beyond technology: people, processes and organizational maturity

In the TRP Project, the issue of digital Facility Management arose in very concrete terms from the very beginning. Having a BIM model available, connecting it to a management platform, or experimenting with new visualization tools was not, in itself, sufficient. The real question was understanding under what conditions these resources could become truly useful for the management of a complex public building. The point, therefore, was not just about the availability of data, but the ability to make it operational within daily management processes.

Indeed, data has limited value if it remains isolated in a model, a table, a document, or a platform. To become useful, it must be capable of being read, verified, updated, associated with a physical object, linked to a space, traced in a document, and used by someone within a procedure. In the case of the Regional Tower, this condition emerged clearly every time an attempt was made to move from the availability of information to its concrete application: locating a room, identifying a component, retrieving a manual, checking a delivery, opening or verifying a maintenance activity, or keeping the data aligned between the model and the FM platform.

It is from this awareness that the concept of FM 5.0 can be correctly introduced. In this research, the term – **FM 5.0** – indicates a state of organizational maturity in which digital technologies, reliable data, explicit processes, operational skills, and usable representations work together to support the management of the built environment. In the case study, tools such as the BIM model, *FactotuM*, codifications, information objects, operational views, and potential immersive interfaces began to generate value only when linked to concrete and recognizable actions. Digitalization thus becomes a resource for Facility Management when it successfully enters the normality of management processes, rather than remaining confined to technical experimentation.

This interpretation finds a direct reference in the **Society 5.0** paradigm, defined as a human-centered society capable of integrating physical space and cyberspace to support economic development and contribute to solving social problems (Cabinet Office of Japan, 2021). The most interesting aspect of this paradigm is not technological intensification in itself, but the way technologies are directed toward human and organizational goals. Literature has highlighted how Society 5.0 proposes a vision where the digital realm becomes meaningful when it improves well-being, accessibility, resilience, agency, and the quality of services (Fukuda, 2020). Applied to Facility Management, this perspective allows FM 5.0 to be viewed as a way to bring technology back to the service of people, places, and processes.

The definition of Facility Management proposed by ISO 41011 also helps clarify this transition. FM is described as an organizational function that integrates people, place, and process within the built environment, with the purpose of improving the quality of life of people and the productivity of the core business (ISO, 2024). This definition is particularly useful because it frames Facility Management as a field of relationships. Managing a building does not merely mean dealing with spaces, systems, or services separately; it means holding together users, places, activities, responsibilities, timelines, documents, and decisions. In the contemporary digital context, technology becomes a fourth component to be considered alongside people, places, and processes. Its role is to make these relationships more legible, controllable, and updatable.

In this research, the term **FM 5.0** is therefore used to indicate a human-centered configuration of Facility Management. The "5.0" numbering recalls the Society 5.0 paradigm and is adopted as an interpretive category, useful for describing a phase where the digital realm acquires value through its capacity to support human and organizational action. In the case of the P*alazzo Unico della Regione Piemonte,* this idea takes on a very concrete form: making the model, codes, documents, FM platform, and operational views usable by different actors within maintenance, control, updating, and decision-making processes. FM 5.0 thus describes a condition in which information can be read, verified, updated, and transformed into management action.

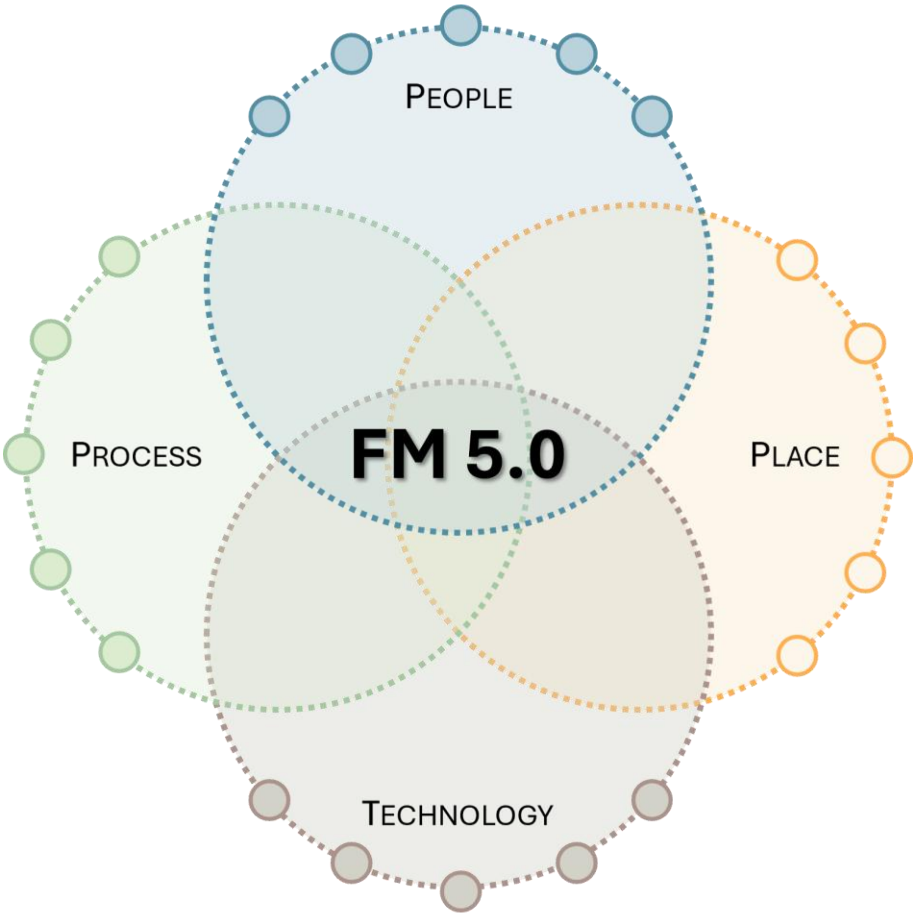


Figure 95 – Conceptual framework of FM 5.0 perspective. [Author's elaboration]

Figure 95 summarizes this way of understanding Facility Management. FM is placed at the center because it holds together dimensions that in practice often tend to separate: those who use the building, those who manage it, the spaces and assets, the administrative and maintenance procedures, and the digital tools called upon to support these relationships. In a complex public building like the Regional Tower, this integration is particularly delicate. The information model or management platform becomes truly useful when it helps answer very concrete questions: *Where is an object located? What space does it belong to? What document describes it? Who must verify it? When was it updated? What process uses it?*

For PA, this aspect takes on even greater weight. Information does not only serve to make a technical activity more efficient, but it supports administrative responsibility, service continuity, transparency, and asset control. In the *TRP Project*, an unstable code, a document not linked to the object, an unverified parameter, or a platform not aligned with the model are not mere digital imperfections. They become management problems, as they make it more difficult to control what has been delivered, update what changes, and reconstruct the relationship between design, operations, and maintenance. This difficulty is also recognized by the literature on BIM-FM in the public sector. Many experiences are still fragmented, built on specific cases, scarcely standardized, and difficult to transfer (Pinti et al., 2022). The crux of the matter is not merely introducing new tools, but understanding how the organization can absorb these tools. A BIM model, an FM platform, or an immersive environment can remain separate devices if they are not supported by clear roles, verifiable requirements, updating procedures, and adequate skills. The work carried out on the Tower demonstrates exactly this transition: the digital component becomes useful when it finds a precise place within a chain of responsibility and use.

The preceding chapters have built this position from multiple points of view. The work on the Record Model showed that the *Torre*'s as-built model, despite being a rich and rare informational baseline in the public context, required selection, verification, and normalization to become oriented towards Facility Management. The analysis of the processes and Information Requirements highlighted the need to link management needs, requirements, delivery, verification, and updates. The chapter dedicated to people and training highlighted the role of skills, because an information system remains fragile if there is a lack of personnel capable of reading, controlling, and maintaining it over time. Within this framework, FM 5.0 allows the research results to be reassembled into a single perspective. Record Model, Information Requirements, BIM-FM processes, training, and the BIM Office are not separate elements, but parts of the same problem: building the conditions for digital Facility Management to become governable within the Public Administration. At the core of this condition lies the trained operator, understood as a subject capable of using different tools because they understand their methodological, documentary, and procedural logic. Their action takes shape through floor plans, models, views, schedules, object data sheets, dashboards, coordination environments, georeferenced photographs, immersive interfaces, and linked documents.

This is where the discipline of **Drawing and Representation** comes into play. For data to become useful for management, it must take shape. It must be selected, ordered, made legible, and linked to a possible action. Graphic representation thus becomes a space of mediation between the information model, the physical object, the management process, and the operational decision. Within the framework of FM 5.0, Drawing contributes to transforming digital information into situated knowledge: knowledge that can be used by an actor, in a specific place, within a process.

8.2 Drawing as the operational interface of Facility Management

In the TRP poject, Drawing does not coincide solely with the production of views, sheets, or images of the model. Rather, it enters into the way information is selected, organized, and made usable. The available as-built model provided a very rich basis, but this richness was not sufficient to make it immediately operational for Facility Management. For an object to become useful for management purposes, it was necessary to understand how to recognize it, where to locate it, which data to associate with it, which documents to link to it, and which process it should enter.

This observation applies to all the test objects analyzed in the transition toward the Record Model. A **Room** becomes a spatial unit when it is connected to a code, a floor, a function, a use, and any workstations or activities; it is not merely an enclosed volume within the model. A **Door** becomes relevant for FM when it can be recognized, coded, linked to its documentation, and checked against the required information. A **Fan Coil Unit**, likewise, is not simply a modeled building-services component: it acquires management value when its representation makes it possible to locate it, connect it to a system, associate it with a maintenance procedure, and make it accessible within the FM platform.

The literature on external representations helps provide a theoretical foundation for this experience. Maps, diagrams, schemes, and graphic representations do not only communicate information that has already been defined; they also support reasoning, reduce cognitive load, and make complex relationships more manageable (Norman, 1992; Scaife and Rogers, 1996; Tversky, 1997). In Facility Management, this aspect is very concrete. Those who need to intervene on an object do not need the entire model, but rather a representation that enables them to understand where the object is located, which information is reliable, which document describes it, which procedure concerns it, and which action must be carried out. Drawing therefore becomes a form of mediation between information and operational work. For the maintenance technician, an effective representation of the fan coil is one that makes it possible to reach the component, recognize it, read the minimum information, consult the procedure, and record the intervention. For the FM manager, the same information may become more useful if aggregated in a dashboard, a criticality map, or a list filtered by priority. For the public administration technician, on the other hand, the most important view may be the one that allows them to verify consistency between the model, approved documents, codes, and the management platform. The same information base therefore produces different representations, because the actors are different and the decisions to be made are different.

This idea also helps clarify a point that is often underestimated in the BIM-FM transition. A very rich model can be difficult to use if all information is left on the same level. In the work on the Palazzo Unico, the issue was not to increase the amount of available information, but to understand which information was truly useful for management and in what form it should be made accessible. Tversky observes that maps and diagrams work because they select, organize, and highlight certain elements in relation to a specific purpose (Tversky, 1997). The same principle can be applied to FM: a representation is effective when it reduces information noise and brings to the foreground what is needed for action. The transition from the as-built model to the Record Model can be read precisely in this light. The federated model of the Tower was a significant starting point, especially in a public context where an as-built BIM base is not a given. In order to become useful for FM, however, it had to be filtered. Some information was retained, some verified, and some reduced or reorganized. In this transition, Drawing does not simply add a new image to the model. It establishes which relationships must become readable: the relationship between object and space, between object and document, between object and code, between object and procedure, and between object and management platform.

The relationship between graphic representation and alphanumeric information is one of the central aspects of this transformation. In Facility Management, the object must be visible, but it must also be queryable. It must have a position, an identifier, a relationship with space, a possible documentary link, an information status, and, when necessary, a connection with maintenance or inventory procedures. Geometry makes it possible to identify and recognize the object; alphanumeric information makes it possible to manage it. Drawing for FM is situated in this intermediate space, where visible form and queryable data support one another. This function becomes even more important when considering the plurality of actors involved in public Facility Management. Public administration technicians, the BIM Office, FM managers, RUPs, economic operators, maintenance technicians, platform managers, internal users, and external suppliers do not read the building in the same way. Each has different priorities, languages, and responsibilities. The concept of boundary object is useful for describing this condition: certain artifacts are able to maintain common recognizability across different communities while also being used locally according to specific needs (Star and Griesemer, 1989). Recent literature has confirmed the role of boundary objects in processes of knowledge integration between different actors and organizational contexts (Caccamo et al., 2023). BIM too has been interpreted as a boundary object, because it makes it possible to mediate between different disciplines, roles, and interests in design, construction, and management processes (Papadonikolaki et al., 2019; Wang et al., 2021).

In the case of public BIM-FM, this mediating function does not remain theoretical. During a review, a technical meeting, or a consistency check, a shared view can become the point around which a problem is discussed: where the object is located, which document describes it, which code identifies it, who must verify it, what status appears in the platform, and which decision needs to be made. Representation thus works as a common space. It allows different actors to look at the same problem without having to start each time from separate archives, misaligned files, or unshared technical languages. This common space can take different forms. In the BIM-FM process of the Tower, Drawing may be a simplified floor plan, a 3D view, a control schedule, an object sheet, a dashboard, an IFC viewer, a 360° photograph, or an immersive environment. These forms do not perform the same function and do not serve the same subjects. What they share is the possibility of connecting data to an object, a space, a document, a responsibility, or a process. In this sense, Drawing operates on two levels: it helps to understand dispersed relationships between model, documents, databases, and platforms; at the same time, it makes these relationships usable in maintenance, control, updating, and decision-making processes.

The BIM-FM logic therefore changes the traditional role of representation. Drawing, understood as a final document, certifies a state. In the digital context, however, representation can become a mode of access to an evolving information system. A view can be queried, updated, compared, linked to a document, or used to verify a deliverable. This interpretation is consistent with the logic of information management, according to which information must be produced in relation to a purpose, a recipient, and a use (UK BIM Framework, 2021). In Facility Management, the question becomes very practical: what information is needed, who needs it, when is it needed, and through which form should it be made accessible?

This leads to an important methodological consequence. The quality of Drawing for FM cannot be assessed only on the graphic clarity of the view. It depends on the consistency between geometry, alphanumeric information, coding, documentation, process, and responsibility. A clear view gains strength when it refers to reliable data. A database becomes usable when it finds comprehensible forms of access. A rich model becomes managerial when it is filtered according to its uses. Drawing for Facility Management constructs precisely these readable relationships between the physical object, the information model, the management process, and the operational decision.

8.3 Graphic and alphanumeric standards for FM-oriented representation

Taking Drawing as the operational interface of Facility Management leads to a very concrete question: what characteristics must a representation have in order to be truly useful for management? The case of the Regional Tower shows that the richness of the model and its operational usefulness do not automatically coincide. An object may be present in the model, visible in plan or in 3D, and still require additional work in order to become usable in FM processes. This work concerns coding, data selection, information verification, links to documents, and integration with the management platform.

The test objects analyzed in the transition from the as-built model to the Record Model made this difference evident. Room, Door, PDL/Workstation, Motorised Double Desk, and Fan Coil Unit belong to the same information system, but they do not pose the same type of problem. The Room functions as a spatial unit: it is used to locate activities, uses, occupancy, and relationships with workstations. The Door is a stable architectural element, useful when its position, code, characteristics, and associated documents are coherent. The PDL and the Motorised Double Desk introduce the issue of movable or semi-movable objects, for which the relationship with space and inventory must remain updateable. Finally, the Fan Coil Unit concentrates the complexity of building-services objects, because it requires position, system affiliation, technical data, maintenance procedures, and intervention history to be held together.

From this analysis, a working criterion emerges: the graphic standard must be calibrated to the management function of the object. For some elements, simplified geometry is sufficient, provided that the object can be located and queried. For others, it is useful to maintain greater technical recognizability. In still other cases, the main value lies in the link between object, space, document, and procedure. The graphic standard, therefore, does not concern only the shape of the object. It concerns the capacity of the representation to support precise actions: identifying, verifying, maintaining, inventorying, updating, and controlling. The distinction between LOG and LOI helps clarify this point. The geometric dimension describes shape, dimensions, position, and recognizability. The informational dimension assigns identity, relationships, function, responsibility, and management value. For FM, the problem is to define which geometry is sufficient in relation to use, and which information must be guaranteed so that the object can enter management processes.

The LOIN logic reinforces this approach, because it links information content to a purpose, an actor, and a moment in the process (UNI 11337-4, 2017; UNI EN 17412-1, 2021).

In *"Torre Regione Piemonte"*, some objects were already recognizable in the model, but not yet fully operational for Facility Management. The transition toward *FactotuM* required coherent identifiers, minimum parameters, documentary links, and stable relationships between objects and spaces. A geometrically simple component can be effective if it is coded, located, connected to a space, associated with a procedure, and updateable over time. The evaluation criterion is therefore not the visual richness of the object, but the possibility of querying, transferring, verifying, and using it. The graphic standard thus assumes a selective character. Geometry must allow the object to be located and its relationship with space to be understood. It must make it possible to recognize the element in the model or in the platform, distinguish it from similar objects, consult it in a coherent view, and, when necessary, compare it with its physical presence in the building. Constructive or technical detail is useful when it supports a management action. In a complex and systems-dense building such as the *Palazzo Unico*, excessively heavy geometry risks increasing consultation difficulty, file size, and the burden of updating.

The experimentation suggests a simple formula: FM requires sufficient **LOG** accompanied by coherent **LOI**. Geometry makes it possible to see, locate, and recognize the object; alphanumeric information makes it possible to manage it. The model must make it possible to query objects, connect them to documents and procedures, verify their status, update them, and make them available to the actors involved in management processes. This is the threshold that makes a representation truly oriented toward Facility Management. The alphanumeric level therefore becomes decisive. Stable identifiers are the first requirement. A persistent code connects the modeled object to the management platform, technical documentation, work orders, maintenance interventions, and subsequent updates. In the case study, this need was addressed through the relationship between objects, spaces, and management codes, including identifiers and attributes such as CSI_ID, EQ_ID, EQ_STD, SITO_ID, BL_ID, and FL_ID. These elements function as devices of informational continuity between the BIM model, the FM platform, registers, documents, and maintenance activities.

Coding constructs the operational identity of the object. A building-services component, a door, a workstation, or a room becomes manageable when it can be uniquely recognized over time, even when the view, software, exchange format, or process in which it is used changes. Coding makes it possible to connect an object to its position, function, relevant documents, related procedures, and interventions that modify its status. Without this continuity, the model, platform, documentation, and maintenance activities risk producing separate readings of the same object.

Alongside identifiers, minimum parameters become important. The analysis of the test objects shows that each category requires a targeted information set. For Rooms, the central elements are building, floor, room code, function, possible use, and relationship with workstations or activities. For Doors, the relevant elements are identifier, position, main characteristics, possible performance requirements, and documentary links. For furniture and workstations, the relationship with space and inventory is key. For Fan Coil Units, the parameters must support component localization, connection with the system, relevant standard, maintenance procedures, technical data, and the FM platform. This difference between categories shows that alphanumeric information must be organized starting from use. A parameter is useful when it enables an actor to perform an action: locate, filter, verify, authorize, maintain, update, or control. The quality of the model for Facility Management depends on the relevance, reliability, and updateability of information in relation to the intended uses. The absolute number of parameters matters less than their function within processes.

Another level concerns documentary links. In Facility Management, much decisive information is found in external documents: technical data sheets, operation and maintenance manuals, certifications, warranties, maintenance plans, specialist drawings, minutes, images, reports, and approved documents. FM-oriented representation must make it possible to reach these contents starting from the object, the space, or the process. This aspect carries significant weight in Public Administration, where the document retains administrative, evidentiary, and contractual value. Drawing for FM makes the document traceable at the point where it is needed, preventing it from remaining separate from the object to which it refers.

In the case of building-services objects, and in particular Fan Coil Units, this need becomes even more evident. The representation must hold together physical position, system affiliation, technical characteristics, accessibility, maintenance procedures, possible spare parts, manufacturer documentation, intervention frequencies, and activity history. The complexity of the object derives from the network of relationships that enables its management. For this reason, in the transition toward *FactotuM*, the most sustainable solution consists in defining a level of granularity capable of connecting the object to procedures and management uses, without generating a proliferation of subcomponents or parameters that are difficult to maintain over time.

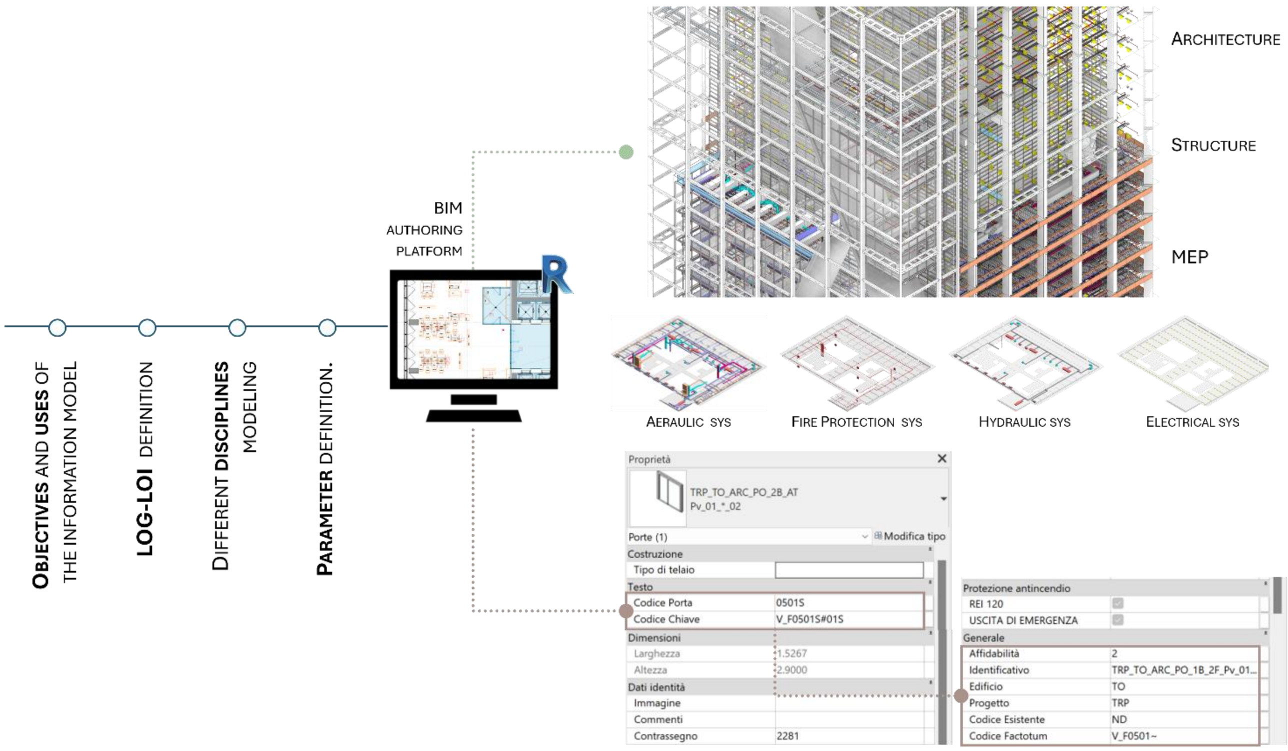


Figure 96 – BIM authoring process and information structuring required for FM-oriented model use. [Author's elaboration]

Figure 96 shows that FM-oriented representation already takes shape within the BIM authoring environment. It is in this phase that model uses, disciplinary structure, the level of geometric and informational development, parameters, and coding are defined. The decomposition of the model into architectural, structural, and building-services components makes the information more consultable and governable. The definition of parameters represents the point at which the graphic object begins to become a management object. If this structure is coherent, then subsequent views, exports, platforms, and interfaces also maintain a reliable relationship with the source information.

The synthesis of the test objects can be translated into a technical-methodological matrix. Table 22 shows how the management function of the object conditions the type of geometry, the necessary alphanumeric data, and the main limits to be considered in the transition toward Facility Management.

Table 22 – From experimentation on objects to FM representation requirements. [Author elaboration]

Test object	Prevailing management function	Necessary geometry	Critical alphanumeric information	Main limit identified
Room	Localization, space use, space management	Coherent and queryable spatial geometry	Space_ID, building, floor, function, possible use/occupancy	Updating over time of use, assignments, and spatial configurations
Door	Architectural element, access, documentary control	Recognizable and correctly located geometry	Object code, position, main characteristics, documentary links	Coherence between model, coding, and associated documentation
PDL	Workstation, relationship between space and use	Simplified and locatable representation	Workstation ID, relationship with Room/Space_ID, possible assignment or status	Mobility, updating, and variation of use configurations
Motorised Double Desk	Furniture/inventory, management of movable or semi-movable assets	Geometry sufficient for recognition and localization	Asset_ID, position, inventory data, relationship with space	Stability of the association between object, position, and use over time
Fan Coil Unit	Maintainable building-services component	Recognizable, locatable geometry connected to the system	EQ_ID, EQ_STD, CSI_ID, SITO_ID, BL_ID, FL_ID, maintenance procedures, technical data	MEP complexity, information granularity, connection between system, object, and maintenance

Table 22 highlights that each object acquires management value in a different way. For spaces, the priority concerns the stability of the relationship between geometry, code, and use. For architectural elements, what matters is the coherence between object, position, and documentation. For furniture and workstations, the main issue concerns mobility and updating. For systems, the critical aspect concerns the connection between component, technical system, and maintenance procedures. The standard therefore emerges as a system of rules capable of ensuring coherence while also recognizing the specificity of the objects.

A FM-oriented representation can be described as a combination of sufficient geometry, reliable information, stable identifiers, and operational links. Sufficient geometry allows localization and recognition; reliable information allows querying and verification; stable identifiers maintain continuity between systems; operational links associate the object with documents, procedures, activities, and updates. The balance between these components makes the representation effectively managerial. From here, the issue of interoperability emerges. In the BIM-FM context, interoperability means maintaining the relationship between object, attributes, classification, properties, documents, and processes recognizable when information passes from the BIM model to the FM platform, from a graphic view to a table, from an authoring environment to a viewer, and from a proprietary format to an open format. Interoperability concerns formats and exchanges, but also the meaning of objects, the responsibility for updating, and the rules for using information.

IFC viewers, dashboards, 360° photographs, VR environments, and XR tools offer more accessible, immersive, or immediate forms of model consultation. Their value depends on the quality of the information structure that feeds them. When objects, parameters, property sets, and operational links are governed, these tools become situated interfaces through which information is brought closer to management action.

8.4 From BIM authoring to IFC and XR: visualization as a situated tool

The transition from graphic and alphanumeric standards to advanced visualization requires a certain methodological caution. In digital Facility Management, IFC viewers, coordination platforms, dashboards, 360° photographs, VR, AR, and XR environments promise more immediate consultation of the model, improved spatial understanding, and a more direct relationship between the physical environment and digital content. In the work on the Regional Tower, these tools were interpreted as possible downstream interfaces within an already structured information chain. Recognizable objects, coherent parameters, readable properties, stable coding, and interoperable exchanges come first. Only then can visualization become truly useful for management.

A view, dashboard, or immersive environment acquires value when it responds to a precise condition of use. A dashboard is useful if it makes priorities, criticalities, backlogs, costs, frequencies, or progress statuses readable. A 360° photograph becomes useful if it makes it possible to compare the surveyed state with the expected state, or if it helps reduce ambiguity between model, document, and physical reality. A VR or XR environment can support orientation, understanding of spatial relationships, operator training, and contextual access to data and procedures. In all these cases, visualization works because it brings information closer to the moment in which it must be used.

The literature on XR technologies in the AECO sector confirms this interpretation. Immersive technologies can support operation and maintenance, inspection, training, remote assistance, spatial understanding, and technical decision-making; however, their integration into management workflows remains fragmented and still under consolidation (Casini, 2022). Studies on BIM-FM in the public sector also highlight the centrality of integrated approaches, shared standards, transferable information flows, and procedures that are sustainable over time (Pinti et al., 2022). Innovation takes shape when the interface dialogues with the information and management system that supports it.

In the case *"Torre della Regione"* the federated as-built BIM model, developed in the authoring environment and subsequently made queryable, exportable, and reconfigurable, made it possible to imagine different modes of access to information. The transition from the Revit model to consultation through IFC, viewers, collaborative platforms, or immersive environments requires an already organized information structure. Property sets, IFC class mapping, export rules, parameter selection, and correspondence between BIM objects and management objects constitute the point at which representation assumes a transferable semantic structure. The sequence can be described progressively: BIM authoring, parameter definition, object coding, property sets, IFC class mapping, IFC export, viewer verification, model coordination, and possible immersive access. Object localization, parameter coherence, the preservation of meaning in IFC mapping, and version control determine the quality of subsequent forms of consultation. Visualization, in other words, inherits the solidity or fragility of the information structure that precedes it. IFC assumes an important role here. In Facility Management, it can keep the relationship between geometry, properties, and object classification readable across different software environments. Its function is not exhausted in model export, but concerns the possibility of preserving a queryable and shareable structure. The delicate point is to maintain continuity between object, attributes, position, documents, processes, and responsibilities.

The relationship between semantics and visualization is therefore decisive. Properties, classifications, identifiers, and information relationships constitute the basis upon which a graphic view, a table, a viewer, or an immersive environment can become an operational tool. A solid information structure can feed different representations, adapting to different uses. The same object can be consulted in a 3D view, filtered in a schedule, queried in an IFC viewer, linked to a technical data sheet, visualized in a dashboard, or located in an immersive environment. The plurality of views depends on the stability of the link between object and information.

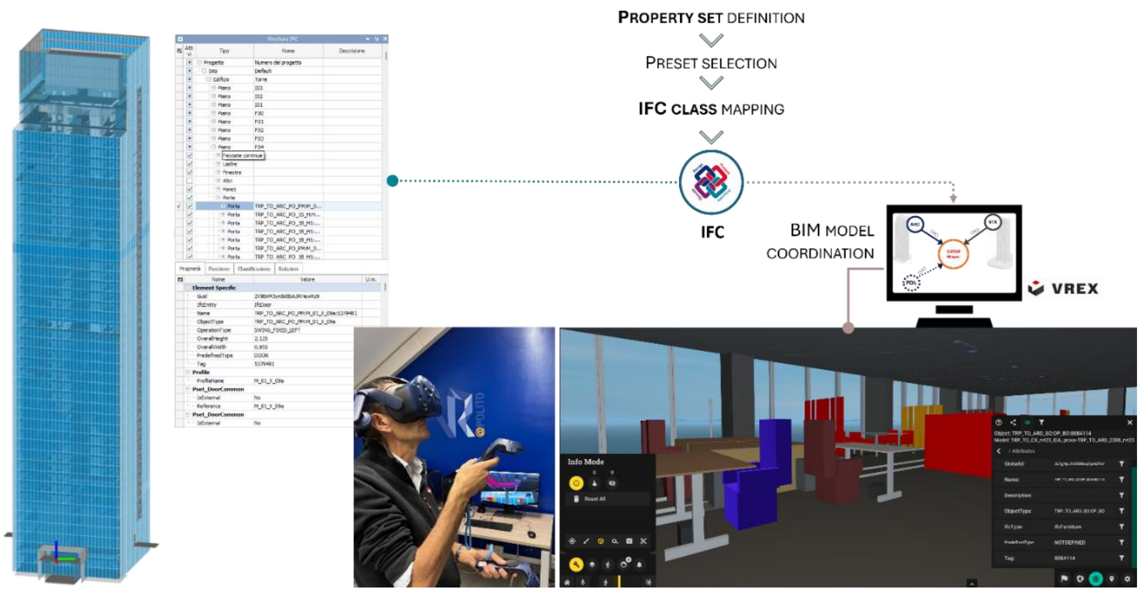


Figure 97 – From IFC semantics to immersive visualization for FM. [Author's elaboration].

Figure 97 represents this transition, that starting from the definition of property sets and the mapping of IFC classes, modeled information is made available in verification, coordination, and visualization environments. IFC viewers, collaborative platforms, and VR environments operate as subsequent devices for consultation and interaction. Their function is to make already structured information more accessible, understandable, and situated. The immersive environment thus becomes one of the possible interfaces through which the operator can access spatial, technical, and maintenance information in a form closer to the experience of the building.

The same reasoning applies to dashboards. A dashboard is useful when it organizes selected information in relation to a responsibility or a decision: monitoring the progress of work orders, identifying critical components, controlling the distribution of maintenance requests, verifying compliance with scheduled frequencies, and reading priorities by building, floor, space, or system. The dashboard is an intentional view of the information system, capable of making knowable what has been structured, validated, and updated according to shared rules.

The 360° photograph works in an analogous way. Its value lies in the possibility of connecting the image to a point, a date, an object, a progress status, a non-conformity, or a verification. Integrated into a BIM-FM logic, it can become a tool for comparing surveyed and expected states, supporting remote checks, documenting accessibility conditions, or recording evidence useful for maintenance. Its value derives from the connection between image, process, and verifiable information.

XR environments accentuate this condition. Visualizing a model at immersive scale, navigating a building, reading attributes, comparing components, or simulating an intervention can be useful for training and for certain management activities. For an operator, seeing a component in VR acquires value when the environment returns reliable and relevant information: correspondence with the real state, correct position, associated data, reference procedure, available documentation, and validation status of the information.

The human-centerd perspective of FM 5.0 makes it possible to evaluate these technologies according to their capacity to reduce the distance between information and action. For a maintenance technician, visualization is useful if it makes it faster to recognize a component, access a data sheet, understand a procedure, or document an intervention. For a BIM Office, it is useful when it enables control of coherence, properties, coding, and information statuses. For an FM manager, it is useful if it makes priorities and criticalities readable. For a Public Administration, it is useful when it strengthens traceability, verifiability, and control.

Visualization must therefore be designed starting from use. In some cases, a simplified plan view is sufficient; in others, an object sheet is needed; in still others, an IFC viewer, a dashboard, or an immersive environment is required. The plurality of interfaces becomes a resource when the information base is coherent. Drawing for FM 5.0 can be understood as a governed representational chain, capable of connecting the authoring model, IFC, viewers, dashboards, immersive environments, and management processes.

The relationship between BIM authoring, IFC, and XR therefore describes a transformation of representation. The authoring model organizes the primary structure of information; IFC allows this structure to be transferred and verified in interoperable environments; viewers and collaborative platforms enable its control and sharing; dashboards and immersive environments make it more accessible to the actors involved in management processes. Each step adds a mode of access. The quality of visualization remains linked to the quality of the process of modeling, coding, verification, and updating.

With structured and governed information, immersive visualization can become an operational interface. It brings information to the place and moment in which it must be used, bringing data closer to action and making the relationships between objects, spaces, procedures, and responsibilities more understandable.

8.5 From representation to action: actors, objects and processes

The path developed in the chapter leads to a very practical question: a representation for Facility Management must provide an actor, at a specific moment in the process, with the information necessary to understand a situation and act on an object. Drawing for FM 5.0 is configured as a system of views, sheets, models, maps, dashboards, and interfaces constructed in relation to uses. The question becomes: who needs this representation, to do what, on which object, and with what level of reliability?

The experience conducted on the case of the Regional Tower helps clarify the relationship between model richness and management usefulness. Information may be correct and yet be of little use; it may be available and yet not very readable; it may be present in the model and remain scarcely accessible to the actor who must use it. A geometrically essential representation may instead be very effective when it clearly connects space, object, code, document, and process. The reference criterion is the sufficient minimum information. The sufficient minimum information indicates the need to select and organize information according to a purpose. This position is coherent with the logic of information management, according to which information must be requested, produced, and delivered in relation to a defined use, recipient, and process phase (UK BIM Framework, 2021). Applied to Facility Management, this logic leads to differentiated representations: a criticality map for the FM manager, an object sheet for the maintenance technician, a control view for the BIM Office, a documentary screen for the RUP, and a simplified floor plan for the internal user.

In the case of PA, this distinction carries particular weight. The actors involved in management processes belong to different operational communities: service managers, public administration technicians, the BIM Office, the RUP, economic operators, maintenance technicians, platform managers, internal users, and external parties. Each reads the building through specific priorities: service continuity, administrative compliance, contract control, safety, accessibility, intervention times, costs, information updating, and documentary quality. An effective representation maintains a common information base and provides differentiated and readable views for the various subjects. The issue emerges clearly in the corrective and planned maintenance processes developed from the case study. In the corrective process, information must make it possible to report a problem, locate it, qualify it, approve it, transform it into a work order, record its execution, and verify its closure. In the planned process, information must make it possible to identify maintainable objects, associate procedures and frequencies, generate activities, control their execution, and update the system status. In both cases, representation connects request, object, space, procedure, responsibility, and information updating.

The same logic applies to the management of spaces, furniture, inventory, and documentation. A Room must be readable as a spatial unit, connected to codes, functions, occupancy, floors, and activities. The Fan Coil Unit must be recognizable as a technical component, located, connected to a system, a maintenance procedure, technical data, and an intervention history. A Door may acquire value in documentary control, in the verification of performance characteristics, or in the relationship with accesses and compartmentation. A PDL or Motorised Double Desk introduces the issue of mobility, inventory, assignment, and updating overtime. Drawing for FM therefore adapts to the management nature of the object.

To make this relationship between actor, process, object, and representative form explicit, the chapter proposes a synthesis matrix. The matrix clarifies a methodological principle: information becomes operational when it is associated with an actor who uses it, a process that justifies its existence, an object that constitutes its reference, and a representation that enables its reading. Representation is situated.

Table 23 – Actor–Process–Object–Representation Matrix for FM-oriented toward PA. [Author elaboration]

Actor	Process	Object	Minimum necessary information
FM Manager	Planning and control of scheduled maintenance	Fan Coil Unit HVAC components	Where the component is, how important it is, maintenance frequency, current status, backlog, costs or priority
Maintenance technician (EO)	Execution of corrective or scheduled intervention	Fan Coil Unit	EQ_ID, EQ_STD, position, accessibility, procedure, technical data sheet, last intervention, possible safety constraints
BIM Office	Information quality control and updating of the Record Model	Door coded assets	Object code, mandatory parameters, validation status, coherence between model, documents, and FM platform
PA technician	Verification of deliverables, compliance, and documentary traceability	Assets and linked documents	Approval status, associated document, revision, responsibility, date, relationship with object/space
Internal User	Fault report or request	Room / PDL	Room_ID or Space_ID, position, problem description, possible photo, perceived priority, contact person
FM Platform Administrator	Data management and coherence between FM platform and model	Room, asset, equipment	Building/floor/space codes, Asset_ID, Space_ID, reference tables, import status, mapping errors
BIM Office + FM Manager	Post-intervention information update	Fan Coil Unit / Door / Room	Intervention outcome, evidence, geometric or informational variation, validation, need for BIM/FM update

Table 23 shows that representation must be designed in relation to the subject who uses it. The maintenance technician needs a representation close to the object, capable of supporting field intervention. The FM Manager requires synthetic views oriented toward priorities, criticalities, and planning. The BIM Office works on coherence, coding, parameters, and validation. The RUP or public administration technician must be able to control traceability, responsibility, and documentary compliance. The internal user needs a simple representation, sufficient to locate and describe a request. The same information base generates different representations because tasks, languages, and responsibilities are different.

The matrix also makes it possible to clarify the role of the test objects within the thesis. They represent operational categories through which to observe the behavior of information in the transition from model to management. The Room highlights the relationship between space, use, and localization; the Door brings out the relationship between architectural object, coding, and documentation; the PDL and the MDD show the fragility of objects linked to changing use configurations; the Fan Coil Unit concentrates the problem of maintenance, building-services coding, the relationship with the system, and procedure. Considered together, these objects make it possible to understand the Record Model as a selective reorganization of information according to differentiated uses.

Drawing performs a connecting function between different levels. It maintains the link with the model and with the spatial representation of the building while, at the same time, connecting that representation to alphanumeric data, procedures, documents, responsibilities, and platforms. Its function consists in making consultable the relationship between database, CDE, FM platform, physical object, and operational process. Drawing works as an infrastructure of translation: it translates data into view, view into understanding, understanding into decision, and decision into verifiable action. This translation function reduces information fragmentation. In the management of a complex building, the BIM model, the FM platform, the CDE, and operational instructions can generate separate information environments. Drawing for FM 5.0 contributes to constructing forms of access capable of keeping visible the link between source, status, responsibility, and use of information. Representation must be readable and traceable. Traceability is particularly important for PA. In a public context, information serves to document a choice, verify a deliverable, control a contract, demonstrate the compliance of a procedure, preserve the memory of transformations, and ensure continuity between different subjects over time. A representation oriented toward public FM must preserve the link with sources, revisions, approval statuses, responsibilities, and updates. Knowing where an object is located is only part of the problem; it is also necessary to know whether the associated information is valid, who produced it, when it was updated, which document it refers to, and which process uses it.

The transition from representation to action requires a double coherence. The first concerns the information system: codes, parameters, objects, spaces, documents, and procedures must be aligned. The second concerns real management processes: information must support actual activities, decisions, and updates. FM 5.0 requires information, representation, process, and action to form a continuous chain.

Facility Management in Public Administration can be innovated when the PA is able to govern the relationship between people, places, processes, and technologies through reliable, use-oriented representations. In this framework, Drawing becomes a structural component of management capacity: it makes it possible to see the building as a system of relationships between spaces, assets, documents, activities, responsibilities, and decisions. The notion of Drawing for FM 5.0 can therefore be understood as a representational ecology. It includes models, plans, views, schedules, sheets, dashboards, viewers, immersive environments, documentary links, and platform interfaces. Their value derives from the capacity to keep the link between data, object, process, and actor stable. In this capacity to transform information into readable, verifiable, and shared action, Drawing assumes a central role in Facility Management 5.0.

FM 5.0 describes the possibility of constructing management environments in which technology is made governable through trained people, explicit processes, information standards, and operational representations. For a PA, this means equipping itself with models, platforms, and a culture of representation capable of connecting what is seen, what is known, what is decided, and what is done. Drawing for FM 5.0 is the device through which digital information becomes situated knowledge, administrative responsibility, and capacity for intervention on the built heritage.

Chapter 9

Discussion and Conclusion

9.1 Discussion

The research developed in this thesis makes it possible to discuss BIM–FM integration in Public Administration through the field of Drawing and Representation. **BIM** is interpreted as a **language for structuring information**, while **Drawing** assumes the role of a **critical and operational practice** through which this language acquires form, hierarchy, meaning, and usability for Facility Management. The case of the *Torre della Regione* has shown that the digital management of a complex public building requires representations capable of connecting model, physical object, code, document, platform, process, and responsibility. Plans, views, schedules, sheets, dashboards, federated models, platforms, and visual environments become devices through which information can be **read**, **verified**, **updated**, and transformed into **action**.

Read against the **Research Questions**, the thesis offers three main answers. The first concerns the reasons behind the persistent difficulty of Italian Public Administration in applying BIM throughout the entire life cycle of public assets. The case study shows that this difficulty derives from a combination of organisational, informational, and representational factors: fragmented processes, insufficiently explicit information requirements, weak continuity between handover and operation, unstable roles, poorly governed updating procedures, and uneven internal competences. The second answer concerns the activities needed to standardise the process of defining a 3D BIM-based model that can be integrated with FM tools. The research identifies a sequence based on verification of the existing model, selection of useful information, geometric and informational simplification, object coding, connection with registers and the management platform, development of BIM-based maintenance processes, and output control. The third answer concerns the impact of the lack of BIM–FM standards in public practice. The absence of shared operational references produces discontinuity between model and use, information requests that are difficult to verify, deliverables poorly aligned with management needs, dependence on individual operators, and weak traceability of updates. The Record Model, AS-FM processes, Capitolato Informativo prototype, Training Framework, and BIM Office respond to this critical issue as coordinated tools for making information more legible, controllable, and transferable.

The innovative contribution of the research lies in the construction of this methodological chain. The **Record Model**, the two **BIM-based maintenance processes**, the protocol for the **Capitolato Informativo**, the **Training Framework**, the **BIM Office**, and **Drawing for FM 5.0** define successive steps in the same operation: transforming building information into **situated knowledge**, usable by different actors to perform procedures, make decisions, verify deliverables, and update data. BIM is thus moved from the level of the **digital model** to the level of **governable representation** for public Facility Management.

The first result concerns the transition from the as-built/as-is model to the Record Model. The availability of a BIM model of the Regione Piemonte Tower provided a relevant information base, rarely available in many public-sector contexts. The analysis clarified that the geometric and documentary richness of the model acquires managerial value through **selection**, **hierarchisation**, **reliability checking**, and correspondence with uses. The Record Model is produced through this critical operation: it reduces, orders, and restructures information according to defined management purposes. Rooms, workstations, doors, movable furniture, and fan coil units become cases through which the behaviour of information can be observed in the transition from model to management. A room gains value when it becomes an identifiable spatial unit; a door when it connects geometry, code, documentation, and verification; a fan coil unit when it can be located, associated with a system, connected to a procedure, and made accessible within the FM platform. In this passage, representation acts as a device for **selection** and **control**.

The second result concerns the two **BIM-based maintenance strategies** developed in the research. **Fault-based maintenance** and **planned maintenance** constitute two operational modes through which Drawing enters the management process. In the fault-based process, representation transforms a generic report into a **localised**, **qualified**, and **traceable** event: the problem is associated with a space, an asset, a request, a work order, a verification step, and a closure. In the planned process, representation makes it possible to recognise the maintainable object and connect it to stable identifiers, procedures, frequencies, planning, and control dashboards. The two strategies clarify that the value of BIM for FM increases when the model supports the transition from object recognition to intervention management.

The experimentation on **building-services assets**, especially **fan coil units**, made a further critical aspect evident. An FM-oriented representation requires **sufficient** and **sustainable** content. A model overloaded with subcomponents or parameters may generate redundancy, fragility, and additional information-maintenance work. The research therefore identifies a rule of balance: keeping in the model what is needed to **recognise**, **locate**, **query**, and connect the asset to the platform; assigning frequencies, activities, work orders, progress, and history to the management procedure. This criterion reinforces the role of Drawing as a discipline of **selection**. To represent for management means deciding which information should be visible, which should be searchable, which should be linked to a document, and which should be maintained within the management system.

The third result concerns the ***Capitolato Informativo***. The analysis of the documents shows that public demand often tends to be structured through recognisable BIM sections, formulas, and references, while the relationship between **requirement**, **deliverable**, **verification**, and **use** sometimes remains poorly legible. Here too, the issue concerns representation: the Capitolato Informativo represents the **information demand of the Contracting Authority**. It describes what the organisation considers necessary, how it expects to receive it, the control criteria, and the responsibilities assigned to the supply chain. The protocol and prototype developed in the thesis aim to make this representation more clear, selective, and controllable. Phase, information uses, roles, exchanges, verifiable requirements, CDE, and **data ownership** are organised as components of a grammar of public clientship.

The fourth result concerns **training** and **organisation**. Representation becomes effective when people are able to read it, query it, and use it. The L0–L3 Training Framework was developed to transform training into observable operational capacity. The Revit AT00–AT12 test, progressive file saving, intermediate outputs, LCAP, and the Activity Perception Table make it possible to observe the way participants move through critical steps: setting up the working environment, linking references, selective modelling, creating parameters, building schedules, exporting and re-importing data, tagging, and checking outputs. Each activity generates a trace and makes the relationship between **representation**, **data**, and **operational capacity** open to discussion. The opening of the **BIM Office** of Regione Piemonte represents the organisational development of this logic, as it places the competence to read and govern digital representations within an internal structure of the administration.

Drawing for FM 5.0 recomposes these results through a disciplinary lens. **Drawing** acts as an **infrastructure of translation** between data, objects, actors, and processes. A simplified plan, a control view, a schedule, an object sheet, a dashboard, an IFC viewer, or an immersive environment has value when it enables an actor to understand a situation and perform a more controlled action. Public Facility Management requires **situated representations**: different representations for the maintenance technician, the FM manager, the RUP, the BIM Office, the internal user, or the Economic Operator, while all are derived from a coherent information base. Representation therefore becomes the place where data acquire **operational** and **administrative** meaning.

The overall result of the research can be expressed in these terms: BIM–FM integration in Public Administration requires a **culture of representation** capable of connecting what is seen, what is known, what is decided, and what is updated. BIM becomes useful when its information structure produces views, checks, sheets, flows, and interfaces capable of supporting everyday work. The thesis contributes to the field of Drawing by proposing **Drawing for FM 5.0** as a **representational ecology** composed of models, plans, schedules, dashboards, platforms, document links, and visual environments. The value of this ecology lies in the stability of the relationship between **information**, **object**, **process**, and **actor**.

9.2 Limitations and future developments

The first limitation concerns the nature of the case study. The "*Torre della Regione Piemonte*" made it possible to work on a complex public building with an **as-built BIM base**, an **FM platform** already in use, and an administrative context open to experimentation. This condition enabled an in-depth reading of the relationship between model, representation, and management. The specificity of the case requires a cautious reading of the results. Transferability concerns the method, the analytical categories, and the representational logic adopted; replication in other organisations will depend on the availability of models, documents, platforms, competences, CDEs, and organisational routines. In the absence of an already structured information base, the pathway will need to start from more elementary forms of knowledge reconstruction and organisation.

A second limitation concerns the categories of objects analysed. The research worked on rooms, workstations, doors, movable furniture, and fan coil units, covering spaces, architectural elements, movable objects, and one building-services component. This selection made it possible to observe different forms of representation for FM, from spatial localisation to document management, from inventory to maintenance. The extension to other MEP asset families requires further testing. **MEP assets** involve denser relationships between systems, components, subcomponents, technical documentation, procedures, frequencies, and maintenance history. The fan coil case showed the risk of overloading the model with information that the FM platform can manage more effectively. Future developments should therefore further investigate the criterion of **sufficient content**, identifying, for each asset category, which representation is genuinely useful for the actor and the process.

A third limitation concerns the two **BIM-based maintenance processes**. The research defined their structure and verified their coherence within the operational context of the case study, with reference to **FactotuM** and to the observed organisational setting. Their medium-term managerial impact remains to be measured. Further work will need to assess whether these processes reduce information retrieval time, improve the quality of records, increase coherence between model and platform, strengthen intervention traceability, and support the updating of the information system. This assessment will require extended applications, comparable data, and comparison with other buildings or services. The current contribution concerns the construction of the methodological and representational device; the extended evaluation of management effects represents a subsequent development.

A fourth limitation concerns the ***Capitolato Informativo*** and the **proposed prototype**. The document analysis made it possible to identify recurring patterns and weaknesses in the representation of public information demand. The corpus is heterogeneous in terms of phase, object, sector, Contracting Authority, and level of detail. This heterogeneity reflects the variety of the Italian context, while limiting the possibility of using the results as a uniform statistical basis. The prototype will need to be applied in real procedures, assessing its capacity to make the demand more legible, improve coherence between requirements and checks, facilitate interpretation by the Economic Operator, and support control by the Contracting Authority. Its development may include further graphic matrices, flow diagrams, verification templates, and synthetic representations of information demand.

A fifth limitation concerns the validation of the **Training Framework** and the stabilisation of the **BIM Office**. The tests adopted produced observable evidence: profiles, versioned files, intermediate outputs, LCAP measures, questionnaires, and restitutions. They make it possible to discuss learning as the capacity to produce, read, and control information representations. Further work is needed to expand the groups involved, repeat the tests in other administrations, and observe effects over time. The BIM Office represents a relevant organisational threshold; its full maturity will depend on continuity of responsibilities, integration with CDEs and FM platforms, the updating of internal standards, and the capacity to produce representations useful to the different actors within the organisation.

Future developments may strengthen the relationship between **Drawing**, **interoperability**, and **management**. A first trajectory concerns the extension of the **Record Model** to other assets, with attention to the definition of views, schedules, sheets, and dashboards differentiated by role. A second trajectory concerns the monitoring of **BIM-based maintenance processes** through indicators of traceability, time, completeness, and updating quality. A third trajectory concerns the application of the **Capitolato Informativo prototype** as a graphic-documentary tool for constructing public information demand. A fourth trajectory concerns the replication of the **Training Framework** in other administrations, using practical tests as tools for assessing the capacity to construct controllable representations. A fifth trajectory concerns CDE, IFC, viewers, XR, dashboards, and possible connections with IoT or BMS. These technologies will acquire managerial value when placed within a reliable information base, a clear representational grammar, and explicit updating responsibilities.

9.3 Conclusions

The thesis has shown that **BIM–FM integration in Public Administration** depends on the capacity to construct and maintain **operational representations of information**. The difficulty of applying BIM throughout the life cycle of public assets emerges from the fragmentation between models, documents, platforms, roles, and management routines. The answer to this condition lies in a more controlled chain of actions: verifying the available information base, selecting and simplifying what is useful for management, coding objects and spaces, connecting them to registers and platforms, defining maintenance processes, and making outputs readable and checkable over time.

This result answers the Research Questions through a common argument. The reticence of Public Administration towards BIM is linked to the weakness of internal governance, uneven competences, and limited continuity between delivery and operation. The activities required to standardise a BIM-based model for FM concern the construction of a **Record Model** and the definition of processes able to connect information to use. The absence of shared BIM–FM standards affects practice by producing ambiguous requirements, fragile deliverables, weak updating procedures, and limited reuse of information. The thesis responds to these issues by proposing a methodological structure that connects model, process, document, training, and organisation.

The disciplinary contribution lies in the role assigned to **Drawing and Representation**. **BIM** is interpreted as a language for structuring information; **Drawing** is the critical practice that gives this language form, hierarchy, legibility, and operational value. A view, a schedule, an object sheet, a dashboard, a workflow, or an immersive interface become meaningful when they allow an actor to understand a condition, verify an output, plan an intervention, or update a record. Through **Drawing for FM 5.0**, representation becomes an infrastructure for action, capable of connecting the real building with the information system that supports its management.

The research therefore proposes a shift from **BIM as a delivered model** to **BIM as a system of governable representations for public asset management**. Its value lies in making information usable within ordinary administrative and maintenance processes: to know the building, interpret data, check deliverables, plan interventions, update records, and support responsible decisions over time.

Only in this way can representation make a public building knowable over time: not only as a built form, but as a responsibility to be maintained, updated, and governed.

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Annex I

Table 12 (Part 1) – Identification of the 40 Italian Information Requirements Documents

Identification code	Institution	Work phase	Building Typology	Years	Cost
CI01_TO-CarcereMinorile	Ministero delle infrastrutture e dei trasporti - Provveditorato Interregionale OOPP Piemonte Valle d'Aosta e Liguria	PD - PE	Edilizia per la Sicurezza e Custodia	2023	174 016.42 €
CI02_RM-ASL03_GrassiOstia	Azienda Sanitaria Locale ROMA3	PFTE	Edilizia Sanitaria	2025	1 785 692.14 €
CI03-VE-ULSS3_AngelinoMestre	Azienda Sanitaria ULSS 3 Serenissima	PFTE	Edilizia Sanitaria	2025	2 427 152.73 €
CI04-GE-PolisportivoSciorba	Comune di Genova	PD - PE - ESE	Edilizia Sportiva	2023	6 255 888.57 €
CI05-RI-Biblioteca	Comune di Riete - Settore V LL.PP. – ufficio impianti sportivi ufficio Speciale Ricostruzione Lazio (USR Lazio)	PD - PE - ESE	Edilizia Culturale	2023	731 976.43 €
CI06-TO-ASL05-OspedaleCambiano	Azienda Sanitaria Locale - A.S.L. TO5	PFTE	Edilizia Sanitaria	2023	10 601 596.10 €
CI07-BO-Studentato	Alma Mater Studiorum – Università di Bologna	ESE	Edilizia Residenziale	2024	984 552.52 €
CI08-TA-PortoTaranto	Autorità del Sistema Portuale del Mar Ionio	ESE	Infrastrutture Portuali-Marittime	2023	2 711 011.11 €
CI09-PR-PonteNavetta	MINISTERO INFRASTRUTTURE E TRASPORTI – Provveditorato Interregionale OOPP Lombardia, Emilia Romagna	ESE	Infrastrutture per Mobilità e Accessibilità	2017	1 342 984.46 €
CI10-RM-LaSapienzaMedicina	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA	PD	Edilizia Accademica	2023	489 294.08 €
CI11-TO-RP_PortaMilano	*Regione Piemonte*	PFTE	Edilizia Culturale	2026	1 082 400.00 €
CI12-TO-RP_EdificiRegionali	SCR PIEMONTE SPA - per conto di *Regione Piemonte*	FM	Edilizia Amministrativa	2024	9 181 613.22 €
CI13-MI-CamCommMilano	Camera di Commercio di Milano Monza Brianza Lodi	ESE	Edilizia Amministrativa	2022	13 633 846.77 €
CI14-MI-CimiteroMilano	Comune di Milano - Area Gare opere Pubbliche	PFTE	Edilizia Storica	2023	2 000 000.00 €
CI15-SP-OspedaleFelettino	Azienda Socio Sanitaria Ligure 5 (SP)	PE - ESE - FM	Edilizia Sanitaria	2022	471 612 541.06 €
CI16-MI-ScuolaBoffaloroST	Comune di Boffalora Sopra Ticino	ESE	Edilizia Scolastica	2025	8 474 621.02 €

CI17-MI-GallVittorioEmIIMilano	Comune di Milano	PFTE	Edilizia Storica	2026	14 825 099.01 €
CI18-FI-CentroDirezionale	Regione Toscana	PFTE	Edilizia Amministrativa	2022	4 164 336.70 €
CI19-RM-SapienzaVulnerabilità	Sapienza Università di Roma	RIL	Edilizia Accademica	2019	821 139.14 €
CI20-RC-QuartiereCandeloro	Comune di Reggio Calabria	PFTE - PE - ESE	Rigenerazione Urbana	2025	1 637 189.58 €
CI21- GE-NuovaDiga	Autorità di sistema portuale del mar ligure occidentale	PFTE	Infrastrutture Portuali-Marittime	2018	13 654 784.96 €
CI22-TO-Superga	Ministero delle infrastrutture e dei trasporti provveditorato inter.ale per le opere pubbliche del piemonte e valle d'aosta	ESE	Edilizia Storica	2025	593 552.46 €
CI23-TO-GAM	Fondazione torino musei	PFTE	Edilizia Culturale	2025	220 000.00 €
CI24-TO-PoliTOAerospazio	Politecnico di Torino	ESE	Edilizia Accademica	2025	30 293 923.18 €
CI25-TO-PoliTOTorinoEsposizioni	Politecnico di Torino	ESE	Edilizia Accademica	2025	44 307 262.94 €
CI26-AP-OspedaleSanBenedetto	Regione marche	PFTE - ESE	Edilizia Sanitaria	2025	7 373 697.01 €
CI27-VA-NordING	Nord ING S.r.l	PFTE - PD - PE	Infrastrutture per Mobilità e Accessibilità	2024	437 695.26 €
CI28-MO-OspedaleSassuolo	Intercent-er agenzia regionale di sviluppo dei mercati telematici	FM	Edilizia Sanitaria	2025	88 054 770.03 €
CI29-RM-PalazzoMarina	Ministero difesa direzione generale lav. Demanio e mater. G.	PFTE - PE	Edilizia Amministrativa	2024	439 084.83 €
CI30-TO-ScuolaCollegno	Comune di Collegno	PFTE - PD - PE - ESE	Edilizia Scolastica	2022	163 741.10 €
CI31-MN-ScuolaMantova	Amministrazione provinciale di mantova	PD - PE - ESE	Edilizia Scolastica	2023	585 668.91 €
CI32-BA-HubRicarica	Comune di Bari	PE - ESE	Infrastrutture per Mobilità e Accessibilità	2025	10 150 000.00 €
CI33-RI-RicostruzioneAmatrice	Regione Lazio – Ufficio Speciale Ricostruzione Lazio	PD - PE - ESE	Infrastrutture Urbane e Sottoservizi	2024	6 539 289.44 €
CI34-BI-PalazzoCisterna	*Regione Piemonte*	PFTE - PE - ESE	Edilizia Storica	2024	1 392 748.98 €
CI35-BG-LineaTramviaria	Tramvie elettriche bergamasche S.P.A	PE - ESE	Infrastrutture per Mobilità e Accessibilità	2022	176 523 340.56 €
CI36-CS-AdDCasermaSanMarcoArgentano	AGENZIA DEL DEMANIO - Direzione Regionale Calabria	PFTE - PE - ESE	Edilizia per la Sicurezza e Custodia	2023	954 321.60 €
CI37-TO-AdDManifatturaTabacchi	AGENZIA DEL DEMANIO - Direzione Regionale Piemonte e Valle d'Aosta	PFTE	Edilizia Culturale	2023	453 818.66 €
CI38-UD-AdDCasermaUdine	AGENZIA DEL DEMANIO - Filiale Friuli Venezia Giulia	PFTE	Edilizia per la Sicurezza e Custodia	2019	452 319.81 €
CI39-NO-AdDCasermaNovara	AGENZIA DEL DEMANIO - Direzione Regionale Piemonte e Valle D'Aosta	ESE	Edilizia per la Sicurezza e Custodia	2025	24 076 349.11 €
CI40-PU-Biblioteca	Provveditorato Interregionale per le OO.PP. Toscana - Marche - Umbria	PFTE	Edilizia Culturale	2025	706 476.11 €

Table 12 (Part 1) – Identification of the 40 Italian Information Requirements Documents

Identification code	Title	CUP	CIG	Artefact	Site
CI01_TO-CarcereMinorile	Gara Europea con procedura aperta, ai sensi dell'Art.60 del D.LGS. 50/2016, per l'appalto di servizi di ingegneria e architettura affernete al servizio di verifica della progettazione ai sensi dell'Art. 26 del D.LGS. 50/2016 e ss.mm.ii. del progetto definitivo ed esecutivo con restituzione in modalità BIM, per gli interventi di miglioramento sismico, efficienza energetica e riorganizzazione funzionale del complesso "Ferrante Aporti", sede dei servizi minorili, dell'esecuzione penale esterna e dell'Istituto penale per minori del DGMC Interdistretto Piemonte - Liguria - Valled'Aosta in Torino.	D13B22000050001	9928372FBF	Istituto penale per i minorenni "Ferrante Aporti"	via Berruti e Ferrero, 1/a - Torino (TO)
CI02_RM-ASL03_GrassiOstia	Procedura aperta, ai sensi dell'art. 71 del D.Lgs. n. 36/2023, per l'affidamento del servizio di architettura ed ingegneria per la redazione del Progetto di Fattibilità Tecnica ed Economica per l'"Intervento di Adeguamento Sismico, Efficientamento Energetico, Ristrutturazione e Ampliamento del P.O. G.B. Grassi di Ostia, Roma"	I82C19000030002	B7EAFAD8D0	Presidio Ospedaliero G.B. Grassi di Ostia	via Gian Carlo Passeroni, 28 - Roma (RM)
CI03-VE-ULSS3_AngelinoMestre	Procedura aperta per l'appalto dei servizi tecnici inerenti alla redazione del progetto di fattibilità tecnico-economica per appalto integrato, dell'ampliamento del presidio ospedaliero dell'Angelo di Mestre denominato provvisoriamente "Angelino"	J75F23000450002	B5964B0C46	Presidio ospedaliero dell'Angelo di Mestre	via Paccagnella, 11 - Venezia (VE)
CI04-GE-PolisportivoSciorba	Affidamento della progettazione definitiva, esecutiva ed esecuzione dei lavori per la realizzazione della Cittadella dello Sport – Impianto Polisportivo Sciorba, in via Adamoli 57, Genova, nell'ambito PNRR M5 C2 I3.1 "Sport e Inclusione Sociale" – Cluster 1.	B35B22000150003	9603551CFB	Impianto Polisportivo Sciorba	via Gelasio Adamoli, 57 - Genova (GE)
CI05-RI-Biblioteca	Procedura aperta per l'affidamento dell'incarico di progettazione definitiva ed esecutiva, compresa relazione geologica, e dell'incarico di direzione lavori e coordinamento della sicurezza in fase di progettazione ed esecuzione, relativo all'intervento di "Adeguamento sismico del complesso Biblioteca Paroniana e museo archeologico di Rieti"	F11B21006900002	9739704201	Biblioteca Paroniana e Sezione Archeologica del Museo Civico	via San Pietro Martire, 28 - Rieti (RI)
CI06-TO-ASL05-OspedaleCambiano	Procedura aperta per l'affidamento dei servizi di ingegneria e architettura inerenti la redazione del Progetto di Fattibilità Tecnica ed Economica (PFTE) per i lavori di realizzazione del Nuovo Ospedale dell'ASL TO5.	J25F23000060005	A03761DF39	Nuovo Ospedale dell'ASL TO5	area ex "Parco Veicoli Inefficienti" - Cambiano (TO).
CI07-BO-Studentato	Gara Europea a procedura aperta per l'affidamento dei servizi di Direzione Lavori, Coordinamento della Sicurezza in fase di Esecuzione e pratica antincendio dell'intervento di Realizzazione Studentato Battiferro – Costruzione nuovo edificio per residenza studenti – via della Beverara – Bologna.	J37B16000640006	B30F7D8974	Studentato Battiferro	via della Beverara - Bologna (BO).
CI08-TA-PortoTaranto	Procedura aperta telematica per l'affidamento di un accordo quadro con un unico operatore economico per i servizi di direzione lavori e coordinamento della sicurezza in fase di esecuzione per opere marittime e portuali finanziate con fondi PNRR e PNC.	D51B21003550001	A004F68803	Porto di Taranto	Porto Mercantile - Taranto (TA)
CI09-PR-PonteNavetta	745 – Lavori di realizzazione del nuovo Ponte Ciclopedonale della Navetta nel Comune di Parma.	D97H15001860001	7134244464	Nuovo Ponte Ciclopedonale Navetta	strada Navetta / via Baganza - Parma (PR).
CI10-RM-LaSapienzaMedicina	Servizio di Progettazione Definitiva e coordinamento della sicurezza in fase di progettazione per l'intervento di riqualificazione architettonica e adeguamento funzionale e impiantistico dell'Edificio di Farmacologia, Farmacia e Medicina sito all'interno della Città Universitaria di Roma "La Sapienza".	B88H23000060005	96443598D0	Edificio di Farmacologia, Farmacia e Medicina.	piazzale Aldo Moro, 5 - Roma (RM)
CI11-TO-RP_PortaMilano	Servizio professionale di redazione della scheda tecnica, del Progetto di Fattibilità Tecnica ed Economica (PFTE), e coordinamento della sicurezza in fase di progettazione per gli interventi di restauro e riqualificazione dell'Edificio principale della ex Stazione Porta Milano per la realizzazione del Museo Ferroviario Piemontese.	J19D24000200001	NA	Ex Stazione Porta Milano di Torino della Ferrovia Torino–Ceres.	corso Giulio Cesare, 15 - Torino (TO)
CI12-TO-RP_EdificiRegionali	Servizio integrato di gestione, manutenzione, conduzione, controllo, fornitura energia negli edifici della *Regione Piemonte* volto a mantenere in completo stato di efficienza gli impianti tecnologici.	NA	B21D40F34B	Edifici di *Regione Piemonte*	N/A

CI13-MI-CamCommMilano	Procedura aperta per l'affidamento dei lavori di riqualificazione dell'edificio di via delle Orsole, 4 – Milano	E43I17000000005	9289802B1E	Edificio Camera di Commercio	via delle Orsole, 4 - Milano (MI)
CI14-MI-CimiteroMilano	Interventi di restauro e consolidamento delle facciate del Cimitero Monumentale – Lotto A	B49D23000660004	NA	Cimitero Monumentale di Milano - Edificio Famedio	piazzale Cimitero Monumentale - Milano (MI)
CI15-SP-OspedaleFelettino	Affidamento in concessione della progettazione, costruzione e gestione del nuovo ospedale della Spezia in località Felettino	D49H09000290008	9194678850	Nuovo ospedale della Spezia in località Felettino	località Felettino, via del Forno - La Spezia (SP)
CI16-MI-ScuolaBoffaloroST	Città Metropolitana di Milano, Stazione Unica Appaltante per conto del Comune di Boffalora Sopra Ticino – Procedura aperta ai sensi dell'art. 71 del d.lgs. 36/2023 per l'affidamento dei lavori di realizzazione del nuovo polo scolastico	B15E22001120006	B330590FAD	Nuovo polo scolastico di Boffalora Sopra Ticino	via Roma, 46 - Boffalora Sopra Ticino (MI)
CI17-MI-GallVittorioEmIIMilano	Progetto di fattibilità tecnico-economica: interventi di consolidamento e restauro della copertura in ferro e vetro della Galleria Vittorio Emanuele II	B49D22000330004	NA	Galleria Vittorio Emanuele II	piazza del Duomo, 19-21 - Milano (MI)
CI18-FI-CentroDirezionale	Concorso di progettazione per la riqualificazione dell'area del centro direzionale della Regione Toscana in Firenze, via di Novoli 26, finalizzato all'acquisizione, in secondo grado, di un progetto con livello di approfondimento pari a un PFTE per la realizzazione del terzo edificio denominato "Terza Torre" e delle aree esterne del lotto.	D12H22000010002	9248118C64	Centro direzionale della Regione Toscana di Novoli	via di Novoli, 26 - Firenze (FI)
CI19-RM-SapienzaVulnerabilità	Appalto per la verifica di vulnerabilità sismica del patrimonio edilizio della Sapienza Università di Roma – Lotto 7.	B81I18001030005	7788236FA6	Edifici universitari "La Sapienza"	N/A
CI20-RC-QuartiereCandeloro	Programma di Azione e Coesione (PAC) "Infrastrutture e Reti" 2014/2020 – Asse B – Interventi di sistemazione e riqualificazione funzionale ed urbanistica delle aree portuali con miglioramento della connessione materiale tra i centri urbani e le aree portuali – "Nuovo quartiere turistico-ricettivo del Candeloro"	H34J22000740008	B7C105AA47	Quartiere Candeloro	N/A
CI21- GE-NuovaDiga	Procedura per l'affidamento del servizio di progettazione di Fattibilità Tecnica ed Economica afferente all'intervento di realizzazione della nuova diga foranea del Porto di Genova, ambito bacino di Sampierdarena	C39B18000060006	7690329440	Nuova diga foranea del Porto di Genova	Porto di Genova, bacino di Sampierdarena - Genova (GE)
CI22-TO-Superga	Pprocedura negoziata senza previa pubblicazione del bando relativa all'appalto dei lavori per l'eliminazione delle barriere architettoniche presso il complesso monumentale della Basilica di Superga di Torino	D17J23000090001	B8BC22618D	Basilica di Superga	strada Comunale alla Basilica di Superga, 73 - Torino (TO)
CI23-TO-GAM	Concorso internazionale di progettazione per la riqualificazione, rifunzionalizzazione, messa in sicurezza e valorizzazione della GAM – Galleria Civica d'Arte Moderna e Contemporanea di Torino	G19D24000090008	B680CE9AE4	Galleria Arte Moderna	via Magenta, 31 - Torino (TO)
CI24-TO-PoliTOAerospazio	Gara europea a procedura aperta, ai sensi dell'art. 71 del D.Lgs. 36/2023, per l'affidamento dei lavori di realizzazione della Piattaforma Aerospazio sita in C.so Marche, Torino. Costruzione dell'opera	E16J22000280005	B66428DADC	Piattaforma Aereospazio	corso Marche - Torino (TO)
CI25-TO-PoliTOTorinoEsposizioni	Gara europea a procedura aperta, ai sensi dell'art. 71 del D.Lgs. 36/2023, per l'affidamento dei lavori di ristrutturazione dei Padiglioni 1 e 3A e costruzione del Padiglione 3B del Complesso di Torino Esposizioni	E19D22000350005	B77C325B9C	Complesso di Torino Esposizioni	corso Massimo d'Azeglio 15 - Torino (TO)
CI26-AP-OspedaleSanBenedetto	Gara Europea a procedura telematica aperta per l'affidamento dei servizi di architettura e ingegneria inerenti alla progettazione di fattibilità tecnica ed economica (PFTE), comprensiva di coordinamento della sicurezza in fase di progettazione (CSP), con riserva di affidamento dei servizi di direzione lavori (DL) e coordinamento della sicurezza in fase di esecuzione (CSE), inerenti all'intervento di realizzazione del nuovo ospedale di San Benedetto del Tronto (AP)	B85F25000150002	B8354B61DF	Nuovo ospedale di San Benedetto del Tronto	via Sgattoni / viale dello Sport - San Benedetto del Tronto (AP)
CI27-VA-NordING	Supporto qualificato di servizi attinenti all'architettura ed ingegneria per la progettazione di opere civili relative ad infrastrutture per la mobilità da restituire anche in modalità BIM	NA	B173231B62	Infrastrutture ferroviarie	Varese
CI28-MO-OspedaleSassuolo	Procedura aperta finalizzata all'affidamento del multiservizio di manutenzione degli immobili in uso all'AUSL di Modena e a Ospedale di Sassuolo S.p.A.	NA	B9B28F02D2	Edifici Ospedalieri	N/A
CI29-RM-PalazzoMarina	Servizio di verifica e supervisione della progettazione di fattibilità tecnica ed economica ed esecutiva per l'appalto integrato dei lavori di restauro e risanamento conservativo delle coperture e delle facciate di Palazzo Marina	D89D24000010001	B0C0FA52E5	Edificio ministeriale Palazzo Marina	piazza della Marina, 4 - Roma (RM)

CI30-TO-ScuolaCollegno	Incarico professionale per aggiornamento PFTE, progetto definitivo, progetto esecutivo, coordinamento della sicurezza in fase di progettazione (CSP) e direzione lavori da eseguire in modalità BIM relativo alla Scuola primaria "Marconi" di via Bendini 40, per lavori di miglioramento statico e sismico della manica est e demolizione della manica ovest.	B87H21001300001	9576738E31	Scuola primaria "Marconi"	via Bendini, 40 - Collegno (TO)
CI31-MN-ScuolaMantova	Appalto congiunto dei servizi di progettazione definitiva con opzione di successivo incarico di progettazione esecutiva e coordinamento della sicurezza in fase di progettazione, nonché di direzione lavori con CSE, per: sede dell'Istituto Superiore Arco–Este di via Tasso 1 a Mantova: adeguamento sismico e sede dell'Istituto Superiore Pitentino di via Tasso 5 a Mantova: adeguamento sismico	G63H19000580001	9874180F18	I.I.S. Carlo d'Arco – I. d'este di Mantova	via Tasso, 1 e 5 - Mantova (MN)
CI32-BA-HubRicarica	Gara Europea a procedura aperta per la conclusione di un accordo quadro triennale per l'affidamento congiunto della progettazione esecutiva ed esecuzione lavori di realizzazione di un hub di ricarica per bus elettrici alla via Mitolo.	J90J21000050006,	B7E17944FD	HuB di ricarica per Bus elettrici	via Mitolo - Bari (BA)
CI33-RI-RicostruzioneAmatrice	Servizi tecnici di architettura e ingegneria per la progettazione di fattibilità tecnico economica, progettazione esecutiva, redazione della relazione geologica, coordinamento della sicurezza in fase di progettazione ed esecuzione e direzione lavori relativi agli interventi di rifacimento delle opere di urbanizzazione e costruzione dei collettori fognari nel Comune di Amatrice e per le frazioni di Macchia e Macchiola nel Comune di Accumoli (RI)	E71B22000160001	NA	Sottoservizi	frazioni di Macchia e Macchiola nel Comune di Accumoli (RI)
CI34-BI-PalazzoCisterna	Accordo quadro per la progettazione, il coordinamento della sicurezza in fase di progettazione, la direzione lavori e il coordinamento della sicurezza in fase di esecuzione per il restauro e la rifunzionalizzazione di Palazzo Cisterna in Biella	J47B23000120001	B24E86E8E5	Palazzo Cisterna	piazza Cisterna, 9 - Biella (BI)
CI35-BG-LineaTramviaria	Procedura aperta per l'affidamento dell'appalto integrato di progettazione esecutiva, coordinamento della sicurezza in fase di progettazione esecutiva, esecuzione dei lavori, fornitura e attrezzaggio dei veicoli tramviari per la realizzazione della linea tramviaria T2 della Valle Brembana Bergamo-Villa d'Almè	H21D18000120001	95630839BC	Linea tramviaria T2	Valle Brembana Bergamo - Villa d'Almè
CI36-CS-AdDCasermaSanMarcoArgentano	Servizi tecnici di progettazione di fattibilità tecnico-economica ed esecutiva, coordinamento della sicurezza in fase di progettazione, adempimenti archeologici/AINOP e BIM, con incarico opzionale di direzione lavori, coordinamento della sicurezza in fase di esecuzione, aggiornamento catastale e certificazione energetica, finalizzati alla realizzazione del nuovo Comando della Compagnia Carabinieri di San Marco Argentano (CS)	E58C23000150001	A00117CE85	Nuovo Comando della Compagnia Carabinieri di San Marco Argentano	via Alcide De Gasperi, zona industriale del Fullone - San Marco Argentano (CS)
CI37-TO-AdDManifatturaTabacchi	Concorso internazionale di progettazione a procedura aperta in due fasi, in forma anonima, per la riqualificazione urbanistica, architettonica e funzionale del complesso storico dell'ex Manifattura Tabacchi di Torino, situata in corso Regio Parco 142, da destinare a nuovo Polo Culturale	E12D23000110001	A02B0C332A	Complesso storico dell'ex Manifattura Tabacchi di Torino	corso Regio Parco, 142 - Torino (TO)
CI38-UD-AdDCasermaUdine	Servizio di progetto di fattibilità tecnica ed economica, compresi rilievi, indagini e prove geologico-tecniche e modellazione BIM, dell'intervento inerente la realizzazione del Nuovo Centro Polifunzionale della Polizia di Stato presso l'ex caserma Cavarzerani di Udine	G29C17000030005	77697833C4	ex caserma Cavarzerani San Gottardo	via Cividale - Udine (UD)
CI39-NO-AdDCasermaNovara	Procedura aperta telematica ai sensi dell'art. 71 del d.lgs. 36/2023 per l'affidamento dei lavori relativi all'ex Caserma Cavalli (scheda NOB0042) - complesso NO0044/parte, sita in viale Francesco Ferrucci 4, Novara (NO)	G12J18008400001	B72576FEBB	ex Caserma Cavalli	viale Francesco Ferrucci, 4 - Novara (NO)
CI40-PU-Biblioteca	Procedura aperta per l'affidamento dei servizi di architettura e ingegneria, in modalità BIM, di progettazione di fattibilità tecnica ed economica (PFTE), relazione geologica, coordinamento della sicurezza in fase di progettazione (CSP), coordinamento della sicurezza in fase di esecuzione (CSE), direzione lavori (DL), direzione operativa per le opere strutturali (DO), verifica vulnerabilità sismica (VVS), attività di indagini per verifica bellica, indagini geologiche/geotecniche (IG) per i lavori di ristrutturazione e ampliamento della Biblioteca Civica "Passionei" e realizzazione uffici comunali - Fossombrone (PU).	I53C23001710009	B843E8756D	Biblioteca Civica "Passionei" e complesso destinato alla realizzazione di uffici comunali	Piazza Dante Alighieri, 2 - Fossombrone (PU)

Annex II

Table 14 (Part 1) – Comparative overview of the 40 Italian Information Requirements Documents

Identification code	Summary	Glossary	oGI pGI	IDP Milestone	IFC	Native formats	Checking	Security	RACI	BCF	I. R. indication
CI01_TO-CarcereMinorile	✓	✓	—	✓	—	—	✓	✓	x	x	x
CI02_RM-ASL03_GrassiOstia	✓	✓	—	x	✓	✓	✓	—	x	✓	x
CI03-VE-ULSS3_AngelinoMestre	x	✓	—	x	✓	✓	—	—	x	x	x
CI04-GE-PolisportivoSciorba	✓	✓	—	x	—	—	—	—	x	x	x
CI05-RI-Biblioteca	✓	✓	—	x	✓	✓	✓	—	x	x	—
CI06-TO-ASL05-OspedaleCambiano	✓	✓	✓	x	✓	✓	✓	—	x	x	—
CI07-BO-Studentato	✓	✓	✓	✓	✓	✓	✓	—	✓	✓	✓
CI08-TA-PortoTaranto	✓	✓	—	x	✓	✓	✓	—	x	x	x
CI09-PR-PonteNavetta	✓	✓	✓	x	✓	✓	✓	✓	✓	x	x
CI10-RM-LaSapienzaMedicina	✓	✓	✓	x	✓	✓	✓	✓	✓	x	x
CI11-TO-RP_PortaMilano	✓	✓	✓	x	✓	✓	✓	✓	x	x	✓
CI12-TO-RP_EdificiRegionali	✓	✓	✓	x	✓	✓	✓	—	✓	x	x
CI13-MI-CamCommMilano	✓	✓	✓	✓	✓	✓	✓	—	✓	x	x
CI14-MI-CimiteroMilano	✓	✓	✓	x	✓	✓	✓	—	x	✓	✓
CI15-SP-OspedaleFelettino	✓	x	x	x	✓	✓	x	x	x	x	x
CI16-MI-ScuolaBoffaloroST	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

CI17-MI-GallVittorioEmIIMilano	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓
CI18-FI-CentroDirezionale	✓	✓	✓	x	✓	✓	✓	✓	x	x	✓
CI19-RM-SapienzaVulnerabilità	✓	✓	✓	x	✓	✓	✓	—	x	x	x
CI20-RC-QuartiereCandeloro	✓	x	—	x	✓	x	—	—	x	x	—
CI21- GE-NuovaDiga	✓	✓	✓	✓	✓	✓	✓	✓	x	✓	✓
CI22-TO-Superga	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓
CI23-TO-GAM	✓	✓	✓	x	✓	✓	✓	✓	x	✓	✓
CI24-TO-PoliTOAerospazio	✓	✓	✓	—	✓	✓	✓	✓	x	x	✓
CI25-TO-PoliTOTorinoEsposizioni	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓
CI26-AP-OspedaleSanBenedetto	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓
CI27-VA-NordING	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓
CI28-MO-OspedaleSassuolo	✓	✓	—	—	✓	✓	✓	✓	x	x	—
CI29-RM-PalazzoMarina	x	x	—	x	✓	✓	✓	—	x	x	✓
CI30-TO-ScuolaCollegno	✓	✓	—	x	✓	✓	✓	✓	x	x	✓
CI31-MN-ScuolaMantova	✓	✓	—	—	✓	✓	✓	—	x	x	✓
CI32-BA-HubRicarica	✓	✓	—	x	✓	✓	✓	—	x	x	—
CI33-RI-RicostruzioneAmatrice	✓	✓	—	x	✓	✓	✓	✓	x	✓	✓
CI34-BI-PalazzoCisterna	✓	✓	—	x	✓	✓	✓	—	x	x	x
CI35-BG-LineaTramviaria	✓	✓	✓	x	✓	✓	✓	✓	✓	x	✓
CI36-CS-AdDCasermaSanMarcoArgentano	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	✓
CI37-TO-AdDManifatturaTabacchi	✓	✓	✓	x	✓	✓	✓	✓	x	✓	✓
CI38-UD-AdDCasermaUdine	✓	✓	✓	x	✓	✓	✓	✓	x	✓	✓
CI39-NO-AdDCasermaNovara	✓	✓	—	x	✓	✓	x	—	x	x	x
CI40-PU-Biblioteca	✓	✓	✓	x	✓	✓	✓	✓	x	✓	✓

Table 15 (Part 2) – Comparative overview of the 40 Italian Information Requirements Documents

Identification code	Pages	LOIN - LOD	Naming	Delivery format	CDE	Work scheme	Roles	Data ownershp	File size
CI01_TO-CarcereMinorile	38	Specific LOD	Omniclass	Digital + hard copy	EO managed	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	300 MB
CI02_RM-ASL03_GrassiOstia	19	Not specified	Uniclass	Not specified	Not specified	Discipline-based coordination	UNI 11337-7 roles	Not specified	Not specified
CI03-VE-ULSS3_AngelinoMestre	16	Specific LOD	Specific coding	Digital	EO managed	Discipline-based coordination	Not specified	Not specified	150 MB
CI04-GE-PolisportivoSciorba	15	LOD according to project phase	Not specified	Hard copy + PDF/A	EO managed	Not specified	UNI 11337-7 roles	Explicitly assigned to the CA	Not specified
CI05-RI-Biblioteca	13	Specific LOD	Not specified	Digital + hard copy	Not specified	Not specified	Not specified	Not specified	500 MB
CI06-TO-ASL05-OspedaleCambiano	37	LOD according to project phase	Specific coding	Hard copy + PDF/A	Not specified	Discipline-based coordination	UNI 11337-7 roles + BIM certif. (PdR 28:2020)	Explicitly assigned to the CA	500 MB
CI07-BO-Studentato	37	LOIN approach	Specific coding	Digital + hard copy	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	400 MB
CI08-TA-PortoTaranto	21	LOD according to project phase	Uniclass	Digital + hard copy	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	Not specified
CI09-PR-PonteNavetta	31	LOD according to project phase	Specific coding	Digital + PDF/A	EO managed	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	Not specified
CI10-RM-LaSapienzaMedicina	23	LOD according to project phase	Specific coding	Digital	EO managed	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	Not specified
CI11-TO-RP_PortaMilano	26	LOD according to project phase	Specific coding	Digital + PDF/A	EO managed	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	Model-based
CI12-TO-RP_EdificiRegionali	23	LOD according to project phase	Specific coding	Digital + PDF/A	EO managed	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	Not specified
CI13-MI-CamCommMilano	41	Specific LOD	Specific coding	Digital + hard copy	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	300 Mb
CI14-MI-CimiteroMilano	9	Not specified	Specific coding	Digital	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	170 Mb
CI15-SP-OspedaleFelettino	80	LOD according to project phase	Uniclass	Digital	EO managed	Discipline-based coordination	UNI 11337-7 roles + experience and competence + certification (optional)	Explicitly assigned to the CA	150 Mb
CI16-MI-ScuolaBoffaloroST	23	LOD according to project phase	EO managed	Digital + hard copy	EO managed	Discipline-based coordination	UNI 11337-7 roles	Not specified	Model-based
CI17-MI-GallVittorioEmIIMilano	30	LOD according to project phase	Specific coding	Digital	EO managed	Discipline-based coordination	UNI 11337-7 roles	Not specified	500 Mb
CI18-FI-CentroDirezionale	16	Not specified	Specific coding	Digital	EO managed	Discipline-based coordination	Roles under Legislative Decree 36/2023	Explicitly assigned to the CA	250 Mb
CI19-RM-SapienzaVulnerabilità	7	Specific LOD	Specific coding	Digital + hard copy	EO managed	Discipline-based coordination	Not specified	Not specified	Not specified

CI20-RC-QuartiereCandeloro	60	LOD according to project phase	Specific coding	Digital + PDF/A	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles + BIM certif. (PdR 28:2020)	Explicitly assigned to the CA	350 Mb
CI21- GE-NuovaDiga	32	LOD according to project phase	Specific coding	Digital + hard copy	EO managed	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Not specified	150 Mb
CI22-TO-Superga	30	LOD according to project phase	Specific coding	Digital + PDF/A	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	Not specified
CI23-TO-GAM	26	LOD according to project phase	Specific coding	Digital + hard copy	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	350 Mb
CI24-TO-PoliTOAerospazio	38	LOD according to project phase	Specific coding	Digital	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	250 Mb
CI25-TO-PoliTOTorinoEsposizioni	62	LOD according to project phase	Specific coding	Digital + hard copy	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	250 Mb
CI26-AP-OspedaleSanBenedetto	71	LOIN approach	Specific coding	Digital	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles + BIM certif. (PdR 28:2020)	Explicitly assigned to the CA	Not specified
CI27-VA-NordING	29	LOD according to project phase	Specific coding	Digital + PDF/A	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	250 Mb
CI28-MO-OspedaleSassuolo	17	LOD according to project phase	Specific coding	Digital + hard copy	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	150 Mb
CI29-RM-PalazzoMarina	29	LOD according to project phase	Specific coding	Digital + hard copy	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	300 Mb
CI30-TO-ScuolaCollegno	18	Specific LOD	Specific coding	Digital + PDF/A	EO managed	Discipline-based coordination	UNI 11337-7 roles + BIM certif. (PdR 28:2020)	Explicitly assigned to the CA	170 Mb
CI31-MN-ScuolaMantova	20	LOD according to project phase	Specific coding	Digital + hard copy	EO managed	Discipline-based coordination	Roles under Legislative Decree 36/2023	Explicitly assigned to the CA	Not specified
CI32-BA-HubRicarica	38	LOD according to project phase	EO managed	Digital	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles +BIM certif. (PdR 28:2020)	Not specified	Model-based
CI33-RI-RicostruzioneAmatrice	14	LOD according to project phase	Specific coding	Digital	EO managed	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	500 Mb
CI34-BI-PalazzoCisterna	43	LOD according to project phase	Uniclass	Digital + flash-USB	EO managed	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	200 Mb
CI35-BG-LineaTramviaria	29	Approccio LOIN	Specific coding	Digital + hard copy	EO managed	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	150 Mb
CI36-CS-AdDCasermaSanMarcoArgentano	230	LOIN approach	Specific coding	Digital	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	3000 Mb
CI37-TO-AdDManifatturaTabacchi	281	LOIN approach	Not specified	Digital	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	3000 Mb
CI38-UD-AdDCasermaUdine	8	Specific LOD	Specific coding	Digital + hard copy	EO managed	Discipline-based coordination	UNI 11337-7 roles	Not specified	150 Mb
CI39-NO-AdDCasermaNovara	58	LOIN approach	Specific coding	Digital	Internal to the CA	Discipline-based coordination	UNI 11337-7 roles + experience and competence	Explicitly assigned to the CA	3000 Mb
CI40-PU-Biblioteca	58	LOIN approach	Specific coding	Digital	EO managed	Discipline-based coordination	UNI 11337-7 roles	Explicitly assigned to the CA	250 Mb

Annex III

Allegato

Prototipo di Capitolato Informativo modulare per la gestione e manutenzione impiantistica BIM-based

Regione Piemonte — Torre della Regione Piemonte

Nota introduttiva al prototipo

Il documento che segue è proposto come **prototipo di Capitolato Informativo** elaborato a fini di ricerca, con l'obiettivo di tradurre in forma operativa le riflessioni sviluppate nel presente capitolo in merito ai processi della Stazione Appaltante, ai Requisiti Informativi e alla continuità BIM–FM.

La sua struttura, così come i contenuti semi-compilati, non devono essere intesi come un modello prescrittivo da applicare in modo invariabile a ogni contesto, ma come una **base metodologica esemplificativa**, costruita per mostrare come un Capitolato Informativo possa essere organizzato in modo più coerente, leggibile e governabile rispetto alle criticità emerse dall'analisi del corpus.

Le formulazioni, i valori soglia, le articolazioni delle sezioni, le voci tabellari e la stessa logica complessiva del documento hanno quindi funzione **orientativa e non esaustiva**. Essi sono stati calibrati sul caso di studio e sugli obiettivi specifici della presente ricerca, e richiedono pertanto di essere letti e utilizzati con **approccio critico**, tenendo conto della fase del processo, della tipologia di intervento, del settore di riferimento, del livello di maturità della committenza e delle effettive esigenze informative del singolo affidamento.

In questa prospettiva, il prototipo non pretende di fornire una soluzione unica o definitiva, ma intende offrire un supporto ragionato alla redazione del Capitolato Informativo, evidenziando una possibile struttura di riferimento e una logica di costruzione del documento fondata sul rapporto tra **processo, requisito, consegna, verifica e aggiornamento**.

0. Identificazione del documento

Tabella 0.1 — Identificazione del documento

CAMPO	*CONTENUTO*
TITOLO DEL DOCUMENTO	*Capitolato Informativo per la gestione e manutenzione impiantistica BIM-based della Torre della Regione Piemonte*
COMMITTENTE	*Regione Piemonte*
CODICE DOCUMENTO	[da compilare]
VERSIONE/REVISIONE	[da compilare]
DATA DI EMISSIONE	[da compilare]
REDATTO DA	[da compilare]
VERIFICATO DA	[da compilare]
APPROVATO DA	[da compilare]

Tabella 0.2 — Identificazione del progetto/intervento

CAMPO	*CONTENUTO*
OGGETTO DELL'AFFIDAMENTO	*Rilievo dell'esistente, strutturazione del modello informativo orientato al Facility Management, integrazione con piattaforma gestionale, supporto ai processi di manutenzione correttiva e programmata degli impianti*
EDIFICIO DI RIFERIMENTO	*Torre della Regione Piemonte*
LOCALIZZAZIONE	*Torino*
TIPOLOGIA DI INTERVENTO	*Gestione e manutenzione di edificio esistente*
FASE DI RIFERIMENTO	*Esercizio/gestione, con attività propedeutiche di rilievo, restituzione e strutturazione informativa dell'esistente*
PROCEDURA DI AFFIDAMENTO	[da compilare]
CUP	[da compilare]
CIG	[da compilare]

Tabella 0.3 — Quadro sintetico iniziale

VOCE	CONTENUTO SINTETICO
OBIETTIVO DEL CI	*Definire i requisiti informativi per la gestione e manutenzione impiantistica BIM-based della Torre*
FOCUS PREVALENTE	*FM / gestione impiantistica*
BASE INFORMATIVA RICHIESTA	*Modello dell'esistente orientato al Record Model*
INTEGRAZIONE RICHIESTA	*Modello BIM ↔ piattaforma FM (Factotum)*
PROCESSI SUPPORTATI	*Manutenzione correttiva; manutenzione programmata; gestione dati asset e spazi*
AMBIENTE DI CONDIVISIONE	*ACDat/CDE della SA + ambiente operativo dell'Affidatario*
PRINCIPIO GUIDA	*Processo → requisito → consegna → verifica → aggiornamento*
PROPRIETÀ DEL DATO	*In capo alla Stazione Appaltante*

Tabella 0.4 — Inquadramento della fase di applicazione del CI

CAMPO	CONTENUTO
STADIO DEL PROCESSO	*Gestione del Cespite*
FASE DI RIFERIMENTO UNI 11337	*Fase 7 – Esercizio e manutenzione*
OBIETTIVO DELLA FASE	*Costruire e governare una base informativa utile alla gestione e manutenzione dell'edificio e dei suoi asset*
FINALITÀ PREVALENTE DEL CI IN QUESTA FASE	*Rendere espliciti i requisiti informativi necessari alla gestione, al controllo, all'aggiornamento e alla tracciabilità del dato*
USI INFORMATIVI COERENTI CON LA FASE	*Identificazione e localizzazione asset; supporto alla manutenzione correttiva; supporto alla manutenzione programmata; costruzione e aggiornamento del Record Model; alimentazione della piattaforma FM*
TIPOLOGIA DI CONSEGNE ATTESE	*Modello informativo dell'esistente; dataset interoperabili; registri; abachi; report di verifica; documentazione tecnica collegata agli asset*
LIVELLO DI VERIFICA ATTESO	*Verifica tecnica, informativa, documentale e gestionale in funzione dell'uso del dato nel FM*
EVENTUALI FASI RICHIAMATE MA NON OGGETTO DIRETTO DEL CI	*Eventuali dati derivati da fasi precedenti sono richiamati solo in quanto necessari alla gestione*

Tabella 0.5 — Variabili di adattamento del prototipo

VARIABILE	EFFETTO SUL CI
FASE	*Modifica usi informativi, livello di approfondimento, natura delle consegne e sistema delle verifiche*
TIPOLOGIA DI INTERVENTO	*Modifica struttura tecnica del documento, natura della base informativa, rapporto tra rilievo, modellazione, aggiornamento e gestione*
SETTORE / TIPOLOGIA EDILIZIA	*Modifica specificità dei contenuti, livelli di prescrizione, priorità informative ed eventuali moduli di approfondimento*

1. Premesse

1.1 Introduzione

Il presente Capitolato Informativo definisce i requisiti informativi richiesti da Regione Piemonte per l'affidamento di servizi finalizzati alla gestione e manutenzione impiantistica BIM-based della Torre della Regione Piemonte. Il documento assume il BIM come infrastruttura informativa a supporto del Facility Management, della costruzione e dell'aggiornamento del Record Model, dell'alimentazione della piattaforma gestionale e del controllo del dato da parte della Stazione Appaltante.

Il Capitolato Informativo costituisce parte integrante della documentazione di gara e, successivamente, dei documenti contrattuali. L'Affidatario dovrà predisporre un Piano di Gestione Informativa (pGI) coerente con i contenuti qui richiesti.

1.2 Priorità e obiettivi

Il presente CI è costruito in funzione di alcune priorità ritenute essenziali per una gestione BIM-based orientata all'esercizio. Tali priorità non devono essere lette come semplici enunciati programmatici, ma come obiettivi che guidano la selezione dei contenuti richiesti e la struttura delle successive verifiche.

Tabella 1.1 — Priorità e obiettivi

N.	PRIORITÀ / OBIETTIVO	ESITO ATTESO
1	Migliorare la conoscenza dell'edificio esistente e dei sistemi impiantistici	Base informativa affidabile e coerente
2	Disporre di una struttura dati utile al FM	Modello e dati leggibili, interrogabili e aggiornabili
3	Garantire identificazione univoca di spazi e asset	Riduzione di ambiguità e doppie verità
4	Supportare manutenzione correttiva e programmata	Attivazione di workflow manutentivi strutturati
5	Assicurare tracciabilità di OdL, evidenze e storico	Continuità informativa nel tempo
6	Integrare modello, documenti, registri e piattaforma FM	Ecosistema informativo coerente
7	Mantenere il controllo del dato in capo alla SA	Proprietà, accessibilità e riuso garantiti

1.3 Acronimi e glossario

Il documento dovrà essere corredato da un glossario e da una lista di acronimi coerente con il quadro normativo richiamato, con i processi BIM–FM adottati e con la struttura informativa prevista dal presente CI. Il glossario dovrà consentire una lettura univoca dei termini utilizzati nel documento, riducendo ambiguità lessicali e differenze interpretative tra Stazione Appaltante, Affidatario ed eventuali soggetti terzi coinvolti.

1.4 Prevalenza contrattuale

Le consegne informative dovranno avvenire in ambiente digitale e comprendere modelli, elaborati, report, registri ed eventuali esportazioni dati in formati nativi e aperti. I contenuti consegnati dovranno risultare reciprocamente coerenti, verificabili e riconducibili agli usi informativi per cui sono richiesti.

Ogni contenuto informativo non derivato direttamente dal modello dovrà essere esplicitamente dichiarato e giustificato dall'Affidatario, indicando le modalità attraverso cui ne viene garantita la coerenza con il sistema informativo complessivo. La Stazione Appaltante si riserva di specificare, in sede di gara o di aggiornamento del pGI, eventuali regole integrative in merito alla prevalenza contrattuale tra modelli, elaborati, dataset ed evidenze documentali.

1.5 Riferimenti normativi

Il presente prototipo assume come quadro di riferimento un insieme di norme e atti regolativi che definiscono il contesto dei contratti pubblici, della gestione informativa digitale, dell'interoperabilità, della sicurezza e del governo del dato.

L'elenco seguente non ha carattere esaustivo né sostituisce la verifica normativa aggiornata in sede di gara, ma definisce il quadro minimo di riferimento per la redazione del presente Capitolato Informativo.

Tabella 1.2 — Riferimenti normativi e tecnici

Famiglia normativa	***Riferimento***	***Ambito / pertinenza nel CI***
Contratti pubblici	**D.Lgs. 36/2023**	Quadro generale del contratto pubblico e della domanda informativa digitale.
Contratti pubblici	**Allegato I.9 al D.Lgs. 36/2023**	Metodi e strumenti di gestione informativa digitale delle costruzioni; riferimento diretto per CI, oGI, pGI, consegne e flussi informativi.
BIM / normazione italiana	**UNI 11337-1**	Modelli, elaborati e oggetti informativi; struttura informativa di processo e prodotto.
BIM normazione italiana	**UNI/TR 11337-2**	Flussi informativi e processi decisionali; utile per strutturare scambi, responsabilità e verifiche.
BIM / normazione italiana	**UNI/TS 11337-3**	Criteri di codificazione di opere, prodotti, attività e risorse.
BIM / normazione italiana	**UNI 11337-4**	Evoluzione e sviluppo informativo di modelli, elaborati e oggetti; LOG/LOI/LOD.
BIM / normazione italiana	**UNI 11337-5**	Flussi informativi nei processi digitalizzati.
BIM / normazione italiana	**UNI 11337-6**	Linea guida per la redazione del Capitolato Informativo.
BIM / normazione italiana	**UNI 11337-7**	Requisiti di conoscenza, abilità e competenza delle figure professionali.
BIM / normazione italiana	**UNI 11337-8**	Sistema di gestione dei processi digitalizzati; rilevante per il governo organizzativo dei dati e dei flussi informativi. UNI ha annunciato la nuova parte 8 nel 2026.
BIM / normazione internazionale	**UNI EN ISO 19650-1**	Concetti e principi per la gestione informativa nel BIM.
BIM / normazione internazionale	**UNI EN ISO 19650-2**	Gestione informativa nella fase di delivery.
BIM / normazione internazionale	**UNI EN ISO 19650-3**	Gestione informativa nella fase di esercizio/gestione del cespite; centrale per FM e AIM.
BIM / normazione internazionale	**UNI EN ISO 19650-4**	Scambio informativo e requisiti di consegna delle informazioni.
BIM / normazione internazionale	**UNI EN ISO 19650-5**	Security-minded information management; sicurezza dell'informazione e protezione del contenuto informativo.
BIM / H&S informativo	**ISO 19650-6:2025**	Classificazione, condivisione e consegna collaborativa delle informazioni relative a salute e sicurezza lungo il ciclo di vita. Utile se il CI vuole esplicitare meglio il trattamento digitale delle informazioni H&S.
Interoperabilità	**UNI EN ISO 16739-1**	IFC per la condivisione dei dati nell'industria delle costruzioni e del facility management.
Sicurezza cantieri/lavoro	**D.Lgs. 81/2008**	Quadro generale di tutela della salute e sicurezza nei luoghi di lavoro; riferimento necessario per gestione delle informazioni di sicurezza e cantieri temporanei o mobili.
Sicurezza cantieri	**Titolo IV del D.Lgs. 81/2008**	Cantieri temporanei o mobili; PSC, coordinamento sicurezza, ruoli e responsabilità.
Trasparenza / dati PA	**D.Lgs. 33/2013**	Trasparenza, accessibilità e pubblicità amministrativa, se pertinente alla governance documentale della SA.
Linee guida interne	**Linee guida Regione Piemonte**	Regole di codifica, naming, parametri, qualità del dato, interoperabilità e compatibilità con il sistema gestionale.

2. Sezione tecnica

2.1 Requisiti tecnici del sistema di informatizzazione: hardware e software

La presente sezione definisce i requisiti tecnici minimi del sistema di informatizzazione richiesto all'Affidatario, con particolare riferimento all'ambiente hardware e software, alle condizioni di interoperabilità, al **CDE**, alla struttura del modello informativo, ai parametri, alle codifiche, ai formati di consegna e alle modalità di verifica tecnica e informativa.

In coerenza con la fase di esercizio e con l'orientamento del presente CI verso il **Facility Management**, i requisiti tecnici qui riportati non devono essere intesi come una sommatoria indistinta di prescrizioni, ma come l'ossatura tecnica minima necessaria a garantire che i dati prodotti risultino leggibili, interoperabili, verificabili e utilizzabili nel tempo all'interno dell'ecosistema informativo della Stazione Appaltante.

L'Affidatario dovrà dimostrare, già in sede di risposta al presente CI e poi nel successivo **pGI**, la coerenza tra l'infrastruttura tecnica proposta, gli usi informativi richiesti, le modalità di consegna e le esigenze di aggiornamento del sistema informativo orientato al FM.

L'Affidatario dovrà disporre di una dotazione hardware congruente con le attività richieste dal presente affidamento, in termini di rilievo, modellazione, verifica, eventuale coordinamento federato, estrazione dati e interoperabilità con la piattaforma FM.

Tabella 2.1 — Dotazione hardware dell'Affidatario

N. UNITÀ	TIPOLOGIA	CARATTERISTICHE TECNICHE	PRESTAZIONI DICHIARATE
[DA COMPILARE]	Workstation fissa	[da compilare]	[da compilare]
[DA COMPILARE]	Workstation portatile	[da compilare]	[da compilare]
[DA COMPILARE]	Unità backup	[da compilare]	[da compilare]
[DA COMPILARE]	Sistema trasmissione dati/rete	[da compilare]	[da compilare]

L'Affidatario dovrà esplicitare nell'oGI e poi nella **pGI** in che modo la dotazione hardware proposta risulti adeguata alle prestazioni richieste e al livello di articolazione del sistema informativo oggetto dell'affidamento.

L'Affidatario dovrà esplicitare l'ambiente software utilizzato per la produzione, gestione, verifica, esportazione e consegna dei dati e dei modelli richiesti dal presente CI, indicando versioni, formati gestiti e compatibilità con l'ambiente informativo richiesto dalla Stazione Appaltante.

Tabella 2.2 — Dotazione software dell'Affidatario

AMBITO	SOFTWARE E VERSIONE	FORMATO NATIVO	FORMATO INTEROPERABILE	COMPATIBILITÀ CON FM TOOLS
AUTHORING MODELLO ESISTENTE	[da compilare]	[da compilare]	[da compilare]	[da compilare]
AUTHORING IMPIANTI	[da compilare]	[da compilare]	[da compilare]	[da compilare]
MODEL CHECKING	[da compilare]	[da compilare]	[da compilare]	[da compilare]
CLASH/COORDINATION	[da compilare]	[da compilare]	[da compilare]	[da compilare]
ESTRAZIONE DATI/ABACHI	[da compilare]	[da compilare]	[da compilare]	[da compilare]
EXPORT DATASET FM	[da compilare]	[da compilare]	[da compilare]	[da compilare]

La semplice disponibilità dei software non sarà considerata sufficiente. L'Affidatario dovrà chiarire in che modo essi verranno utilizzati in relazione agli usi informativi richiesti, ai formati di consegna e ai criteri di verifica previsti.

2.2 Interoperabilità e formati di consegna

I contenuti informativi oggetto del presente affidamento dovranno essere consegnati in formati che consentano, ove richiesto, sia la conservazione del formato nativo sia la possibilità di riuso, verifica, archiviazione e interoperabilità con i sistemi adottati dalla Stazione Appaltante.

Tabella 2.3 — Formati di consegna richiesti

MODELLO / ELABORATO / DATO	FORMATO NATIVO RICHIESTO	FORMATO APERTO/ INTEROPERABILE RICHIESTO	NOTE
MODELLO BIM	*Sì*	*IFC*	*Obbligatorio*
ELABORATI GRAFICI	*Sì*	*PDF/PDF-A*	*Se richiesto, anche DWG*
ABACHI / REGISTRI	*Sì*	*XLS/CSV*	*Compatibili con FM*
REPORT VERIFICHE	*Sì*	*PDF*	*Obbligatorio*
DATASET PER FM	*Sì*	*CSV/XLS o equivalente*	*Coerenti con Factotum*
DOCUMENTAZIONE TECNICA ALLEGATA	*Sì*	*PDF/PDF-A*	*Manuali, schede, certificazioni*

I formati richiesti dovranno essere coerenti con gli usi informativi dichiarati e con la necessità di garantire tracciabilità, verifica, archiviazione e aggiornabilità del dato nel tempo.

2.3 Requisiti CDE

Il **CDE** deve essere inteso come ambiente di processo e non come semplice archivio documentale. Esso dovrà consentire la gestione controllata di stati documentali, versioni, revisioni, permessi, tracciabilità e audit trail, in coerenza con la logica di produzione, verifica, accettazione e aggiornamento dei contenuti informativi richiesti dal presente CI. La Stazione Appaltante dovrà disporre di un proprio **CDE**, mentre l'Affidatario potrà disporre di un ambiente operativo interno funzionale alla produzione e gestione delle attività di propria competenza. In ogni caso, la struttura del sistema dovrà garantire continuità, leggibilità e controllo del patrimonio informativo in capo alla SA.

Tabella 2.4 — Requisiti CDE

VOCE	REQUISITO
ACDAT DELLA SA	Deve essere disponibile e governato dalla Stazione Appaltante
ACDAT DELL'AFFIDATARIO	Obbligatorio per la gestione operativa interna
TRACCIABILITÀ	Obbligatoria
VERSIONAMENTO	Obbligatorio
WORKFLOW STATI DOCUMENTALI	Obbligatorio
AUDIT TRAIL	Obbligatorio
PERMESSI DIFFERENZIATI	Obbligatori
SICUREZZA DEL DATO	Obbligatoria
ACCESSIBILITÀ CONTROLLATA	Obbligatoria
CONSERVAZIONE NEL TEMPO	Obbligatoria

Tabella 2.5 — Sistema di riferimento e coordinate

CAMPO	CONTENUTO
SISTEMA DI RIFERIMENTO	[da definire nel pGI]
UNITÀ DI MISURA	Sistema metrico
LOGICA DI ORIENTAMENTO	Coerente con edificio reale
RIFERIMENTO COMUNE TRA MODELLI	Obbligatorio
COORDINATE CONDIVISE	Obbligatorie
METODO DI IMPOSTAZIONE	Da esplicitare nel pGI

2.4 Sistema di riferimento, coordinate e criteri di impostazione

Il sistema informativo dovrà essere costruito secondo regole di riferimento spaziale e metrico coerenti con l'edificio reale, con le esigenze di coordinamento e con la possibilità di relazione tra modelli, elaborati, registri e sistemi esterni.

Tabella 2.6 — Sistema di riferimento e coordinate

CAMPO	CONTENUTO
SISTEMA DI RIFERIMENTO	[da definire nel pGI]
UNITÀ DI MISURA	Sistema metrico
LOGICA DI ORIENTAMENTO	Coerente con edificio reale
RIFERIMENTO COMUNE TRA MODELLI	Obbligatorio
COORDINATE CONDIVISE	Obbligatorie
METODO DI IMPOSTAZIONE	Da esplicitare nel pGI

2.5 Oggetti, spazi ed entità informative da modellare o gestire

Gli oggetti e le entità informative richieste dal presente CI dovranno essere selezionati in funzione degli usi informativi dichiarati e della fase di esercizio cui il documento si riferisce. La richiesta non implica la modellazione indiscriminata di tutti gli elementi presenti, ma la costruzione di una base informativa coerente con le esigenze di gestione, manutenzione, identificazione e aggiornamento.

Tabella 2.6 — Oggetti e spazi da modellare / gestire

CATEGORIA	OGGETTO / ENTITÀ	FINALITÀ INFORMATIVA	NOTE
ASSET IMPIANTISTICI	*Fan coil e altri elementi impiantistici*	*Gestione manutenzione correttiva e programmata*	Prioritari
SPAZI	*Locali*	*Gestione spaziale e localizzazione asset*	Obbligatori
SPAZI	*PDL / postazioni di lavoro*	*Space management*	Se pertinenti
SISTEMI	*Sistemi tecnologici*	*Gerarchizzazione e classificazione*	Obbligatori
DOCUMENTAZIONE	*Manuali/schede/allegati*	*Collegamento documentale all'asset*	Obbligatorio

2.6 Regole di naming, codifica e classificazione

Le regole di naming e codifica costituiscono uno dei presupposti minimi per garantire coerenza tra modello, documenti, registri e piattaforme gestionali. L'Affidatario dovrà attenersi alle regole stabilite dalla Stazione Appaltante e dalle Linee guida regionali, esplicitando nel pGI eventuali necessità integrative o casi particolari.

Tabella 2.7 — Regole di naming e codifica

AMBITO	REGOLA / STANDARD	FONTE
CARTELLE	*Secondo schema SA*	*Linee guida RP*
FILE	*Secondo schema SA*	*Linee guida RP*
FAMIGLIE	*Secondo schema SA*	*Linee guida RP*
TIPI	*Secondo schema SA*	*Linee guida RP*
PARAMETRI	*Struttura parametri condivisa*	*Linee guida RP*
SPAZI/LOCALI	*Codifica univoca*	*Linee guida RP / FM*
ASSET	*Codifica univoca*	*Linee guida RP / FM*
SISTEMI	*Gerarchizzazione coerente*	*pGI + SA*

2.7 Parametri minimi orientati al FM

I parametri richiesti dal presente CI dovranno essere selezionati in funzione degli usi informativi e non dovranno dar luogo a una proliferazione indiscriminata di attributi. L'obiettivo è costruire una base informativa sufficiente a rendere l'oggetto identificabile, localizzabile, gestibile, verificabile e aggiornabile nel tempo.

Tabella 2.8 — Parametri minimi orientati al FM

GRUPPO PARAMETRI	CONTENUTI MINIMI
IDENTIFICAZIONE	Asset_ID / codice univoco
LOCALIZZAZIONE	Sito, edificio, piano, locale
CLASSIFICAZIONE TECNICA	Categoria, tipologia, standard
GESTIONE	Procedura associata, frequenza, stato
INTEGRAZIONE FM	Campi richiesti dalla piattaforma
DOCUMENTAZIONE	Collegamento a manuali/schede
TRACCIABILITÀ	Storico interventi / evidenze

L'Affidatario dovrà esplicitare nel **pGI** la struttura parametrica adottata, motivando eventuali integrazioni o riduzioni in funzione degli usi richiesti e dell'effettiva sostenibilità del sistema.

2.8 Struttura del modello e coordinamento federato

Qualora richiesto dalla complessità dell'edificio, dalla distribuzione disciplinare dei contenuti o dalla necessità di controllare peso e leggibilità dei file, il sistema di modelli dovrà essere organizzato secondo una logica di coordinamento federato. Tale articolazione dovrà essere coerente con la fase del processo, con gli usi informativi richiesti e con le esigenze di interoperabilità e aggiornamento del sistema.

Tabella 2.10 — Struttura del sistema informativo e coordinamento federato

ASPETTO	REQUISITO
COORDINAMENTO FEDERATO	*Da adottare se necessario alla governabilità del sistema*
ARTICOLAZIONE DISCIPLINARE	*Da esplicitare nel pGI*
RELAZIONE TRA MODELLI, REGISTRI E DATASET	*Da esplicitare nel pGI*
RESPONSABILITÀ DI COORDINAMENTO E PUBBLICAZIONE	*Da esplicitare nel pGI*
COERENZA CON OBIETTIVI E USI INFORMATIVI	*Obbligatoria*

2.9 Dimensione massima dei file

La dimensione dei file dovrà essere gestita in modo da garantire leggibilità, utilizzabilità, manutenibilità del sistema informativo e compatibilità con i flussi di verifica, coordinamento e aggiornamento. In linea generale, la dimensione massima dei file di modello non dovrà superare 200 MB, salvo motivate eccezioni da esplicitare e approvare.

Tabella 2.11 — Regole di controllo della dimensione dei file

VOCE	REQUISITO
DIMENSIONE MASSIMA FILE MODELLO	200 MB
EVENTUALI ECCEZIONI	Da motivare nel pGI
COERENZA CON STRUTTURA FEDERATA	Obbligatoria
OBIETTIVO	Garantire gestibilità, interoperabilità e controllo

2.10 Requisiti tecnici verificabili

Al fine di evitare formulazioni eccessivamente generiche, i principali requisiti tecnici del presente CI dovranno poter essere ricondotti a una logica di verifica. L'Affidatario dovrà pertanto chiarire nel **pGI** in che modo intende dimostrare la conformità della propria proposta tecnica rispetto ai requisiti richiesti.

Tabella 2.12 — Matrice sintetica dei requisiti tecnici verificabili

ID REQUISITO	AMBITO	AZIONE RICHIESTA	OGGETTO	CRITERIO DI VERIFICA	EVIDENZA ATTESA
RT-01	Hardware	Dimostrare adeguatezza della dotazione	Postazioni e infrastruttura tecnica	Verifica di congruenza con attività richieste	Elenco attrezzature / scheda tecnica
RT-02	Software	Esplicitare ambiente software utilizzato	Software e versioni	Verifica compatibilità e coerenza con i formati richiesti	Elenco software / schema interoperabilità
RT-03	Interoperabilità	Garantire esportazione e riuso dei dati	Modelli, dataset, elaborati	Verifica dei formati consegnati	File di test / export di prova
RT-04	CDE	Esplicitare struttura e regole dell'ambiente	CDE e workflow	Verifica di stati, permessi, tracciabilità	Schema CDE / regole operative
RT-05	Parametri	Garantire presenza dei parametri minimi richiesti	Oggetti e asset	Verifica informativa su campi e attributi	Abaco parametri / report
RT-06	File size	Rispettare la soglia dimensionale prevista	File di modello	Verifica del peso file e coerenza con struttura	Elenco modelli / dimensione file

3. Sezione gestionale

3.1 Obiettivi informativi strategici e usi dei modelli e degli elaborati

La presente sezione stabilisce gli obiettivi informativi strategici richiesti dalla Stazione Appaltante e i relativi usi del modello e degli elaborati nel quadro della gestione impiantistica BIM-based della *Torre della Regione Piemonte.*

Gli usi informativi non devono essere intesi come semplici etichette lessicali, ma come relazioni esplicite tra attore, decisione, attività supportata, output atteso e momento del processo. In questa prospettiva, il modello e il dato non vengono richiesti in quanto tali, ma in quanto strumenti capaci di supportare azioni, controlli, verifiche e aggiornamenti coerenti con la fase di esercizio.

Tabella 3.1 — Obiettivi informativi strategici e usi del modello

OBIETTIVO INFORMATIVO	USO DEL MODELLO / DATO	ATTORE PRINCIPALE	DECISIONE / ATTIVITÀ SUPPORTATA	MOMENTO DEL PROCESSO	OUTPUT ATTESO
RILIEVO E STRUTTURAZIONE DELL'ESISTENTE	*Costruzione della base informativa iniziale*	*Affidatario / SA*	*Impostazione del sistema informativo di gestione*	*Avvio dell'affidamento*	*Modello dell'esistente coerente*
IDENTIFICAZIONE ASSET	*Localizzazione, codifica e classificazione degli elementi*	*SA / OE*	*Associazione univoca tra asset, spazio e documentazione*	*Impostazione e aggiornamento del sistema*	*Registro asset*
MANUTENZIONE A GUASTO	*Supporto a ticket, diagnosi e ordini di lavoro*	*OE / FM manager / SA*	*Apertura, presa in carico, esecuzione e chiusura intervento*	*Gestione operativa*	*Tracciamento interventi*
MANUTENZIONE PROGRAMMATA	*Associazione asset–procedura–frequenza*	*OE / SA*	*Pianificazione e attivazione della manutenzione preventiva*	*Programmazione e controllo*	*Piano MP e OdL*
ALIMENTAZIONE PIATTAFORMA FM	*Export / import e riallineamento dati*	*Affidatario / SA*	*Integrazione tra modello, registri e FM*	*Consegna e aggiornamento*	*Dataset compatibili*
AGGIORNAMENTO RECORD MODEL	*Riallineamento FM–BIM*	*SA / OE / soggetto incaricato*	*Mantenimento della coerenza del sistema informativo*	*Dopo interventi / revisioni*	*Modello aggiornato*
GESTIONE SPAZI E LOCALIZZAZIONI	*Supporto alla relazione tra ambienti, asset e usi*	*SA / FM manager*	*Lettura spaziale e localizzazione dei dati*	*Gestione corrente*	*Registro spazi coerente*

Gli usi sopra indicati costituiscono la base per la definizione dei requisiti informativi, delle consegne e delle verifiche successive. Eventuali usi ulteriori dovranno essere motivati e resi coerenti con la fase di esercizio e con gli obiettivi del presente CI.

3.2 Livello di fabbisogno informativo (LOIN)

Il livello di fabbisogno informativo dovrà essere coerente con gli usi sopra indicati e proporzionato agli obiettivi del presente affidamento. Il modello dovrà quindi essere costruito secondo una logica selettiva, aggiornata e orientata al Facility Management, evitando sia richieste eccessivamente generiche sia una proliferazione incontrollata di contenuti non realmente utili alla gestione.

Il LOIN dovrà essere esplicitato nel **pGI** in funzione degli oggetti, delle attività e delle verifiche previste, chiarendo quali informazioni risultino effettivamente necessarie per identificare, interrogare, gestire, verificare e aggiornare gli asset e gli spazi oggetto dell'affidamento.

Tabella 3.2 — Criteri generali di definizione del LOIN

AMBITO	CRITERIO DI DEFINIZIONE	FINALITÀ
ASSET IMPIANTISTICI	*Informazioni sufficienti a identificazione, localizzazione, gestione, procedura e tracciabilità*	*Supporto alla manutenzione correttiva e programmata*
SPAZI / LOCALI	*Informazioni utili alla localizzazione, al collegamento con asset e alla gestione spaziale*	*Supporto al FM e allo space management*
DOCUMENTAZIONE COLLEGATA	*Informazioni sufficienti a collegare manuali, schede e allegati agli oggetti*	*Tracciabilità documentale*
DATASET PER FM	*Informazioni coerenti con i campi richiesti dalla piattaforma gestionale*	*Integrazione BIM ↔ FM*
AGGIORNAMENTO	*Informazioni necessarie a distinguere tra aggiornamento gestionale, informativo e geometrico*	*Continuità informativa nel tempo*

3.3 Ruoli, responsabilità e autorità ai fini informativi

La presente sezione chiarisce i ruoli principali e le rispettive responsabilità informative ai fini dell'attuazione del CI. La distribuzione dei ruoli non riguarda soltanto l'Affidatario, ma anche la struttura interna della Stazione Appaltante, che deve mantenere il presidio della domanda informativa, delle verifiche, dell'accettazione e del governo del dato.

Tabella 3.3 — Ruoli e responsabilità principali

RUOLO	RESPONSABILITÀ PRINCIPALE
AZIONE APPALTANTE	Definizione della domanda informativa, verifica, accettazione, governo del dato
RUP / REFERENTE DEL CONTRATTO	Presidio procedurale e contrattuale
DIGITAL INFORMATION CONTINUITY OFFICER (DICO)	Presidio dei flussi, continuità tra modello, documenti, registri e FM
AFFIDATARIO	Produzione e consegna dei contenuti informativi richiesti
REFERENTE BIM / FM DELL'AFFIDATARIO	Coordinamento tecnico-informativo e integrazione con FM
OE MANUTENTIVO	Esecuzione delle attività, restituzione evidenze, aggiornamento gestionale ove previsto

L'Affidatario dovrà esplicitare nel pGI la propria struttura organizzativa e informativa, chiarendo ruoli, interfacce e responsabilità effettive rispetto alle richieste del presente CI.

Tabella 3.4 — Matrice RACI minima

PROCESSO / ATTIVITÀ	SA	RUP	DICO	AFFIDATARIO	OE MANUTENTIVO
RILIEVO ESISTENTE	I	I	C	R	-
MODELLAZIONE / STRUTTURAZIONE DATI	I	I	C	R	-
VERIFICA MODELLO	A	C	R	C	-
PUBBLICAZIONE IN ACDAT	I	I	C	R	-
ALIMENTAZIONE FM	C	I	A	R	C
MANUTENZIONE CORRETTIVA	I	I	C	C	R
MANUTENZIONE PROGRAMMATA	I	I	C	C	R
AGGIORNAMENTO RECORD MODEL	A	I	R	C	C

Legenda: **R** = Responsible, **A** = Accountable, **C** = Consulted, **I** = Informed

** La compilazione della presente matrice RACI è esemplificativa per la redazione del presente prototipo di Capitolato Informativo."*

3.4 Strutturazione e organizzazione della modellazione digitale

Il modello richiesto dal presente CI deve essere concepito come **Record Model orientato al FM**, cioè come base informativa e geometrica utile alla gestione, depurata dei contenuti non necessari all'esercizio e coerente con i registri, la documentazione tecnica e la piattaforma FM.

Tabella 3.5 — Requisiti del Record Model

VOCE	REQUISITO	FINALITÀ
NATURA	*Modello dell'esistente depurato dalle informazioni inutili alla gestione*	*Supporto al FM*
CONTENUTI MINIMI	*Asset, spazi, parametri, relazioni con procedure e documentazione*	*Base informativa coerente*
AGGIORNABILITÀ	*Obbligatoria*	*Continuità informativa*
INTEROPERABILITÀ CON FM	*Obbligatoria*	*Integrazione BIM ↔ FM*
COERENZA CON REGISTRI	*Obbligatoria*	*Evitare doppie verità*
RIUTILIZZABILITÀ	*Obbligatoria*	*Uso nel tempo*
OCE	*Requisito*	*Finalità*

Tabella 3.6 — Abachi e registri informativi obbligatori

REGISTRO / ABACO	FINALITÀ	OBBLIGATORIETÀ
REGISTRO SPAZI	Gestione locali e relazioni spaziali	Obbligatorio
REGISTRO ASSET/APPARECCHIATURE	Identificazione e classificazione asset	Obbligatorio
STORICO MANUTENTIVO	Tracciamento interventi	Obbligatorio
ABACO PARAMETRI FM	Verifica struttura dati	Obbligatorio
REGISTRO DOCUMENTAZIONE TECNICA	Collegamento schede/manuali	Obbligatorio

3.5 Requisiti informativi verificabili

Al fine di rendere la domanda informativa realmente controllabile, i contenuti richiesti dal presente CI dovranno essere espressi, per quanto possibile, in forma verificabile. Ogni requisito dovrà poter essere ricondotto a una relazione esplicita tra fase o milestone, uso informativo, azione richiesta, oggetto, criterio di verifica ed evidenza attesa.

Tabella 3.7 — Matrice dei requisiti informativi verificabili

ID REQUISITO	PRIORITÀ	FASE / MILESTONE	USO INFORMATIVO	AZIONE RICHIESTA	OGGETTO	FORMATO / CONTENITORE	CRITERIO DI VERIFICA	EVIDENZA ATTESA	SOGGETTO VERIFICATORE
RI-01	*Alta*	*M1*	*Costruzione base informativa*	*Restituire il modello iniziale dell'esistente*	*Modello BIM*	*Nativo + IFC + CDE*	*Coerenza con rilievo e struttura richiesta*	*Report verifica iniziale*	*SA / DICO*
RI-02	*Alta*	*M2*	*Identificazione asset*	*Attribuire codifica e parametri minimi*	*Asset e spazi*	*Modello + abachi*	*Presenza e correttezza dei campi richiesti*	*Abaco parametri / registro*	*SA / DICO*
RI-03	*Alta*	*M3*	*Alimentazione FM*	*Restituire dataset interoperabili*	*Dataset FM*	*XLS / CSV + CDE*	*Compatibilità con FM*	*Export test / report*	*SA / referente FM*
RI-04	*Media*	*M3*	*Manutenzione programmata*	*Associare procedure e frequenze agli asset*	*Asset impiantistici*	*Dataset / piattaforma / report*	*Coerenza asset–procedura–frequenza*	*Report configurazione*	*SA / referente FM*
RI-05	*Alta*	*M4*	*Aggiornamento Record Model*	*Restituire contenuti finali coerenti e verificati*	*Modello, registri, report*	*Tutti i formati richiesti*	*Completezza, coerenza, interoperabilità*	*Verbale di validazione*	*SA*

La presente matrice ha valore esemplificativo e dovrà essere sviluppata e integrata dall'Affidatario nel **pGI**, in coerenza con il perimetro dell'affidamento.

3.6 Definizione degli elaborati e delle consegne informative

Le consegne informative dovranno essere pianificate in modo da rendere leggibile il rapporto tra milestone, contenuto atteso, ambiente di scambio, verifica ed evidenza. Le consegne non devono essere trattate come semplice trasmissione di file, ma come passaggi informativi strutturati, collegati a momenti di controllo e accettazione.

Tabella 3.8 — Piano delle consegne informative / IDP

MILESTONE	CONSEGNA	FORMATO	CONTENUTO ATTESO	SOGGETTO VERIFICATORE	VERIFICA	EVIDENZA
M1	*Base rilievo e struttura iniziale modello*	*Nativo + IFC*	*Stato iniziale dell'esistente*	*SA / DICO*	*Tecnica / informativa*	*Report verifica*
M2	*Modello strutturato con codifiche e parametri*	*Nativo + IFC + abachi*	*Asset, spazi, parametri minimi*	*SA / DICO*	*Tecnica / FM*	*Report parametri*
M3	*Dataset per integrazione FM*	*CSV / XLS + report*	*Campi, mappature, coerenza dataset*	*SA / referente FM*	*Gestionale / FM*	*Export test*
M4	*Consegna finale*	*Tutti i formati previsti*	*Modello, report, registri, relazione specialistica*	*SA*	*Validazione finale*	*Verbale accettazione*

3.7 Verifica, validazione e accettazione

La verifica delle consegne dovrà articolarsi su più livelli, in modo da controllare non solo la correttezza tecnica del modello, ma anche la qualità informativa, la leggibilità documentale e l'effettiva utilità dei dati per il FM.

Tabella 3.9 — Livelli di verifica

LIVELLO DI VERIFICA	DESCRIZIONE
VERIFICA TECNICA	*Controllo geometrico, strutturale, modellativo*
VERIFICA INFORMATIVA	*Controllo parametri, codifiche, completezza dati*
VERIFICA DOCUMENTALE	*Controllo allegati, report, relazioni, coerenza consegne*
VERIFICA GESTIONALE/FM	*Controllo leggibilità, utilità e integrabilità per FM*

Tabella 3.10 — Criteri di accettazione delle consegne

CRITERIO	DESCRIZIONE
COMPLETEZZA	*Tutti i contenuti richiesti risultano presenti*
COERENZA	*Nessuna contraddizione tra modello, registri e documenti*
CONFORMITÀ	*Rispetto di codifiche, naming, parametri e regole*
INTEROPERABILITÀ	*Utilizzabilità dei dati nei flussi previsti*
UTILITÀ PER FM	*Informazione leggibile e riusabile nella gestione*
TRACCIABILITÀ	*Evidenze e storico associabili agli asset*

Tabella 3.11 — Non conformità e richieste di integrazione

VOCE	DESCRIZIONE
SEGNALAZIONE NON CONFORMITÀ	*Tramite report/verifica formalizzata*
RESPONSABILE RISPOSTA	*Affidatario*
TEMPO DI RISPOSTA	*[da definire]*
MODALITÀ DI REVISIONE	*Nuova emissione / integrazione documentata*
EVIDENZA DI CHIUSURA	*Report aggiornato / verbale / validazione*

3.8 Aggiornamento del dato e continuità informativa

La continuità informativa richiede che il sistema distingua chiaramente tra aggiornamenti di natura gestionale, informativa e geometrico-sostanziale. L'aggiornamento del dato non deve essere lasciato a pratiche occasionali, ma ricondotto a regole leggibili, coerenti con la struttura del sistema informativo e con il rapporto tra FM, modello, registri e documentazione.

Tabella 3.12 — Regole di aggiornamento del dato

TIPOLOGIA DI AGGIORNAMENTO	SOGGETTO PRINCIPALE	AMBIENTE DI AGGIORNAMENTO	NOTE
AGGIORNAMENTO SOLO GESTIONALE	*OE manutentivo*	*Piattaforma FM*	*Non modifica la geometria*
AGGIORNAMENTO INFORMATIVO CON IMPATTO SULL'ASSET	*Affidatario / gestore FM*	*FM + eventuale BIM*	*Da valutare*
AGGIORNAMENTO GEOMETRICO/SOSTANZIALE	*Gestore FM / Ufficio BIM / soggetto incaricato*	*Modello BIM + FM*	*Obbligatorio riallineamento*

Tabella 3.12 — Catena di aggiornamento FM–BIM

FASE	ESITO INFORMATIVO
INTERVENTO	Evento operativo
EVIDENZA	Documento/foto/report/riscontro tecnico
VALIDAZIONE	Controllo e conferma della SA o soggetto delegato
AGGIORNAMENTO FM	Modifica del dato gestionale
EVENTUALE AGGIORNAMENTO BIM	Riallineamento del modello
RIALLINEAMENTO DEL SISTEMA	Coerenza tra FM, BIM, registri e documenti

4. Allegati richiamati

Il presente prototipo potrà essere completato, se ritenuto opportuno, mediante i seguenti allegati:

ALLEGATO	CONTENUTO	FUNZIONE PRINCIPALE DELL'ALLEGATO
ALLEGATO A	*Tabella sintetica del CI*	*Rendere immediatamente leggibili dati identificativi, obiettivi, fase, focus, proprietà del dato e quadro generale del documento*
ALLEGATO B	*Matrice usi informativi*	*Esplicitare il rapporto tra attore, decisione, attività supportata, output atteso e momento del processo*
ALLEGATO C	*Matrice RACI*	*Dettagliare ruoli, responsabilità, livelli di consultazione e flussi decisionali*
ALLEGATO D	*Piano di consegna informativa / IDP*	*Strutturare milestone, contenuti attesi, formati, verifiche, evidenze e soggetti coinvolti*
ALLEGATO E	*Schema codifiche e naming*	*Esplicitare regole di denominazione, classificazione, codifica e gerarchizzazione*
ALLEGATO F	*Struttura parametri FM*	*Definire in modo più analitico i parametri minimi richiesti e la loro relazione con gli usi informativi*
ALLEGATO G	*Livelli di verifica e accettazione*	*Dettagliare criteri, soggetti, momenti e modalità di verifica e validazione*
ALLEGATO H	*Regole di aggiornamento del Record Model*	*Chiarire procedure, responsabilità e condizioni per il riallineamento tra FM, BIM, registri e documenti*
ALLEGATO I	*Quadro di applicazione della fase*	*Esplicitare la relazione tra fase dichiarata, obiettivi, usi, consegne e verifiche*
ALLEGATO L	*Matrice dei requisiti informativi verificabili*	*Rendere controllabile la domanda informativa attraverso ID requisito, milestone, criterio di verifica ed evidenza attesa*
ALLEGATO A	*Tabella sintetica del CI*	*Rendere immediatamente leggibili dati identificativi, obiettivi, fase, focus, proprietà del dato e quadro generale del documento*

**Gli allegati dovranno inoltre mantenere piena coerenza con il corpo principale del documento. In caso di contrasto, lacuna o disallineamento, la Stazione Appaltante potrà richiedere all'Affidatario il riallineamento dei contenuti o la riformulazione delle parti non coerenti.*

5. Checklist di verifica per il prototipo di Capitolato Informativo

SEZIONE 0 – INTRODUZIONE

1. Identificazione del documento: Verificare che siano presenti e correttamente compilati tutti i dati anagrafici del CI.

- ☐ Titolo completo del documento
- ☐ Committente / Stazione Appaltante
- ☐ Codice documento
- ☐ Versione / revisione
- ☐ Data di emissione
- ☐ Redatto da
- ☐ Verificato da
- ☐ Approvato da

2. Identificazione del progetto/intervento: Verificare che il perimetro dell'intervento sia definito in modo chiaro e non ambiguo.

- ☐ Oggetto dell'affidamento
- ☐ Progetto / edificio / cespite / patrimonio di riferimento
- ☐ Localizzazione
- ☐ Tipologia di intervento
- ☐ Fase di riferimento del processo
- ☐ Procedura di affidamento
- ☐ CUP
- ☐ CIG
- ☐ Perimetro fisico dell'intervento
- ☐ Perimetro informativo dell'intervento
- ☐ Eventuali esclusioni o limiti del perimetro

3. Quadro sintetico iniziale: Verificare che il CI renda immediatamente leggibili obiettivi, focus e logica generale.

- ☐ Obiettivo del CI
- ☐ Focus prevalente del documento
- ☐ Base informativa richiesta
- ☐ Integrazione richiesta con sistemi/piattaforme/ambienti esterni *(es. Piattaforma FM)*
- ☐ Processi supportati
- ☐ Ambiente di condivisione dati previsto
- ☐ Principio guida del documento
- ☐ Proprietà del dato
- ☐ Output/consegne attesi in forma sintetica

4. Inquadramento della fase: Verificare che la fase non sia richiamata solo come etichetta, ma come criterio ordinatore del CI.

- ☐ È esplicitato lo stadio del processo
- ☐ È esplicitata la fase di riferimento secondo la UNI 11337
- ☐ È chiarito l'obiettivo della fase
- ☐ Sono esplicitati gli usi informativi coerenti con la fase
- ☐ Sono chiarite le tipologie di consegna attese in relazione alla fase
- ☐ Sono esplicitati i livelli di verifica coerenti con la fase
- ☐ Sono chiarite eventuali fasi richiamate ma non oggetto diretto del CI
- ☐ Sono chiarite eventuali esclusioni

5. Variabili di adattamento del prototipo: Verificare che la modularità del CI sia esplicitata e governata.

- ☐ È chiarito in che modo la fase modifica il CI
- ☐ È chiarito in che modo la tipologia di intervento modifica il CI
- ☐ È chiarito in che modo il settore / tipologia edilizia modifica il CI
- ☐ Il documento mantiene un core stabile pur adattandosi al caso specifico

SEZIONE 1 – PREMESSE

6. Introduzione: Verificare che la parte introduttiva chiarisca il senso del documento.

- ☐ È esplicitato a quale finalità principale è orientato il CI
- ☐ È chiarito che il BIM è assunto come infrastruttura informativa e non solo come rappresentazione
- ☐ È specificata la natura del caso *(esistente, nuova costruzione, riqualificazione, gestione, ecc.)*
- ☐ È chiarito il rapporto tra modello, documentazione, processo e uso previsto del dato
- ☐ È esplicitato che il documento costituisce parte della documentazione di gara / contrattuale
- ☐ È chiarito il rapporto tra CI e successivo oGI / pGI

7. Priorità e obiettivi: Verificare che gli obiettivi non siano generici, ma legati a risultati attesi.

- ☐ Miglioramento del livello di conoscenza del bene / edificio / patrimonio
- ☐ Strutturazione informativa coerente con la fase del processo
- ☐ Identificazione univoca di spazi, elementi, sistemi o asset
- ☐ Supporto ai processi principali oggetto dell'affidamento
- ☐ Tracciabilità delle attività, delle evidenze e dello storico
- ☐ Integrazione tra modello, documenti, registri e sistemi gestionali
- ☐ Controllabilità delle consegne da parte della Stazione Appaltante
- ☐ Aggiornabilità del dato nel tempo
- ☐ Coerenza tra obiettivi dichiarati e contenuti richiesti nel CI

8. Acronimi e glossario: Verificare che la terminologia sia governata e non lasciata implicita.

- ☐ Sono presenti tutti gli acronimi utilizzati nel documento
- ☐ I termini specialistici sono definiti in modo chiaro
- ☐ La terminologia è coerente con il quadro normativo richiamato
- ☐ Non sono presenti espressioni ambigue o usate con significati diversi nel testo

9. Prevalenza contrattuale: Verificare che sia chiaro il rapporto tra i diversi contenuti documentali e informativi.

- ☐ È chiarito cosa ha prevalenza contrattuale
- ☐ È chiarito il rapporto tra modello, elaborati, report, allegati e dataset
- ☐ È chiarito l'uso dei formati nativi
- ☐ È chiarito l'uso dei formati aperti
- ☐ È chiarito l'uso di eventuali formati documentali di supporto
- ☐ È chiarito come garantire coerenza tra modello ed elaborati
- ☐ È chiarito come trattare contenuti non derivati direttamente dal modello
- ☐ È chiarito il rapporto tra consegna documentale e consegna informativa

10. Riferimenti normativi: Verificare che il quadro normativo sia coerente con l'obiettivo del CI.

- ☐ Sono stati inseriti riferimenti normativi in materia di contratti pubblici
- ☐ Sono state inserite norme nazionali e internazionali in materia di BIM e gestione informativa
- ☐ Sono state inserite norme nazionali e internazionali in materia di interoperabilità
- ☐ Sono state inserite norme o riferimenti in materia di sicurezza, ove pertinenti
- ☐ Sono stati inseriti riferimenti a linee guida, atti organizzativi o regole interne della Stazione Appaltante
- ☐ Il quadro normativo richiamato è coerente con fase, obiettivo e natura dell'affidamento

SEZIONE 2 – SEZIONE TECNICA

11. Infrastruttura hardware: Verificare che siano richieste dotazioni hardware coerenti con le attività previste.

☐ Sono richieste le dotazioni hardware necessarie
☐ Le richieste sono coerenti con il tipo di rilievo / modellazione / verifica previsto
☐ Le richieste sono coerenti con l'eventuale coordinamento federato
☐ Le richieste sono coerenti con l'eventuale integrazione con altri sistemi informativi

12. Infrastruttura software: Verificare che il CI richieda la definizione dell'ambiente software necessario alla prestazione.

☐ Sono richiesti software di authoring coerenti con il tipo di affidamento
☐ Sono richiesti software o strumenti per verifica e coordinamento
☐ Sono richiesti strumenti per estrazione dati e report
☐ Sono chiariti i formati nativi e interoperabili gestiti
☐ Sono richieste versioni o compatibilità minime, se necessario
☐ È richiesta la compatibilità con gli ambienti digitali della SA, se pertinente

13. Interoperabilità: Verificare che il tema dell'interoperabilità sia trattato in modo operativo e non solo dichiarativo.

☐ Sono indicati i formati interoperabili richiesti
☐ È chiarito il rapporto tra modelli, dati alfanumerici, documenti e piattaforme
☐ Sono richieste modalità di export/import coerenti con gli usi informativi
☐ Sono previste verifiche di interoperabilità, se necessarie
☐ Sono chiariti eventuali sistemi esterni con cui il modello/dato dovrà dialogare

14. CDE: Verificare che l'ambiente di condivisione dati sia descritto come ambiente di processo.

☐ È chiarita l'esistenza dell'ACDat/CDE della SA
☐ È chiarita l'eventuale necessità di un ambiente dell'Affidatario
☐ Sono esplicitati stati documentali e workflow
☐ Sono esplicitati permessi e livelli di accesso
☐ Sono esplicitati versionamento e audit trail
☐ Sono esplicitate regole di sicurezza e tracciabilità
☐ È chiarito il rapporto tra archiviazione, pubblicazione e accettazione

15. Sistema di riferimento e coordinate: Verificare che siano chiariti i riferimenti spaziali e metrici del sistema informativo.

☐ Sistema di coordinate
☐ Unità di misura
☐ Logica di orientamento
☐ Riferimento comune tra modelli / elaborati
☐ Metodo di impostazione / condivisione dei riferimenti

16. Oggetti, spazi ed entità informative: Verificare che il perimetro informativo sia chiarito in relazione agli oggetti e alle entità da trattare**.**

☐ Sono chiariti gli oggetti / elementi / asset compresi nel CI
☐ Sono chiariti gli spazi / locali / ambienti compresi nel CI
☐ Sono chiariti eventuali sistemi o aggregazioni
☐ Sono chiariti eventuali documenti o allegati da collegare alle entità
☐ Sono chiarite priorità o classi di oggetti principali
☐ Sono chiarite eventuali esclusioni

17. Naming, codifica e classificazione: Verificare che le regole di denominazione e codifica siano coerenti, stabili e governabili.

- ☐ Regole per cartelle
- ☐ Regole per file
- ☐ Regole per famiglie
- ☐ Regole per tipi
- ☐ Regole per parametri
- ☐ Regole per spazi / locali
- ☐ Regole per asset / elementi / componenti
- ☐ Regole per sistemi / aggregazioni
- ☐ Coerenza con linee guida o standard della SA
- ☐ Coerenza con eventuali standard classificativi esterni

18. Parametri minimi e attributi informativi: Verificare che il CI richieda i campi realmente necessari agli usi previsti.

- ☐ Identificativo univoco
- ☐ Localizzazione
- ☐ Classificazione tecnica / funzionale
- ☐ Standard o tipologia dell'oggetto
- ☐ Relazioni con procedure / attività / usi
- ☐ Campi richiesti da sistemi esterni, se pertinenti
- ☐ Collegamenti documentali
- ☐ Campi di tracciabilità e storico
- ☐ Coerenza tra parametri richiesti e usi informativi dichiarati

19. Modello federato e struttura del sistema informativo: Verificare che sia chiarita la logica organizzativa del modello o del sistema di modelli.

- ☐ Logica di coordinamento federato, se prevista
- ☐ Articolazione disciplinare, se prevista
- ☐ Schema di relazione tra modelli / dataset / registri
- ☐ Responsabilità di coordinamento e pubblicazione
- ☐ Coerenza tra struttura tecnica e obiettivi del CI

20. Dimensione massima dei file: Verificare che il CI chiarisca eventuali soglie dimensionali e loro motivazione.

- ☐ Soglia massima file indicata
- ☐ Eventuali eccezioni chiarite
- ☐ Coerenza tra soglia e struttura federata / organizzazione del sistema

21. Formati di consegna: Verificare che i formati richiesti siano coerenti con la domanda informativa e con gli usi attesi.

- ☐ Formati nativi
- ☐ Formati aperti
- ☐ Formati documentali
- ☐ Formati tabellari / dataset
- ☐ Eventuali formati per issue management / coordinamento
- ☐ Coerenza tra formati richiesti e processi supportati

SEZIONE 3 — SEZIONE GESTIONALE

22. Obiettivi informativi strategici e usi: Verificare che gli usi del modello e del dato siano scritti in modo operativo.

- ☐ Gli usi informativi sono esplicitati
- ☐ Ogni uso è collegato a una decisione / attività /output atteso
- ☐ Gli usi sono coerenti con la fase del processo
- ☐ Gli usi sono coerenti con il perimetro dell'affidamento

23. LOIN / livello di fabbisogno informativo: Verificare che il livello di informazione richiesto sia proporzionato e coerente con gli obiettivi.

- ☐ È chiarito il livello di fabbisogno informativo richiesto
- ☐ È chiaro il rapporto tra LOIN e usi informativi
- ☐ Non sono richieste informazioni superflue
- ☐ Il livello informativo è coerente con fase e obiettivo del CI

24. Ruoli e responsabilità: Verificare che ruoli e responsabilità siano esplicitati in modo non ambiguo.

- ☐ È chiarita la struttura informativa interna della SA
- ☐ È chiaro il modo in cui l'Operatore Economico deve presentare la propria struttura
- ☐ Sono esplicitati i ruoli chiave richiesti
- ☐ Sono chiarite le responsabilità dei diversi soggetti
- ☐ È chiarita la funzione del DICO, se prevista

25. Matrice RACI: Verificare che la distribuzione delle responsabilità sia resa operativa.

- ☐ È presente una matrice RACI
- ☐ La matrice copre i processi principali richiesti
- ☐ La matrice distingue chi produce, verifica, approva, aggiorna e usa
- ☐ La matrice è coerente con i ruoli descritti nel testo

26. Record Model / modello informativo di riferimento: Verificare che sia chiara la natura del modello richiesto e il suo rapporto con l'uso gestionale.

- ☐ È chiarita la finalità del modello
- ☐ È chiarita la relazione tra modello e gestione
- ☐ Sono chiariti i contenuti minimi del modello
- ☐ È chiarita l'aggiornabilità del modello
- ☐ È chiarita la coerenza con registri e dataset
- ☐ È chiarita l'interoperabilità con eventuali sistemi gestionali

27. Abachi e registri informativi: Verificare che il CI chiarisca quali registri e abachi debbano essere costruiti o alimentati.

- ☐ Elenco spazi/locali
- ☐ Elenco asset / elementi / apparecchiature
- ☐ Abaco dei parametri / attributi informativi
- ☐ Registro documentazione tecnica
- ☐ Altri registri coerenti con l'obiettivo del CI

28. Requisiti informativi verificabili: Verificare che la domanda informativa sia formulata in modo controllabile.

☐ Sono presenti requisiti di ID
☐ Sono presenti priorità
☐ È chiarita la fase / milestone di riferimento
☐ È chiarito l'uso informativo associato
☐ È chiarita l'azione richiesta
☐ È chiarito l'oggetto del requisito
☐ È chiarito il criterio di verifica
☐ È chiarita l'evidenza attesa
☐ È chiarito il soggetto verificatore

29. Consegne informative: Verificare che il CI distingua chiaramente tra tipologie di output e relative evidenze.

☐ Modelli
☐ Elaborati
☐ Report
☐ Registri/Liste/Elenchi/Abachi
☐ Dataset / export
☐ Relazioni specialistiche
☐ Altre evidenze richieste
☐ Richiamo esplicito a pGI e consegne informative

30. IDP / Piano delle consegne: Verificare che le consegne siano pianificate e verificabili.

☐ Milestone stone definite
☐ Formato di ciascuna consegna definito
☐ Contenuto atteso definito
☐ Contenitore / ambiente di scambio definito
☐ Soggetto che consegna definito
☐ Soggetto che verifica / accetta definito
☐ Verifica definita
☐ Evidenza definita
☐ Collegamento con fasi, SAL o altri momenti contrattuali definito

31. Verifiche: Verificare che il CI renda espliciti livelli e modalità di controllo.

☐ Verifica tecnica
☐ Verifica informativa
☐ Verifica documentale
☐ Verifica gestionale / d'uso, se pertinente
☐ È chiarito chi verifica
☐ È chiarito con quali criteri si verifica
☐ È chiarito in quale momento si verifica

32. Criteri di accettazione: Verificare che l'accettazione non sia implicita ma fondata su criteri espliciti.

☐ Completezza
☐ Coerenza
☐ Conformità
☐ Interoperabilità
☐ Utilità rispetto all'obiettivo dichiarato
☐ Coerenza tra criterio di accettazione e contenuto richiesto

33. Non conformità: Verificare che il CI chiarisca come trattare errori, integrazioni e revisioni.

- ☐ Modalità di segnalazione delle non conformità
- ☐ Responsabile della risposta
- ☐ Tempi di risposta
- ☐ Modalità di revisione
- ☐ Evidenza di chiusura della non conformità

34. Sicurezza del contenuto informativo: Verificare che il CI tratti la sicurezza del dato in modo coerente con il contesto.

- ☐ Misure di sicurezza del dato esplicitate
- ☐ Accessi e permessi chiariti
- ☐ Tutela dei contenuti sensibili chiarita
- ☐ Collegamento con norme sulla sicurezza, se pertinente
- ☐ Collegamento con sicurezza operativa / di cantiere, se pertinente

35. Proprietà del dato: Verificare che la titolarità del contenuto informativo sia esplicitata in modo netto.

- ☐ Proprietà del dato in capo alla SA esplicitata
- ☐ Assenza di lock-in esplicitata
- ☐ Diritti di riuso e accesso chiariti
- ☐ Regole di conservazione nel tempo chiarite
- ☐ Coerenza tra proprietà del dato e struttura del CDE

36. Aggiornamento del dato: Verificare che il CI chiarisca come il contenuto informativo possa restare vivo nel tempo.

- ☐ Aggiornamento solo gestionale distinto
- ☐ Aggiornamento informativo distinto
- ☐ Aggiornamento geometrico / sostanziale distinto
- ☐ Soggetti responsabili chiariti
- ☐ Ambiente di aggiornamento chiarito
- ☐ Regole di riallineamento chiarite

37. Catena di aggiornamento: Verificare che sia esplicitata la sequenza minima di mantenimento della continuità informativa.

- ☐ Intervento / evento
- ☐ Evidenza
- ☐ Validazione
- ☐ Aggiornamento del dato gestionale
- ☐ Eventuale aggiornamento del modello
- ☐ Riallineamento del sistema complessivo

SEZIONE 4 – CHECK TRASVERSALE

38 . Check finale trasversale: Prima di chiudere il prototipo, verificare che il documento sia leggibile, coerente e governabile.

- ☐ Sono presenti tutti gli allegati necessari per espletare le richieste del CI
- ☐ Si capisce chiaramente a cosa è orientato il CI
- ☐ È chiaro il caso / oggetto / contesto di riferimento
- ☐ È chiaro quale modello o base informativa viene richiesta
- ☐ È chiaro il rapporto con eventuali sistemi o piattaforme esterne
- ☐ È chiara la proprietà del dato
- ☐ È chiara la presenza e la funzione del CDE
- ☐ È chiara la coerenza tra fase dichiarata e contenuti richiesti
- ☐ È chiara la logica uso → requisito → consegna → verifica
- ☐ È chiaro chi fa cosa
- ☐ È chiaro cosa si consegna e quando
- ☐ È chiaro come si verifica
- ☐ È chiaro come si aggiorna il dato nel tempo
- ☐ Il documento evita sia la genericità sia la proliferazione inutile

Annex IV

Cognitive questionare

SEZIONE 1: DATI PERSONALI

Q1.1

1. Nome ………………
2. Cognome…………

Q1.2 Genere

3. M ☐
4. F ☐
5. Nessuna Risposta ☐

Q1.3 Età (in anni compiuti)

1. Fino a 18 anni ☐
2. 18 - 25 anni ☐
3. 26 - 35 anni ☐
4. 36 - 45 anni ☐
5. 46 - 55 anni ☐
6. 56 - 65 anni ☐
7. oltre 65 anni ☐

Q1.4 Titolo di studio

1. Licenza elementare ☐
2. Licenza scuola media ☐
3. Diploma scuola superiore ☐
4. Laurea Triennale ☐
5. Laurea magistrale/ciclo unico ☐
6. Dottorato di ricerca ☐
7. Altro…..… ☐

(3–7) → **Q1.4.3** Specifica la tipologia di titolo di studio

……………………………………

Q1.5 Stai partecipando a questa indagine in qualità di ?

1. Studente universitario □
2. Studente di corso non universitario □
3.
4. Dottorando □
5. Ricercatore □
6. Dipendente della Regione Piemonte □
7. Altro…….

Q1.5.1a Frequenti un corso di laurea triennale o magistrale?

1. Laurea Triennale □
2. Laurea magistrale/ciclo unico □

Q1.5.1b Qual è la denominazione del tuo corso di laurea?

……………………………..

Q1.5.1c In quale città è situata la tua università?

………………………..

Q1.5.2a Come si chiama il corso che stai frequentato?

………………………..

Q1.5.2b In quale regione è stato tenuto il corso?

1. Abruzzo □
2. Basilicata □
3. Calabria □
4. Campania □
5. Emilia-Romagna □
6. Friuli Venezia Giulia □
7. Lazio □
8. Liguria □
9. Lombardia □
10. Marche □
11. Molise □
12. Piemonte □
13. Puglia □
14. Sardegna □
15. Sicilia □
16. Toscana □
17. Trentino-Alto Adige □
18. Umbria □
19. Valle d'Aosta □
20. Veneto □

Q1.5.3 Qual è il tuo ambito lavorativo/di studio **(per RP indicare il settore di appartenenza)?**

…………………………

SEZIONE 2: CONOSCENZE SOFTWARE

Q2.1 Hai mai utilizzato la piattaforma di BIM Authoring: Revit?

1. Si □
2. No □

→ **Q2.1.1** Da quanto tempo utilizzi Revit?

1. 0-3 mesi □
2. 3-6 mesi □
3. 6-12 mesi □
4. 1-2 anni □
5. 2-3 anni □
6. più di 3 anni □

Q2.2 Hai mai utilizzato altre piattaforme di BIM Authoring?

1. Si □
2. No □

→ **Q2.2.1** Quali altre piattaforme di BIM Authoring hai utilizzato?

……………………………..

Q2.3 Hai mai utilizzato software di progettazione CAD?

1. Si □
2. No □

→ **Q2.3.1** Quali software di progettazione CAD hai utilizzato?

……………………………..

SEZIONE 3: SALVATAGGIO E CONSENSO

Q3.1 Codifica del nome del file salvato (ES. TPR_ESE_COGN_AT00). Riportare l'esempio inserendo le prime 4 lettere del proprio cognome.

…………………………………………………………………

Q3.2 CONSENSO AL TRATTAMENTO DEI DATI PERSONALI

Ai sensi dell’artt. 13 e 23 del D.Lgs. n. 196/2003 e dell’articolo 13 del Regolamento UE 679/2016 (“GDPR”) al trattamento dei dati personali. I dati da Lei forniti verranno trattati per fini di RICERCA SCIENTIFICA. Il trattamento sarà effettuato con modalità informatizzata. Il conferimento dei dati è facoltativo. I dati potranno essere/saranno comunicati a Università e/o Politecnico di Torino.

1. Acconsento □
2. Non acconsento □

Annex V

Esercitazione pratica Progetto “Obiettivo BIM per la PA”

Eseguire tutte le attività di seguito riportate ricordando di salvare il file per ogni attività svolta. Troverete tutto il materiale necessario per svolgere l'esercitazione nella cartella del Desktop *"Esercitazione_TRP"*. Al termine di ogni attività inserire il **Livello di Complessità dell'Attività Percepito (LCAP)** con un numero da 1 (molto basso) a 5 (molto alto).

0. Aprire Revit19. Creare un nuovo progetto partendo dal file template denominato "*Template_Esercitazione.rt*e" nella cartella Esercitazione_TRP. **Salvare** con nome il file di progetto in formato *.rvt* denominandolo "TRP_ESE_COGN-AT00".
Attenzione*: COGN sono le prime 4 lettere del vostro cognome (Es. ZUCCO, TRP_ESE_ZUCC_AT00).*

LCAP 0:___/5

1. Aprire la vista in pianta "ARC_LF05-PiantaEsercitazione". Collegare correttamente al file di progetto il file "TRP_TO_STR.rvt". Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT01"

LCAP 1:___/5

2. Importare e posizionare correttamente il file CAD "TRP_PiantaEsercitazione" dentro al progetto e bloccarlo. Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT02".

LCAP 2:___/5

3. Inserire l'oggetto porta come in pianta CAD importata (solo quelle con identificativo *rosso, non quelle del nucleo*) secondo il seguente criterio:

CODICE PORTA CAD	FAMIGLIA	TIPO	COSTO	SERRATURA ELETTRICA
501: A, B, C, D, E, F, G, H, I	TRP_TO_ARC_PO_1B_VE	Pv_01_*_06	815 €/cad	no
501: N, S, Y, X	TRP_TO_ARC_PO_2B_AT	Pv_01_*_02	980 €/cad	sì
502: A, B	TRP_TO_ARC_PO_2B_AT	Pv_01_*_03	1245 €/cad	no

Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT03".

LCAP 3:___/5

4. Creare i Locali delle singole stanze, come in pianta CAD importata (escluso *locali del nucleo*). Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT04".

LCAP 4:___/5

5. Collegare al progetto il file TXT dei parametri condivisi denominato "TRP_ESE_ParametriCondivisi" e creare i seguenti **parametri condivisi**:

NOME	TIPO DI PARAMETRO	GRUPPO DI PARAMETRO
Codice Chiave	Testo	Codifica
Costo Unitario	Valuta	Manutenzione
Serratura Elettrica	Sì/No	Manutenzione

Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT05".

LCAP 5:___/5

6. Caricare i parametri condivisi del file TXT e quelli precedentemente creati come **parametri di progetto**. Seguendo le seguenti caratteristiche:
Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT06".

NOME	PARAMETRO di	CATEGORIA
Codice Factotum	Istanza	LOCALI - PORTE
Codice Porta	Istanza	PORTE
Codice Chiave	Istanza	PORTE
Costo Unitario	Tipo	PORTE
Serratura Elettrica	Istanza	LOCALI - PORTE

LCAP 6:___/5

7. Creazione di un abaco per categoria (non multicategoria) denominato "TRP_ABC_ESE-Porte" realizzato in modo tale che siano presenti i campi:

- Livello
- Famiglia
- Tipo
- *Codice Factotum*
- *Codice Porta*
- Costo Unitario
- Serratura Elettrica
- Conteggio.

Organizzare l'abaco in modo che i campi siano nell'ordine sopra riportato, attivare un filtro sul Livello LF05 e attivare il calcolo dei totali.
Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT07".

LCAP 7:___/5

8. Esportare l'abaco in Excel usando il plug-in BIMOne. Compilare tutto l'abaco su Excel con i valori riportati nel file CAD. I parametri Costo Unitario e Serratura Elettrica dovranno essere compilati secondo i valori riportati nella tabella all'attività n.3.
Importare l'abaco successivamente in Revit.
Risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT08".

LCAP 8:___/5

9. Etichettare le porte, selezionando la famiglia dell'etichetta denominata "TRP_ET-Porta".
Terminata l'etichettatura, risalvare il file di progetto cambiando nome in "TRP_ESE_COGN-AT09".

LCAP 9:___/5

10. Creazione di un **abaco dei locali** denominato “TRP_ABC_ESE-Locali” realizzato in modo tale che siano presenti i campi:

- Livello
- *Codice Factotum*
- Serratura Elettrica

Organizzare l’abaco in modo che i campi siano nell’ordine sopra riportato, attivare un filtro sul Livello LF05 e valorizzare l’abaco.
Risalvare il file di progetto cambiando nome in “TRP_ESE_COGN-AT10”.

LCAP 10:___/5

11. Etichettare i locali in pianta, selezionando la famiglia dell’etichetta locale denominata “TRP_ET-CF_Locali”.
Terminata l’etichettatura, risalvare il file di progetto cambiando nome in “TRP_ESE_COGN-AT11”.

LCAP 11:___/5

12. Modifica dell’abaco delle porte in modo tale da visualizzare il costo **totale** delle porte. Risalvare il file di progetto cambiando nome in “TRP_ESE_COGN-AT12”.

LCAP 12:___/5

Annex VI

Questionario formazione Corso “Modellazione Digitale d’Impianti”

SEZIONE 1: DATI PERSONALI

Dati generali dell'utente e consenso al trattamento dei dati

Email*____

Questo modulo raccoglie gli indirizzi email.

Q.0. CONSENSO AL TRATTAMENTO DEI DATI PERSONALI

ai sensi e per gli effetti degli artt. 13 e 23 del D. L.gs. n. 196/2003, con la sottoscrizione del presente modulo, al trattamento dei dati personali secondo le modalità e nei limiti di cui EX ART. 13 DEL D.LGS. N. 196/2003. I dati da Lei forniti verranno trattati per fini di RICERCA SCIENTIFICA. Il trattamento sarà effettuato con modalità informatizzata. Il conferimento dei dati è facoltativo. I dati potranno essere/saranno comunicati a Politecnico di Torino.

1. ACCONSENTO
2. NON ACCONSENTO

SEZIONE 2: PROFILO DEL PARTECIPANTE

Q1.1 – Genere

1. M ◻
2. F ◻
3. Altro: …..... ◻

Q1.2 – Età

1. Nessuna (non conosco il BIM / non ho mai usato software BIM) ◻
2. Base (conosco i concetti principali; ho fatto solo lezioni introduttive o prove guidate, senza autonomia) ◻
3. Intermedia (ho modellato almeno un progetto in ambito universitario/tirocinio; so creare e gestire un modello semplice in modo abbastanza autonomo) ◻
4. Avanzata (ho lavorato su più progetti; uso il BIM con buona autonomia e metodo: famiglie/parametri, template, esportazioni, gestione modello) ◻
5. Professionale (uso BIM regolarmente o quotidianamente in contesto lavorativo; esperienza su progetti reali e processi strutturati/collaborativi) ◻

Q1.3 – Esperienza pregressa con BIM (prima del corso)

1. Nessuna ◻
2. Base ◻
3. Intermedia ◻
4. Avanzata ◻
5. Professionale ◻

Q1.4 – Esperienza pregressa con il mondo MEP (prima del corso)

1. Nessuna ◻
2. Base ◻
3. Intermedia ◻
4. Avanzata ◻
5. Professionale ◻

Q1.5 – Esperienza pregressa con le tecniche Scan-to-BIM / Point Cloud (prima del corso)

1. Nessuna □
2. Base □
3. Intermedia □
4. Avanzata □
5. Professionale □

Q1.6 - Tipologia di studente

1. Funzionario pubblico/Dipendente PA □
2. Studente Universitario □

Dopo la sezione 2
Sezione 3 di 8

6 - Sezione Funzionari Pubblici
Descrizione (facoltativa)

Q6.1 - Specificare la Direzione Regionale di afferenza

*____

Q6.2 - Definire il "SETTORE REGIONALE" di afferenza.
*____

Q6.3 - Le competenze apprese sono applicabili nel mio lavoro in PA

*1	2	3	4	5
per nulla				moltissimo

Q6.4 - Il corso mi ha aiutato a capire cosa richiedere in una gara/servizio BIM

*1	2	3	4	5
per nulla				moltissimo

Q6.5 - Il corso mi ha aiutato a capire cosa controllare/verificare in un modello BIM

*1	2	3	4	5
per nulla				moltissimo

Q6.6 - Mi sento più efficace nel dialogo con progettisti/fornitori BIM
*1 2 3 4 5
per nulla moltissimo

Q6.7 - Quali utilizzi concreti vedi per queste competenze in PA?
*____
Altro:

Q6.8 - Quali ostacoli prevedi per applicarle in PA?
*
Altro:____

Q6.9 - Quanto consiglieresti a un tuo collega questo tipo di approccio formativo?
*1 2 3 4 5
per nulla moltissimo

Dopo la sezione 3
Sezione 4 di 8
7 - Sezione per Studenti Universitari
Descrizione (facoltativa)

Q7.1 - Specificare il Corso di Laurea
*____

Q7.2 - La presenza di funzionari PA ha reso più concreto ciò che studio?
*1 2 3 4 5
per nulla moltissimo

Q7.3 - Ho capito meglio i vincoli reali e i processi del mondo professionale
*1 2 3 4 5
per nulla moltissimo

Q7.4 - Ho migliorato la mia capacità di giustificare scelte tecniche
*
1 2 3 4 5
per nulla moltissimo

Q7.5 - Questa esperienza è utile per il mio futuro professionale
*1 2 3 4 5
per nulla moltissimo

Q7.6 - Da studente quale formato didattico è stato più efficace
*____

Q7.7 - Quanto dovrebbe rimanere "contaminata" la classe in futuro?
*____

Dopo la sezione 4
Sezione 5 di 8
2 - Partecipazione e coinvolgimento (engagement)
Descrizione (facoltativa)

Q2.1 - Frequenza di partecipazione al corso
*____

Q2.2 - Ho partecipato attivamente alle attività del corso?
*1 2 3 4 5
per nulla moltissimo

Q2.3 - Il corso mi ha motivato ad approfondire BIM/MEP oltre le lezioni
*1 2 3 4 5
per nulla moltissimo

Q2.4 - Le attività pratiche (esercitazioni) sono state utili per capire i contenuti
*1 2 3 4 5
per nulla moltissimo

Q2.5 - Il livello di difficoltà era adeguato al mio background
*1 2 3 4 5
per nulla moltissimo

Dopo la sezione 5
Sezione 6 di 8
3 - Efficacia della contaminazione
Descrizione (facoltativa)

Q3.1 - La compresenza di studenti e funzionari ha migliorato la qualità complessiva dell'esperienza
*1 2 3 4 5
per nulla moltissimo

Q3.2 - Il confronto tra background diversi ha migliorato il mio apprendimento
*1 2 3 4 5
per nulla moltissimo

Q3.3 - La contaminazione ha reso più realistici i casi e le discussioni sul lavoro
*1 2 3 4 5
per nulla moltissimo

Q3.**4 - La contaminazione ha migliorato la capacità di comunicare temi tecnici**
*1 2 3 4 5
per nulla moltissimo

Q3.5 - La contaminazione ha creato difficoltà di ritmo/linguaggio/competenze
*1 2 3 4 5
per nulla moltissimo

Q3.6 - Rifarei un corso con questa formula contaminata
*1 2 3 4 5
per nulla moltissimo

Dopo la sezione 6
Sezione 7 di 8
4 - Competenze acquisite
Descrizione (facoltativa)

Q4.1 - Ritengo di aver acquisito delle competenze del flusso BIM: modello - informazioni - usi

*1	2	3	4	5
per nulla				moltissimo

Q4.2 - Ritengo di aver acquisito delle competenze di modellazione BIM di elementi semplici (famiglie)

*1	2	3	4	5
per nulla				moltissimo

Q4.3 - Ritengo di aver acquisito delle competenze di gestione di parametri e informazioni (LOG/LOI, proprietà, codifiche, etc)

*1	2	3	4	5
per nulla				moltissimo

Q4.4 - Ritengo di aver acquisito la capacità di verificare/coerenza del modello (qualità informativa)

*1	2	3	4	5
per nulla				moltissimo

Q4.5 - Ritengo di aver acquisito delle competenze di comprensione delle logiche MEP in BIM (impianti - sistemi - circuiti)
*

1	2	3	4	5
per nulla				moltissimo

Q4.6 - Ritengo di aver acquisito delle competenze di modellazione MEP in ambito meccanico (MEP-HVAC)

*1	2	3	4	5
per nulla				moltissimo

Q 4.7 - Ritengo di aver acquisito delle competenze di modellazione MEP in ambito elettrico (ELE)

*1 2 3 4 5
per nulla moltissimo

Q4.8 - Ritengo di aver acquisito delle competenze di modellazione MEP in ambito idraulico (IDR)

*1 2 3 4 5
per nulla moltissimo

Q4.9 - Ritengo di aver compreso il processo Scan-to-BIM (fasi, criticità)

*1 2 3 4 5
per nulla moltissimo

Q4.10 - Ritengo di aver acquisito capacità di lavorare con le nuvole di punti (orientamento, lettura, uso)

*1 2 3 4 5
per nulla moltissimo

Q4.11 - Ritengo di aver acquisito la capacità di "interpretare" lo stato di fatto reale e tradurlo in modello BIM

*1 2 3 4 5
per nulla moltissimo

4.12 - Ritengo di aver compreso il concetto di "processo" (workflow, responsabilità, WBS/OBS)

*1 2 3 4 5
per nulla moltissimo

4.13 - Ritengo di aver acquisito la capacità di lavorare con standard/minime regole di modellazione e naming

*1 2 3 4 5
per nulla moltissimo

Q4.14 - Ritengo di aver acquisito la capacità di collaborare in gruppo (coordinamento, comunicazione tecnica)

*1 2 3 4 5
per nulla moltissimo

Dopo la sezione 7
Sezione 8 di 8
5 - Impatto della contaminazione: cosa ho appreso "dagli altri"
Descrizione (facoltativa)

Q5.1- In quali aspetti la classe contaminata ti ha dato più valore
*________________________________
Altro:

Q5.2 - In cosa la classe contaminata ha creato più criticità?
*________________________________
Altro:

Annex VII

List of publications

Proceedings: Ugliotti, F. M., & Zucco, M. (2023). Foster teacher-student interaction in the classroom and active learning through instant polling within the framework of drawing courses. In *ICERI 2023 16th International Conference of Education, Research and Innovation* (Vol. 1, pp. 2349–2358). IATED. https://doi.org/10.21125/iceri.2023.0647

Book chapter: Zucco, M., Del Giudice, M., & Osello, A. (2024). Digital Twin for BIM-FM data comparison: A decision support system based on graphical interfaces. In A. Giordano, M. Russo, & R. Spallone (Eds.), *Advances in Representation: New AI- and XR-Driven Transdisciplinarity* (pp. 587–605). Springer. https://doi.org/10.1007/978-3-031-62963-1_36

Proceedings: Del Giudice, M., Zucco, M., Iacono, E., Donato, A. J., Fratto, A., & Osello, A. (2024). Verso il Cognitive Digital Twin: interfacce grafiche per la comprensione e la gestione dei Big Data. In *Misura / Dismisura. Atti del 45° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione – Measure / Out of Measure. Transitions. Proceedings of the 45th International Conference of Representation Disciplines Teachers* (pp. 1285–1300). FrancoAngeli. https://doi.org/10.3280/oa-1180-c535

Scientific paper: Osello, A., Zucco, M., Iacono, E., & Del Giudice, M. (2024). Hidden logic of complexity: Graphical interfaces and algorithms for the building system / Logiche nascoste della complessità: Interfacce grafiche e algoritmi per il sistema edificio. *AGATHÓN, 16*, 202–211. https://doi.org/10.19229/2464-9309/16172024

Book chapter: Zucco, M., Del Giudice, M., & Vozzola, M. (2025). BIM nelle pubbliche amministrazioni: una barriera o un catalizzatore per la digitalizzazione? / BIM in public administrations: A barrier or a catalyst for digitalization? In T. Empler, A. Caldarone, & A. Fusinetti (Eds.), *Proliferazioni* (pp. 328–339). Publica.

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