

THE ROLE OF PROJECT SUPERVISOR WITHIN THE BIM EXECUTION PLAN

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Abstract

In the AECO sector, the BIM approach is used to manage and exchange information between the different stakeholders involved in the development of a project. Central models, available on CDE, store the information that could be retrieved according to the role and to the specialism involved. Drawing the right set of properties is crucial for successful workflows, hence cross-information is fundamental to achieve information exchange between disciplines, managed by each BIM coordinator. According to ISO 19650 series the client specifies those requirements in the EIR, nevertheless, few cases show the implementation of Health and Safety measures in it. European Directive 89/391/EEC on health and safety (H&S) on workplaces and more specifically the directive 92/57/EEC addressing Project Supervisors can be both seen as a beacon in this field for their clear and neat list of compulsory and optional requirements. This work aims to create an integrated standard example to be used from the clients at the tender stage (pre-BEP) to verify and validate the completeness of H&S design outcome. Such integrations aim to facilitate the information flow among the different specialists reducing the occurrence of onsite accidents.

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Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2023.

Keywords: BEP, CoSIM, Construction Site, Health and Safety, Project Supervisor.

1. Introduction

European Directive 89/391/EEC concerns the application of measures carried out to promote the improvement of the safety and health of workers in the workplace. Given the specific nature of a construction site and the necessity to have a defined figure, appointed in order to obtain workers' health and safety, the European Community then enforced Directive 92/57/EEC, introducing the role of the "Project Supervisor (PS) as *any natural or legal person responsible for the design and/or execution and/or supervision of the execution of a project, acting on behalf of client*". Its role has since been variously interpreted by European country member parties blurring its definition in different ways.

Anyway, the Project Supervisor has the due to assure health and safety (H&S) both in the design and the construction phase of a project. To carry out the task, the PS needs specific tools and a number of information such as to analyze and assess if the design documentation includes health and safety construction issues, coordinated with all the other design disciplines.

The PS, as well as the employer, can refer his control activity to the thematic areas detailed by the 89/391/EEC as "General obligations on employers" where eight H&S prevention measures are detailed.

Acting in a BIM environment, the tool here proposed aims to help the PS in defining the appropriate level of H&S information need to be requested from designers. Then, designers participating in the tender will have to meet and enhance in their offer those requirements to receive the tender score from the PS. For the goal is necessary to specify the contents of the documents postulated by the standard ISO 19650-6: the EIR (Exchange Information Requirements) representing the call and the BEP (BIM Execution Plan), saying the answer.

Especially, since the EIR, drafted by the SP, establishes the hierarchies and requirements related to the exchange of information within a BIM process, it represents a key point in the tender process that incorporates within it the inputs of OIR (Organizational), AIR (Asset) e PIR (Project).

It is advisable that within the Organizational Information Requirements (OIR), construction site health and safety issues are cited as strategic corporate objectives in order to develop policies that safeguard workers' lives. As stated in EN ISO 19650-1 the Asset Information Requirement (AIR) specifies in the technical aspects the detailed information to incorporate and extend the addresses to the security requirements stated in the OIR; to ensure that information generated during the construction process is used to update the model for possible subsequent construction projects. As the appointing party should develop PIR's for Health & Safety in collaboration with their Nominated Individual for Health & Safety Information so should do the Lead Appointed Party for H&S coordination in design.

The role of the Nominated Individual for H&S can correspond to the PS or as an alternative can be an assistant.

By drafting an EIR and assessing the BEP, the SP then assumes a responsibility, normally borne by the principal in construction site H&S, by having the ability, capacity, and appropriate tools to define what information is relevant for the purpose of assessing potential damage events related to the construction activities specific to each design discipline. For their part, the designers will become aware of the potential risks inherent in their own project considering the possibility of eliminating or reducing them.

The creation of a Level of Information Need form by the Project Supervisor can therefore be the meeting point between these last two documents discussed: optimizing the bidding phase.

2. Literature Review

Good management and structuring of EIR help make more informed decisions, facilitate workflow and automate processes. The most widely used file format for drafting is a text-based document (DOC). Alternatively, the spreadsheet is also used for required information set standardization or commercial applications: they allow the drafting of EIRs containing predefined sets and rules for model checking [1].

Therefore, it's important to formalize and uniform the information request to facilitate the application of BIM to all projects.

In the AECO sector, many incidents occur due to limiting factors affecting the health and safety of workers, such as their poor training and the limited technologies implemented to prevent, and monitor risks. BIM aims to improve project management, planning, and validation, strengthening collaboration between the actors involved in a project and reducing risks and accidents [2].

BEP assists contractors in project coordination and management. Its compilation takes place at the beginning and during the various phases of the implementation of the project, facilitating the collection of data in the BIM model [3].

The site layout design and safety is an essential part of an effective integration process but is usually performed by manual, inefficient, and error-prone observation [4]. We have building designers who do not yet have a collaborative approach since the role of the Project Supervisor has not been fully learned following the European directive 92/57.

The use of interoperable BIM tools allows the development of a semi-automatic review of the compliance of projects with current regulations, improving the accuracy and reliability of the validation process [4].

3. Information flow setting

Following a BIM approach, according to ISO 19650:6, safety and health design needs a project information protocol containing the specific Exchange Information Requirements (EIR), the proper level of information need, the minimum acceptance criteria, and all those supporting information needed by the tenderer in order to reach a suitable response to the tender, delivering his preliminary BIM Execution Plan (pre-BEP). All the Design Teams tendering will find the tender documents in a Client's project Common Data Environment (CDE).

The first step to reach the goal has been the setup of a RACI matrix, so as to identify among the Client Project Team and the tendering Design Team those who are Responsible, Accountable, Consulted, and Informed within the documents workflow that is shown in Figure 1.

As the Client is represented by the Project Supervisor, according to 92/57/EEC, he will be always only informed about safety and health design tender development and its outcome. His only duty can be the appointment of the Client Project Team (CPT).

Assuming a general approach, the CPT has been composed of the Project Supervisor and his staff: the BIM Advisor, the Safety Advisor, and, after the preBEP delivery the Design Auditor. On the other side, the Design Team called to tender has been composed of the Design Manager and his staff: the BIM Coordinator, and all the Designers involved, including the Safety Coordinator (set by the 92/57/EEC), all of them assumed as BIM Specialists. The project phase considered is the so-called "project strategy phase" which includes the tender phase.

The actions involved in that phase will be the EIR and other inherent documents definition (responsible: BIM Advisor, accountable: Project Supervisor, consulted: Safety Advisor), preBEP drafting (responsible: BIM Coordinator, accountable: Design Manager, consulted: Designers), preBEP validation, referred to health and safety issues (responsible: Design Auditor, accountable: Project Supervisor, consulted: BIM and Safety Advisors) and tender award.

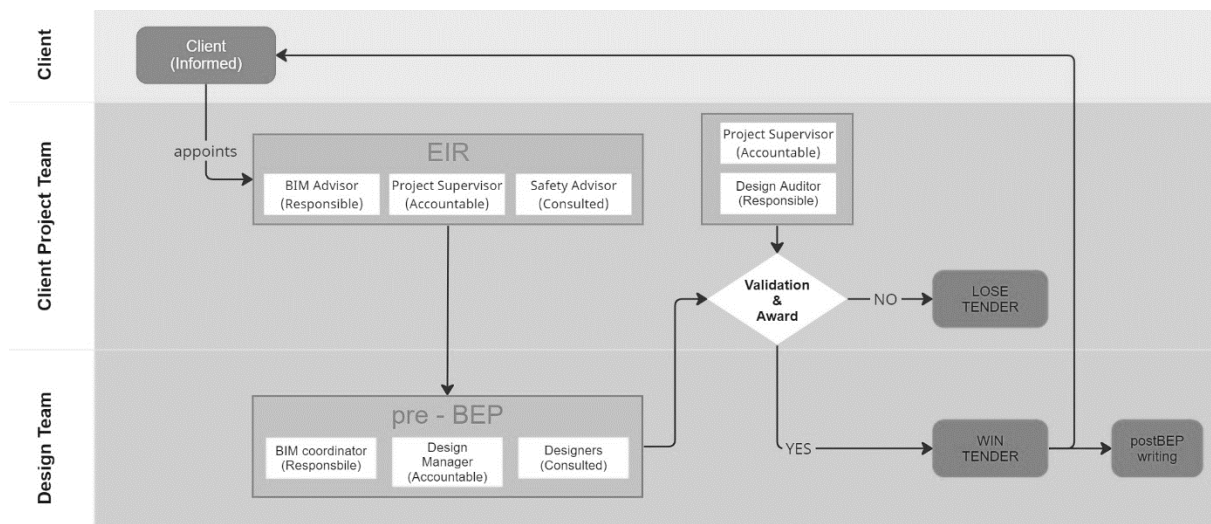


Fig. 1. RACI application and documents workflow

4. Working hypothesis

To establish the level of information need by the Project Supervisor, regarding health and safety on the construction site, the research focused on a very special "BIM object": manpower. A Construction Site Information Model (CoSIM), in fact, needs to be populated by a number of workers assumed as "objects" whose life, health, and safety have to be protected. All these "objects", inserted in strategic

points of the CoSIM at different construction stages can enlighten dangerous operating situations to be examined.

As the research explores the tendering sub-phase of the strategic one, at a pre-BEP level is impossible to preview in detail those kinds of situations.

A suitable problem solution has been considered to add a list of possible damage events affecting workers with each design discipline involved in the project.

In the case of a client-proposed contract based on a master plan, each discipline and its pertinent designers have an overview of the principal operational criticalities in order to assess the risk level associated with damaging events. By implementing safety factors such as training and on-site/off-site monitoring, it is possible to minimize or, ideally, eliminate potential sources of risk.

5. Method

The chosen method by which H&S information is to be delivered, based on the requirements expressed by the Project Supervisor within the EIR, is the Information Delivery Specification (IDS) that works in parallel with the IFC standard thus fostering Quality and Assurance control over the information exchanged.

The analysis of the IFC schemas produced by BuildingSMART: 'IFC 4.0.2.1' (IFC4 ADD2 TC1) currently in force and 'IFC 4.3.x dev' now under approval revealed the absence of entities referring to construction workers.

Therefore, as an EIR operational tool, a computerized document dedicated to the S&H Level Of Information Need was proposed, interoperable between the Project Supervisor's team and the tendering Designers' team aimed at facilitating the validation activity by the Design Auditor and adjudication by the Project Supervisor, implementable as part of subsequent development of BuildingSMART's information schemes.

Consequently, the first step has been the definition of a new IFC entity referred to the figure of the worker to be associated with the risks to might be exposed in the execution of the works identified in the tender master plan for each project discipline. This entity was then associated with the skills needed to avoid them by providing information related to its education, information, and training.

The proposed entity is named **IfcConstructionWorker** and contains all the information necessary for the Project Supervisor to assess whether the Design Team has gained awareness regarding the need to adopt design measures for the prevention and protection of the health and safety of workers required by European Directive 89/391/EEC.

setting this information also allows the CPT to verify the actual consistency between the technologies proposed by the DT tendering for project implementation, the organization of the construction site, and the predictable protective conditions for workers.

Having identified the information that the IfcConstructionWorker entity has to contain, this was then schematized following the logic of openBIM, defining the PSet, Properties, and Value fields in which the information required by the European Directive could be entered.

At present, the IFC4_ADD2_TC1 scheme defines PSet_Risk to provide information related to risk assessment. This PSet, however, finds application to only the IfcProcess entity defined as a single activity or event that has sequence relationships with other processes of the same type and is therefore poorly integrated within the schema and poor in all the information that is of interest there.

The IFC4x3_ADD1 schema currently under development, conversely, has been expanded, modified, and integrated more within other entities. In fact, the new update provides for the applicability of PSet to entities, such as IfcGroups, IfcProduct, IfcTypeProcess, IfcTypeProduct, and the existing IfcProcess itself.

The analysis of these IFC entities revealed that they refer only to entities involving objects, groups of objects, or events. None of these admit the possibility of considering the risk applied to a person who, for example, uses an object predicted in the model.

Thus, the introduction of an `IfcConstructionWorker` is intended to have connected the `PSet_Risk` to allow the association of risk assessment with a representative entity of people. The `IfcConstructionWorker` entity will then have the ability to contain information about the type and nature of the risk, and properties already defined by `buildingSMART` within the schema. This would make it possible to provide from the outset a description of the generic nature of the context or hazard to which the worker might be exposed, using the property "RiskType."

The new `BuildingSMART` scheme expanded the "RiskType" property from `IFC4_ADD2_TC1`, going so far as to define 52 risk types, selectable in the `PEnum_RiskType`. However, the ability to choose from 52 risk types was found to be too broad, leading the Tendering Design Team to become confused when compiling and evaluating the risks that the worker may incur. For this reason, we propose to make groupings within the `PEnum_RiskType` to make the list smoother and less scattered. By way of illustration, a case is given in which we show how some of the 52 specific risks contained in the `Pset` of the `IFC4x3ADD1` scheme can be grouped into at least 28 harmful events which the worker may incur. The following tables show some examples.

The first table shows how the reported `PEnum_RiskTypes` can be an enumeration of the Fall from height damaging event. The specific indication of the point from which it is possible to fall may be reported later, within other properties defined by the schema for the `PSet_Risk` such as the `AssociatedLocation` that allows precisely to indicate the location that can trigger the hazard.

Damage Event	PEnum_RiskType
Fall from height	Fallfromopenedge
	Fallthroughfragilematerial
	Fallfromscaffold
	Fall_ladder

Tab.1 "Fall from height" enumeration options

Table 2 shows how the malicious event "Struck by ..." can be representative of the enumerations provided by the `IFC4x3ADD1` schema.

Damage Event	PEnum_RiskType
Struck by ...	Struck
	Struckfallingobject
	Struckvehicle

Tab.2 "Struck by ..." enumeration options

The scheme has also incorporated properties into the `PSet_Risk` to provide information regarding the procedure used to assess the risk, the actual value of the risk prior to the implementation of appropriate security measures, and the value after the security measures have been implemented.

The adopted risk mitigation method is specified in a dedicated property of the `PSet_Risk`. The ability to link this `PSet` to the proposed `IfcConstructionWorker` entity enables standardised input within a BIM model for the risk assessment information that must be validated by the Project Supervisor.

This streamlines and unifies the delivery of required information to the PS. The information submitted to the PS must also address the training of the `IfcConstructionWorker`-identified worker.

For this reason, three new `PSets` have been proposed for inclusion in the scheme currently under development that address the topic of worker training:

- `ProfessionalTrainingEducation`,

- TheoreticalProfessionalEducation,
- ProfessionalInformation.

The worker's training, suitability for performing the work with which he or she is associated, and knowledge of the technologies and equipment used are all information that must be provided because they are required by European Directive 89/391/EEC. The following is an excerpt from the organization of the mentioned PSets.

The PSet_ProfessionalTrainingEducation provides information regarding the hours of training that must be shown to have been carried out by the worker in the event that the worker is qualified to use construction site equipment or other equipment that requires specific qualifications.

The properties defined, with simulator and with real vehicle, express the number of hours achieved that can also provide the Project Supervisor with an understanding of the experience level of the worker identified by the company to perform the associated work.

The following image proposes the schema of the PSet_ProfessionalTrainingEducation just described.

Entity - New IFC	PSet	Properties		
		Properties	Data Type	Description/Causes
IfcConstructionWorker	ProfessionalTrainingEducation			
IfcConstructionWorker	ProfessionalTrainingEducation	With Simulator	IfcNumber	Specifies how many hours construction worker was trained with the simulator for that working
IfcConstructionWorker	ProfessionalTrainingEducation	With Real vehicle	IfcNumber	Specifies how many hours construction worker was trained with a real vehicle for that working

Fig. 2. PSet_ProfessionalTrainingEducation

The second PSet, namely PSet_TheoreticalProfessionalEducation, enables the provision of information pertaining to the quantity of training hours that an enterprise is willing to offer to its employees.

The allocation of theoretical training hours could have taken place either at an external location or within the premises of the organization.

Entity - New IFC	PSet	Properties		
		Properties	Data Type	Description/Causes
IfcConstructionWorker	TheoreticalProfessionalEducation			
IfcConstructionWorker	TheoreticalProfessionalEducation	On Site	IfcNumber	specifies how many hours construction worker followed theoretical lectures on site. Theoretical lectures on site could be about correct behavior during an emergency in a construction site, how to perform a specific work, ...
IfcConstructionWorker	TheoreticalProfessionalEducation	Off Site	IfcNumber	specifies how many hours construction worker followed theoretical lectures off site. Theoretical lectures off site could be about correct behavior to follow, ...

Fig. 3. PSet_TheoreticalProfessionalEducation

The study also took into account the provision of on-site information to workers regarding operational procedures and potential hazards of interference.

The final PSet_ProfessionalInformation seeks to furnish data on the duration of time that an employer will need to allocate for the purpose of informing their employees about the intricacies of their job responsibilities. This will encompass the employment of either conventional paper-based or digital tools, while also specifying the language employed for communication. The aforementioned property is widely regarded as being of utmost significance with regards to global labor mobility.

Entity - New IFC		PSet		
		Properties		
		Properties	Data Type	Description/Causes
lfcConstructionWorker	ProfessionalInformation			
lfcConstructionWorker	ProfessionalInformation	by digital model	lfcNumber	It's important to inform construction workers the project they're realizing. Indicate how many hours they spend on a digital model to study it
lfcConstructionWorker	ProfessionalInformation	by drawing sheets	lfcNumber	It's important to inform construction workers the project they're realizing. Indicate how many hours they spend on drawing sheets to study it
lfcConstructionWorker	ProfessionalInformation	language	lfcString	identifies in which language information was given: official language and/or other

Fig. 4. PSet_ProfessionalInformation

6. Conclusion

The proposed OpenBIM approach, despite lacking a structured framework as previously outlined, was utilised in the design of the demolition and reconstruction site of the Teatro alla Scala's appurtenances in Milan. The systemization of the approach was carried out subsequent to the experience.

The research findings suggest that the proposed outcome can serve as an initial step towards transcribing information into computer language. This can be followed by the integration of the information into Building Information Modelling (BIM) authoring software and Employer's Information Requirements (EIR) documentation. The purpose of this integration is to facilitate the work of the Project Supervisor and the tendering Design Team.

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