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Year VII, v.2 2026 | Submission: 05/06/2026 | Accepted: 08/06/2026 | Publication: 11/06/2026

Information management in BIM and occupational safety: preventive integration in electrical installations and construction.

BIM Information Management and Occupational Safety: Preventive Integration in Electrical Installations and Construction

Management of BIM information and occupational safety: preventive integration in electrical and construction installations

Adriano Cesar Notari

Electrical Engineer, Civil Engineer, specialist in Electrical Installations and Engineering.
Workplace Safety

Summary

This article analyzes the integration between information management in BIM, the compatibility of electrical installations, 4D planning, and risk prevention in construction. The narrative review uses international standards and scientific literature relevant to the topic. Information requirements, interoperability, interference detection, constructability, prevention by design, control of hazardous energies, validation, and organizational maturity are discussed. A conceptual matrix is proposed that relates the phases of the life cycle, minimum information, preventive decision-making, and evidence, without presenting it as a clinically or empirically validated method. It concludes that BIM can anticipate conflicts and improve traceability when integrated with professional responsibilities, standards, technical review, and team participation. Technology does not replace inspection, safety procedures, or engineering judgment.

Keywords: BIM; information management; occupational safety; electrical installations; 4D planning; prevention through design

Abstract

This article analyzes the integration of BIM information management, electrical installation coordination, 4D planning, and risk prevention in construction. This narrative review draws on international standards and scientific literature relevant to the subject. It discusses information requirements, interoperability, clash detection, constructability, design-based prevention, hazardous energy control, validation, and organizational maturity. A conceptual matrix links life cycle phases, minimum information, preventive decisions and evidence, without presenting it as an empirically validated method. The paper concludes that BIM can anticipate conflicts and improve traceability when integrated with professional responsibilities, standards, technical review and workforce participation. Technology does not replace inspection, safety procedures, or engineering judgment.
Keywords: BIM; information management; occupational safety; electrical installations; 4D planning; prevention through design

Introduction

Construction brings together disciplines, organizations, and decisions that evolve at different paces.

Incompatibilities between architecture, structure, and installations can lead to late alterations.

While planning failures expose workers to unforeseen conditions, BIM offers...

A digital platform for coordinating information, but its benefit depends on the process. The ISO series

19650 shifts the focus from the three-dimensional archive to the requirements, production, exchange, and use of

information throughout the life cycle (ISO, 2018a).

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Electrical installations have specific requirements regarding space, segregation, protection, access, and
Maintenance. Conflicts may not be visible collisions. A tray may fit geometrically and
still prevent panel opening, reduce working distance, or block route. Coordination
It needs to integrate geometry, properties, sequence, and risk. This breadth makes the topic suitable for...
Convergence between electrical engineering, civil engineering, and occupational safety.
Construction remains a high-risk sector. International occupational statistics show declines.
Impacts, entrapments, and electrocutions are among the recurring causes of fatalities. Technology can...
Support prevention by allowing hazards to be discussed before implementation. 4D BIM studies.
They show applications in area planning, temporary protections, and communication, but warn...
for dependence on schedule and data quality (PHAM et al., 2020).
The objective is to examine how information management in BIM can support compatibility and
Safety of electrical installations during design, construction, and operation. The guiding question is:
What process requirements enable transforming digital visualization into preventive decision-making?
Traceable? The article differentiates between potential capability, evidence, and limitation, avoiding attributing responsibility to the tool.
Results that depend on culture, competence, and field control.

Methodology

A narrative and critical review of standards and studies on BIM and construction safety was conducted.
Prevention through design, 4D planning, and facility coordination. The ISO series were prioritized.
19650, publications from occupational safety agencies and peer-reviewed articles.
The descriptors covered BIM information management, interference detection, and facilities.
Electrical, safety, occupational health, 4D planning, prevention by design and life cycle.
Promotional texts, sources without identifiable methodology, and productivity claims were excluded.
without basis. The analysis distinguished between reviews, case studies, system proposals, and standards, as these
Different types of evidence have different scopes.
The findings were grouped by process function: information governance, compatibility,
Time planning, lifecycle integration, electrical safety, and validation. The table was
Developed as a conceptual synthesis derived from these categories, it organizes decisions and evidence.
but it does not constitute a normative protocol or a model of proven effectiveness.
Limitations include heterogeneity of BIM definitions, differences between jurisdictions, and...
The studies focused on specific cases. No meta-analysis or evaluation was performed.
experimental. Therefore, the conclusions identify conditions for responsible use and gaps, without
Estimate the universal percentage reduction in accidents or rework.

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1. BIM as an information management system

Building Information Modeling should be understood as an information management process, and not just as three-dimensional modeling. The ISO 19650 series organizes production concepts, Exchange, review, versioning, and use of information throughout the asset lifecycle. Models Geometric elements are part of this environment, but their value depends on defined requirements. Responsibilities, approval statuses, and traceability. When applied to electrical installations and In the context of occupational safety, BIM allows for the coordination of objects, spaces, activities, and risks on a unified basis (ISO, 2018a; ISO, 2018b).1

The quality of information begins with its purpose. A model designed for precise compatibility... content different from that used for budgeting, planning, operation, or analysis of Security. Demanding indiscriminate detail increases effort and can create false confidence. Information requirements should indicate which decisions will be supported, who produces each piece of data, when it is needed and how it will be validated. This discipline prevents visually structured models from being created. sophisticated products may contain incomplete or inadequate properties for their intended use.

The common data environment organizes versions and reduces the circulation of conflicting files. States Work in progress, shared, published, and archived tasks help control the degree of reliability. However, the platform does not replace governance. Naming conventions, Authorization, review, and approval must be consistent with the size of the project. Management must to allow identification of origin and responsibility without disproportionate bureaucracy, preserving sufficient evidence for technical decisions and changes.

Interoperability remains a challenge. Disciplines utilize software, libraries, and levels of... distinct developments. Losses in the exchange can affect connectivity, properties, classification, and geometry. Open formats and export checks reduce dependency, but do not guarantee Complete equivalence. Validation must compare received information with requirements, and not just... Confirm that the file opens. In electrical installations, a small error in reference or ownership... It can compromise quantitative data, spatial analysis, or coordination.

Information management has a human dimension. Designers, planners, implementers, those responsible. For safety reasons, operators interpret risks in different ways. Coordination meetings

[1] 1BIM is used in the context of information management processes, according to the ISO 19650 series, and not merely as... Three-dimensional model.

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Measures supported by the model can make conflicts visible, but decisions need to be recorded and...
Communicated in accessible language. BIM creates value when it brings disciplines closer together and anticipates...
choices. If used only as a final delivery, it loses its preventative capacity and becomes...
belated representation of decisions already made.

2. Compatibility of electrical installations

Electrical installations share space with structures, architecture, plumbing, air conditioning,
Fire protection and communication systems. Geometric conflicts may arise in
Trays, conduits, switchboards, shafts, and technical rooms. Automatic detection identifies intersections,
But a geometric collision is only one type of mismatch. The analysis should include access,
radius of curvature, heat dissipation, segregation, maintenance, expansion, and escape routes.
Engineering judgment remains indispensable for distinguishing between genuine conflict, tolerance, and resolution.
acceptable.

Coordination must occur before the consolidation of the details. Late changes have
higher costs because they affect purchasing, manufacturing, scheduling, and services already performed. Models
Federated systems allow for comparison of disciplines without eliminating authorship. Interference reports should
Assign responsibilities and deadlines, avoiding lengthy lists without priority. Severity criteria can...
Consider safety, functional impact, cost, and difficulty of correction. The coordination meeting.
You need to make decisions, not just visualize problems.

Electrical objects should contain useful properties, such as identification, circuit, voltage, power,
Phase, origin, classification, and maintenance requirements. The reliability of this data depends on
Rules and validation. Generic libraries may not represent products, but they can still support analysis.
Spatial. In later stages, properties should be updated as needed. Excess of
Uncontrolled attributes increase inconsistencies. A minimum reliable set is more valuable than
hundreds of empty fields.

Constructability analysis relates the model to the assembly conditions. Sequence, access of
Equipment, support, lifting, and temporary areas all influence the execution. A route
What is technically possible in the project may become impractical after a wall is closed or...
Installation of another system. The participation of field professionals in the reviews improves the...
anticipation. Models should support concrete questions about how to assemble, test, power and
Maintain, and not just locate, components.

The "as-built" update should record relevant changes with discretion. A simple...
Delivery of the project model does not represent the executed asset. On-site verifications,

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Documentation of deviations and formal acceptance are required. For operation, the information needs to be...
linked to manuals, tests, and physical identification. Digital continuity between design and maintenance.
It reduces diagnostic time, provided the database remains governed and up-to-date.

3. 4D Planning and Risk Prevention

BIM 4D associates components with activities and time. This relationship allows visualization of the evolution of...
Construction site, space conflicts, access, and simultaneous interfaces. In terms of security, the value lies in...
to anticipate conditions that do not yet physically exist. Studies demonstrate applications for
Positioning of temporary protective barriers, planning of work areas, and risk communication.
(SULANKIVI et al., 2010; PHAM et al., 2020). Simulation does not predict all human behavior.
but it expands the ability to review sequences before exposure.2
Prevention by design seeks to eliminate or reduce hazards at their source. Decisions regarding access, areas
Maintenance procedures, anchor points, de-energization, and assembly all influence future safety.
BIM can associate rules and risk information with objects, facilitating interdisciplinary reviews.
The application must respect the hierarchy of controls: delete, replace, apply controls.
engineering, managing, and using personal protective equipment. Visualization should not displace priority.
for less effective measures.
Security planning requires reliable timing information. If the schedule does not represent the
In a real sequence, the simulation may obscure exposures. Activities need to be detailed at the level.
necessary for the decision, without excessive fragmentation. Installation milestones, removal of protection.
Temporary changes, energization, and access changes should be highlighted. Integration between planning is crucial.
Security allows us to analyze when a risk arises, how long it persists, and what barriers exist.
It should be available.
Visual communication benefits teams with different backgrounds, but it does not replace dialogue.
Simulations can support preparation meetings, training, and preliminary risk analysis. Scenarios
They should be short, focused, and accompanied by questions. A complex animation can impress.
and still leave operational questions unanswered. The person in charge must confirm understanding and incorporate the information.
Worker knowledge. The tool is a mediator of collective learning, not a source of worker knowledge.
Automatic safe behavior.
ISO 19650 Part 6, published in 2025, structures the health and safety information cycle in
BIM context. The document reinforces the identification, use, sharing, and generalization of

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2. 4D planning associates model elements with activities or time intervals in the schedule.

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Risk information throughout the asset lifecycle. Its existence signals international maturity.
of the topic. However, its application requires adaptation to local obligations, the maturity of the organization, and...
Nature of the project. Standardization guides the process, but does not transfer professional responsibility.
to the model (ISO, 2025).

4. Integration between life cycle, information and preventive control

Effective prevention distributes decisions throughout the life cycle. At the design stage, it defines requirements and
It eliminates fundamental incompatibilities. In the design phase, it coordinates disciplines and incorporates secure access.
In planning, it relates sequence, space, and temporary protection. In execution, it controls
Changes and communicates conditions. During commissioning, verifies functions and records. During operation,
It maintains information for inspection and maintenance. The table summarizes this logic without intending to...
replace specific regulatory procedures.
The division into phases does not imply rigid boundaries. Operational decisions should inform the design.
while field observations should provide feedback to libraries and future requirements. The cycle of
Information makes learning reusable. To achieve this, records of incidents, deviations, and difficulties are essential.
These need to be translated into design criteria or verification rules. Filing reports without
Incorporating lessons limits prevention to each isolated project.
Responsibilities should accompany decision-making authority. The BIM coordinator does not assume these responsibilities.
automatically assumes responsibility for electrical calculations or safety. Disciplinary designers,
Planners, implementers, and security professionals each have their own specific responsibilities. The matrix of
Responsibilities clarifies who produces, reviews, approves, and uses each piece of information. This definition
It reduces gaps and avoids the false idea that software centralizes distinct professional skills.
Changes are inevitable and constitute a significant source of risk. A geometric change can affect
Safety distance, escape route, load, support, or sequence. The change flow must be recorded.
Justification, impacts, responsible parties, and approval before publication. Urgent on-site revisions.
They require a proportional mechanism, but they cannot remain outside the register. The model must reflect
authorized decisions, not all hypotheses discussed.
The proposed table functions as a conceptual traceability matrix. It relates the stage,
minimal information, preventive decision-making, and evidence. It does not present quantitative effectiveness and should not
to be interpreted as empirical validation. Its proper use is to support the organization of requirements and

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Audits. Each project must complement the matrix with standards, risks, and responsibilities.

specific.3

Step	**Information and preventive decision-making**	**Evidence of control**
Conception and project	Define requirements and coordinate models. preserving access, segregation, and maintenance.	Requirements and coordination Approved.
Planning	Relate schedule, spaces and protections. Temporary steps to review sequences and interfaces.	4D Simulation and risk analysis.
Execution and commissioning	Control versions, changes, power-ups, and tests. of the final configuration.	Records of Field and trials.
Operation	Maintain the model as built and the history. to guide inspection and isolation.	Records of maintenance.

Table 1. Conceptual matrix of integration between information and preventive decision-making. Source: [Company Name] by the author based on ISO (2018a, 2018b, 2025), Sulankivi et al. (2010) and Pham et al. (2020).

5. Electrical safety and control of hazardous energies

Electricity can produce shock, electric arcs, fire, and explosion. OSHA recognizes these.
Hazards in construction and maintenance activities. Prevention begins with the elimination of hazardous work.
energized when technically possible, followed by isolation, lockout, verification and control.
Accessibility. BIM can represent zones, sources, and relationships, but the safety condition depends on...
appropriate procedures, competence, and tools. The model does not confirm the absence of tension.4
The representation of circuits and sources aids in isolation analysis. Systems with generation
Distributed systems, batteries, or generators can maintain power through non-obvious pathways. Diagrams
Updated single-line diagrams and device identification are essential. Links between object and
Documentation can facilitate consultation, provided the information is verified. Security requires...
Consider stored energy, feedback, auxiliary power, and mobile sources. Graphical simplifications.
They shouldn't hide the real paths.

3. The table is a conceptual summary and does not replace preliminary risk analysis, standards, or specific procedures.
4. The expression "prevention by design" refers to the advance consideration of construction, use, maintenance, and decommissioning risks in design and detailing decisions.

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Coordination between design and power-up sequence reduces exposure. Partially protected areas
Completed projects may contain active equipment near work fronts. 4D planning
It can mark testing, power-up, and delivery stages, allowing for review of barriers and access points. Changes
Sequential actions should trigger a new assessment. Visualization supports situational awareness, but...
Formal authorization and field communication remain indispensable.
Working distances, access spaces, and escape routes need to be protected against occupancy.
by other disciplines. Conflicts may not appear as collisions, as they involve volumes of
Safety and maintenance. These volumes can be modeled as verification objects. Rules.
Automated systems identify intrusions, but results need review to avoid excessive alarms.
The criteria must be traceable to the applicable standard and the type of equipment.
Risk information must remain accessible during operation and maintenance. Changes,
Replacements and expansions can modify currents, selectivity, and incident energy. The model
It should indicate that studies have dates and premises, avoiding their use out of context. Governance
Documentation and periodic review are as important as the initial modeling. Electrical safety is
Continuous process of configuration control.

6. Limitations, validation, and organizational maturity

Adopting BIM does not automatically lead to a reduction in accidents or rework. Studies indicate...
Interoperability barriers, competence, cost, data quality, and organizational resistance.
Evidence of benefit often depends on the context and method of evaluation. It is inadequate.
To attribute causality to a tool without controlling for changes in process, team, and project. The value
This must be demonstrated through indicators and transparent comparison, while acknowledging limitations.
(WAQAR et al., 2024).
Validation should occur in layers. Files are checked for format and integrity;
models, in terms of geometry and properties; processes, in terms of states, responsibilities and
Approvals; uses, regarding the ability to support decisions. An automatic verification can
Approve fields filled with incorrect values. Sampling, semantic rules, and review.
Techniques need to coexist. The intensity of control should reflect criticality.
Possible indicators include conflict resolution time, number of changes after execution,
Delivery compliance, information availability, and risk closure. Each metric can...
It can generate undesirable behavior if used in isolation. Reducing recorded conflicts may mean...
Better design or lower detection. Indicators should be interpreted with qualitative evidence.
and trends. The goal is learning, not producing favorable numbers.

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Maturity must evolve from limited uses to broader integration. Starting with
Coordination of a critical discipline, planning of a project, or requirements management can generate
Controlled learning. Expansion requires standards, training, and support. Pilot projects should have
Success criteria and lessons learned. Comprehensive implementation without governance capabilities can
Increase complexity and reduce trust.
Professional judgment remains the fundamental limit. Models don't perceive all the...
Field conditions, improvisation, human factors, or deterioration. Technology enhances observation.
and memory, but it does not replace inspection, dialogue, and accountability. A preventive culture utilizes
BIM is used to formulate questions earlier and make decisions traceable. The goal is not to digitize.
existing documents, but improving the quality of the process produces security and performance.

7. Information and delivery requirements for operation.

The transition from project to operation often reveals a discontinuity of information. Models
They may contain detailed geometry but still lack identification, warranty, testing procedure, or...
Link to the physical asset. Organizational and asset information requirements must be defined.
before hiring. They indicate what data will support inspection, maintenance, replacement and
Security. Without this definition, the delivery tends to replicate the conveniences of the design software.
Acceptance must verify samples and rules. Names, classifications, units, and codes need to be...
Consistent. Critical properties cannot be accepted simply because a field is filled.
Attached documents must correspond to the installed equipment. The operating team must...
Participate in the definition and verification, as you are familiar with the workflows that will utilize the data.
This participation reduces digital deliveries that have no practical use.
Physical and digital identification must remain synchronized. Labels for panels, circuits,
Devices and areas allow relating field, model, and maintenance system. Changes should
Update all relevant representations. If the identification differs, the worker can isolate the source.
incorrect or inadequate instruction. Governance must assign authority to modify.
Records and require evidence of completion.
The operation also produces new information. Inspections, failures, tests, and replacements alter the...
understanding of the asset. A mature process incorporates these records selectively, while maintaining
History and current configuration. Not all data needs to be included in the three-dimensional model. Systems
Specialists can remain the primary source, provided that identifiers and
Responsibilities should allow for integration. The goal is coherence, not an artificial concentration of all...
the information.

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At the end of life, information regarding materials, energies, contamination, sequence, and access is required. They support safe decommissioning. Prevention doesn't end with delivery. Design decisions that record Residual risks facilitate future interventions. ISO 19650 part 6 reinforces this cyclical perspective. complete. Its use requires that health and safety information be understandable, up-to-date and proportional to the risk.

8. Critical discussion and implications for practice

Evidence suggests that BIM enhances the ability to anticipate, but does not authorize assigning all responsibility. Improvement to the model. Organizations that adopt BIM frequently change meetings, Responsibilities and communication at the same time. Studies should separate, whenever possible, the effect of visualization, governance, and collaboration. In practice, this limitation suggests evaluating The entire process should not be measured solely through the quantity of detected interferences. Automating rules shows promise for repetitive checks, but rules contain language. Contextual. Translating a requirement into a computable rule demands interpretation and updating. False. Positive results can overwhelm teams, while false negatives produce undue confidence. Rule libraries need authorship, versioning, scope, and validation. Critical decisions must remain subject to professional review.

Human factors deserve greater attention. Interfaces, information overload, and deadline pressure. They affect how alerts are interpreted. Models can improve spatial understanding, but also To induce focus on what is being represented. Emerging risks, improvisation, and weather conditions. They may be left out of the digital environment. Processes should encourage workers to question the model. and record discrepancies.

Small organizations face specific barriers related to cost, training, and standardization. Proportional deployment can utilize limited uses, lean requirements, and tools. interoperable. The goal is not to replicate the infrastructure of large projects, but to preserve it. Principles of coordination and traceability. Open guides and libraries can reduce barriers. provided they do not replace local suitability.

The research agenda includes longitudinal studies, comparable metrics, and information quality assessment. It is necessary to understand which uses generate benefits at different scales and which... Skills underpin results. Publishing failures and limitations would avoid favorable bias.

For engineering, the central contribution of BIM is to make relationships visible and decisions traceable. Making it clear that security depends on people, processes, and verification.

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Conclusion

BIM contributes to safety and compatibility when it functions as an information management process. Geometry enhances understanding, but requirements, accountability, review, and version control underpin reliable decisions.

In electrical installations, the analysis must overcome potential conflicts. Access, segregation, maintenance, energization, and safety volumes need to be represented and discussed. The model must respond to defined uses.

4D planning allows you to link risk and time. Its usefulness depends on the accuracy of the schedule and the participation of the teams. Simulations support preparation, but do not replace field verification.

Prevention through design increases the opportunity to eliminate hazards before construction. Safety information linked to objects can preserve knowledge throughout their lifecycle, especially when changes are controlled.

The conceptual matrix presented organizes stages, information, decision, and evidence. It does not measure effectiveness and should be adapted. Its merit lies in making explicit the relationship between produced data and preventive decision-making.
Electrical safety requires procedures independent of the platform. Lockout/tagout, voltage absence verification, source control, and competence remain fundamental. The model assists in location and communication, but does not certify a safe condition.
Adoption should be gradual, validated, and guided by interpretable indicators. Data quality, interoperability, and human maturity limit results. Universal claims of cost savings or accident reduction are not justified by heterogeneous evidence.

It is concluded that the integration between BIM, electrical engineering, construction, and safety can anticipate conflicts and strengthen traceability. The positive impact depends on governance, standards, technical review, and learning, while preserving professional responsibility at all stages.

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