Use of Standards for filling the gaps towards integrated BIM based ways of working – The InPro example

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ABSTRACT: This paper is focusing on the potential solutions provided by current Building and Construction standards to fill the gaps (missing or uncompleted functionalities) raised by new ways of working around a BIM based "Open Information Environment". The study focuses on different processes belonging to the Early Design Phase of a construction project. As a conclusion, solutions are proposed to fill some of the identified gaps.

1 INTRODUCTION

1.1 *Context*

This paper is inspired by the work done in the InPro project which main objective is to develop an "Open Information Environment" (OIE) supporting the Early Design Phase. In other words, we are aiming to establish and develop a model-based collaborative way of working that is relevant to the entire lifecycle of a building. Our vision in InPro is to achieve interoperability in buildings' early design phases through open standards. Among several issues raised by this "new way of working", we will concentrate for this paper on the current difficulties to implement BIM based scenarios and on the potential solutions provided by the use of standards. As a conclusion we will provide recommendations using BuildingSMART standards to provide answers to fill some of the identified gaps.

1.2 *The Key processes*

InPro industry partners have selected in total seven different major key processes (KPs), which are based on their current knowledge and characterized the BIM implementation. In this paper six of them are mentioned. The analyzed KPs are presented briefly. More detailed presentation is available on the InPro web-site.

KP1 - Coordination of Architectural & Building Service Design: It is raising a couple of general questions about integrated design based on a shared IFC model. The main identified gaps are related to Clash detection, quality control and change management as these points are essential concepts that are relevant for many design processes and thus should be solved in a way that is easily adjustable to serve other requirements.

KP2 – Collaboration and Approval Workflow: KP2 is at the heart of any collaborative action and it cannot be considered outside the definition of a collaborative framework. Every study takes its hypothesis from other existing data, so every study must know the history and the validity of these data, among its lifecycle. If the link is kept with a project data global container, any user will take benefits from being informed.

KP3 – Energy Analysis: Energy analysis is for predicting the use and cost of energy in buildings. Energy analysis has a big role in the early design approach. This KP is impacted by many stakeholders, because the design solutions of the various disciplines in the design process have effect on the energy efficiency: building and spatial layout from the architect, properties of structures from the structural designer and system specifications from the HVAC and electrical designers. Additionally building owner and end users provide the main input for energy analysis.

KP4 – Model Based Scheduling: Within the scope of construction scheduling, 4D visualisation is commonly the most desired application area of model based working and there exists already a range of commercially available software packages (Porkka & Kähkönen 2007). But several shortcomings of the available solutions still hinder the effective use of this new technique. Especially the isolated approach with a focus on visualisation only often doesn't give enough benefit to justify the very high effort necessary to set up and manage a 4D visualisation throughout several design iteration loops.

KP6 – Client Requirements Management: This KP addresses the needs for a framework for communicating the objectives, needs, wishes and expectations of the client that describes the desired building. Processing of client requirements has a fundamental impact on the design, the construction and the whole lifecycle performance of a building. The client project goals are expressed in non-design terms and translated into targets and design requirements expressed and communicated in non-design terms and/or by using international standards.

KP7 – Cost Management: The focus of this KP is on investment cost and on life-cycle cost during early design phase. The aim is to enrich cost data during early design phase and to ensure re-usability of the data during later phases of the process. This means that both life-cycle and design estimates become gradually more accurate whenever a new piece of information is available.

1.3 *Methodology*

These scenarios, so called key processes (KPs), have been described from a traditional situation ("as is" situation) and then revisited to a BIM based way of working ("to be" situation). Then analyses of these BIM based KPs have been carried out. As a result of these analyses, several gaps have been identified in each KP. These gaps stress the missing functionalities or in a more generic way, the missing supports that could enable a smooth adoption of a collaborative environment focusing on the early design phase.

For each of these gaps or issues, we have formulated recommendations or actions that could at least tackle the identified issue or solve it. We have classified the identified gaps according to different classes of potential solutions. The table below shows the different classes of gaps and the related responsible or solution.

Table 1 Gap's Categories

Category	Responsible / Solution
Lack of data exchange use case (requirements & implementation guidelines) definitions	Users (requirements) / Standard / Software
Information definitions' scope of data exchange / sharing standard	Standard
Information sharing concepts of the data ex-change / sharing standard	Standard
Information scope of the software	Software
Domain functionality of software	Software
Data exchange / sharing content of software	Software
Data exchange / sharing functionality of software	Software
BIM content and structure	Users, modelling guidance

Among these classes, two are of particular interest in the scope of this paper, namely "Users Requirements" and "Standard".

The need for better user requirements is evident. The most difficult aspect here is more about how to produce such requirements, how to re-use and capitalise on existing requirements by just adapting them or including them in our needs. The identification and formal description of the KPs have appeared all along the InPro project as difficult and time consuming tasks. This exercise led us to elaborate Process Maps using the BPM Notation. This current result should be considered as a first step leading to a more formal description, of course encompassing the process map itself but also a description of the data exchanged among the sub-processes mentioned on the process map and as far as possible the technical solution binding the exchange requirement with an existing exchange format (IFC).

We at InPro consider openness and interoperability as the minimal mandatory conditions to have efficient exchange of information. The use of standards is the only solution to provide interoperability in our fragmented sector. This is particularly vital in a collaborative environment and even more in the Construction domain when collaboration is evolving rapidly depending on construction projects. Today, the different actors involved in early design are all using computer based solutions. But, as stressed in the conclusion of an InPro deliverable (InPro -D2 / 2007), most of the time there is an important loss of data when exchanging information (electronically) among these solutions. To that regards, the chapter on Standardisation provides a short state of the art of the standards already in use in the construction sector and then in a second part comes forward with propositions or recommendations on how to bridge some of these gaps by using relevant standards.

2 GAPS

The main gaps identified in the different KPs are summarized below.

2.1 *KP1 - Coordination of Architectural and Building Service Design*

The main gaps identified are:
- Coordination of openings for HVAC equipment;
- Clash detection;
- Quality control of design solutions.

2.2 *KP2 – Collaboration and Approval Workflow*

Several problems were raised concerning the exchange of data based on IFC. Some root attributes such as GUID and "OwnerHistory" are poorly managed. The GUID are not stable and the changes are not managed. This KP stresses also the need for a better integration of collaborative functions (definition of partner's roles & rights / partial views /etc.)

2.3 *KP3 - Energy Analysis*

The main output of the analysis performed for this KP is about the need for a better quality. The quality of the information stored in a BIM is currently hard to estimate as there are no common agreements on it. There is even a need to extend IFC properties to take into account these new data.

2.4 *KP4 - Model Based Scheduling*

The analysis shows the lack of "model based" practice in 4D simulation and stresses the reasons that brake such adoption (import/export issues, insufficient visualisation capabilities, lack of open software, need for specific breakdown objects oriented towards scheduling needs instead of structural needs/etc.) (Tulke, 2008).

2.5 *KP6 - Client Requirements Management*

It appears that at present the ICT support is "basic" and the manual processing of client requirements relies on individuals more than on collaborative work based on multi-disciplinary knowledge and joint goal and ICT support. It is essential that the ICT support facilitates a flow in data creation and decisions – minimizing rework. Decision making should be based on best possible (updated) data, after a decision; there should be no going back.

2.6 *KP7 - Cost management*

This KP emphasizes especially the collaboration between construction and building services. The analysis shows the poor quality of information exchange among partners (Missing data and properties / use of different units / etc.).

3 PROPOSITION FROM STANDARDS

The different lists of gaps identified in the previous chapter prove that the InPro new way of working, based on a centralised BIM approach, is not applicable directly today. Actually, and it is not surprising, a first glimpse at the gaps shows that the main expectation revolves round the need for better integration and support of the information produced all along the selected KPs. Such expectation addresses directly the need for harmonised, shared ways and tools for working in a collaborative environment. The use of standards is the answer to provide interoperability and common understanding all along the exchanges. Among the difficulties linked to the exchange of information between multiple partners, the critical aspect is to ensure a semantic interoperability among partners. This semantic interoperability is obtained when actors of a considered process are able to share meaning or in other words when actors are able to understand each other. Achieving this semantic interoperability implies to have a technical interoperability (structure and format of the messages exchanged) but also common and agreed framework stating what to exchange and why (formalisation of the process).

The present chapter starts describing what the needs for an efficient semantic interoperability are. Then technical and organisational solutions that enable the semantic interoperability are described. The analysis of the KPs performed in the previous chapters has led to a gap list for each of them. These gap lists stress the missing functionalities that could enable a smooth development of each KP based on the OIE as a central point for collaboration and sharing. The final aim of this chapter will be then to identify these functionalities and the underlying data and propose solutions relying on the use of standards. Because of the context of the project, sector-based standards will be privileged in the proposed solutions.

3.1 *The Need for Interoperability*

The Interoperability need leads to the adoption of common, shared, agreed solutions. To play the role of a reference, available and usable for all, these references have to be maintained by neutral standardisation bodies. BuildingSMART defines the three mandatory pillars to support an efficient exchange of information as follow:

1 The format for information exchange must be shared and unique (how to exchange),
2 The information exchange has to be based on a common, standardized understanding (what is exchanged), and
3 The orchestration of the exchanges has to be specified (when is it ex-changed).

The answers provided by BuildingSMART for these pillars are:

1 IFC as a common exchange language;
2 IFD as a formalised way for representing our vocabulary;
3 IDM as a formalised way to express and represent processes and data ex-changes;

These three items represents the prerequisite for a true computerized interoperability between two or more information parties.

3.2 *The Need for Collaboration*

Interoperability through a common semantic data model, like mentioned in the previous paragraph is enough for point to point exchanges specially for exchanging snapshots of the building project at a given lifecycle stage. When it comes to collaboration, needs for collaboration processes and data management arise. InPro has identified that simply exchanging data is not enough; instead data sharing is needed introducing notions like data access rights, data ownership, organizational and disciplines based data context, change management, versioning management and approvals. Those notions are needed in the identified InPro KPs in order to (for instance) compare different design proposals (from different stakeholders), trace information changes and data validity, filter data (not all the building information data is needed for each stakeholder – only the required data for the work to be performed), consolidate data from multiples sources, etc ...

For managing data along the collaboration processes the international standard PLCS (ISO 10303-239) is used for filling the gaps the IFC data model can't solve. Therefore the OIE is recommended to be based on that standard and fed by (but not only) IFC data streams. The usage of PLCS is not detailed in this paper and will be explained in a next paper.

3.3 *Recommendations regarding the gaps*

The aim of this chapter is to organise the different gaps identified and categorised as Users Requirements / modelling issues or Standardisation issues. The first step consists in placing these gaps along one generic / high level process and then explains how methods and standards could bridge them.

3.3.1 *Organisation of the Gaps along a generic process*

Regarding the work issued by key process owners and other partners of the InPro consortium, Eurostep has established a generic key process so called "Coordination Process" which encompasses into a single and simplified view the different KPs.

This Coordination Process could be represented as shown in figure below.

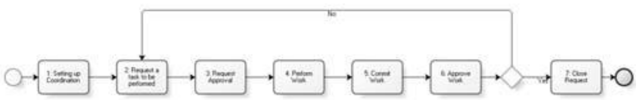

Figure 1: The Coordination process

The seven steps of this coordination process can be described as follow:

1 *Setting-up Coordination:* The main lead in this task is to organise and make explicit the exchanges among partners based on the use of the collaborative plat-form as a central node. Defining these exchanges consists in making an agreement on the work to be performed (client requirements) and on the way it will be performed (collaboration rules; technical environment).

2 *Request a task to be performed:* This is a basic collaborative task. An actor receives a request to perform a work. Details of the request should have been discussed earlier (during the setting-up of the collaboration). These details could be for instance the definition of the expected results, a deadline, etc…)

3 *Request approval:* Having received the request, the actor has to approve it, stating in that way he agrees to perform the work under the conditions expressed in the request.

4 *Perform Work:* According to the different KPs and the request received, the actor will perform a study, an analysis, a design work, a meeting or a review…

5 *Commit Work:* having performed the requested work, the actor has to commit it. This means, the work done has to be recorded into the collaborative system. The commitment can take several levels (proposal, draft, revision, final, etc.).

6 *Approve Work:* Approver(s) (defined in Setting-up Coordination task) receive a notification of the work committed. According to the work request, they control the work and make a decision (Approved/not Approved – If not approved, there is an iteration starting with a "Request a task to be performed").

7 *Close Request*: The committed work has been approved.

After a first analysis of the different gaps, the ones categorised as "User requirements"/ Users Modelling Guidance or "Standardisation" have been placed along the process as described by the figure below.

Then we have tried to identify similarities among the gaps and to propose solutions relaying on standards. The results are presented in a table organized with the following columns:

- Gap Category;
- The Gap itself as previously identified;
- The KP(s) concerned;
- The missing / needed Functionality(ies);
- A proposition of Standard support;
- (if appropriate) Standards extension needs;
- Locations of the solution along the generic process.

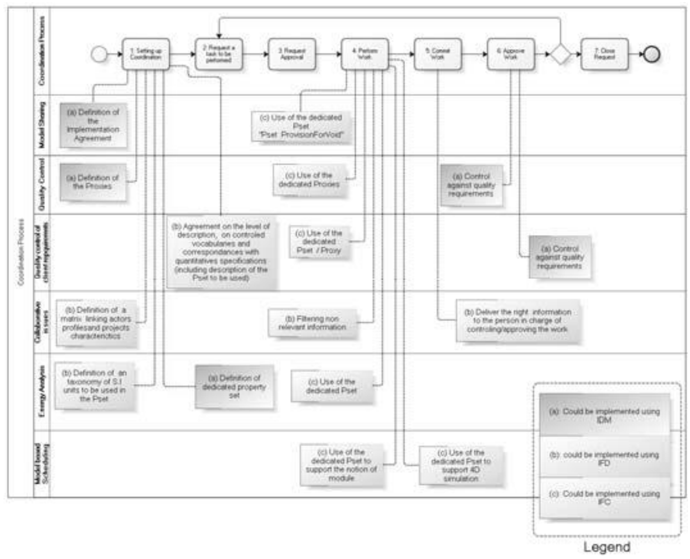

Figure 2: Location and identification of propositions along the Coordination process

The Figure 2 shows where the different proposed solutions take place along the coordination process. It is interesting to notice that most of the gaps need a two steps answer. The first step consists in defining explicitly the exchanges what will be performed. The importance of the task 1 (Setting-up Coordination) is crucial to map the meaning of the data to the exchange structure. Having done this first step, the next consists in implementing the right structure (Pset or Proxy) to convey the meaning during task 4 (Perform Work).

3.3.2 *IFC Property sets and proxy*

Many of our recommendations provided above are promoting the use of Property Sets and Proxies. It is important to stress the assets of such mechanism. Most of the IFC objects can have properties attached to them. The IFC model differentiates between attributes that are directly attached to the object as attribute of the entity, and properties, group in a property set and assigned to the object by a relationship. The latter is the more flexible way to extent applicable properties.

Furthermore these properties may be specific to particular regions, projects or process. The IFC schema supports storing and transmitting these properties in named sets (so called property sets). Therefore, a property set is a collection of properties that can be declared outside of the IFC schema but that can assigned to all objects defined within the IFC schema (including proxies).

In the case of a BIM way of working and a process driven approach, we can imagine that property sets commonly agreed by parties could support the Information delivery. There-fore, the purpose and structure of such property sets could be declared as a standard

Therefore, in the case of InPro, we can imagine Proxy objects well suited to support the needs of the various KPs. These “ad hoc” proxy objects could be an aggregation of relevant property sets according to the KP concerned. This could be a way to define explicitly the requirements for an efficient data exchange.

The management of collections of property sets and collections of proxies could be done trough the support of IFD mechanisms as illustrated by the figure below.

A proxy object could be defined with several facets according to the different contexts in which this object is used. On the OIE, the full description of the object will be stored but for exchange purposes (import and export) in an identified scenario, only needed proper-ties will be selected. This will provide several advantages (reducing the weight of the IFC files, quicker upload/download of data, easier quality checking…).

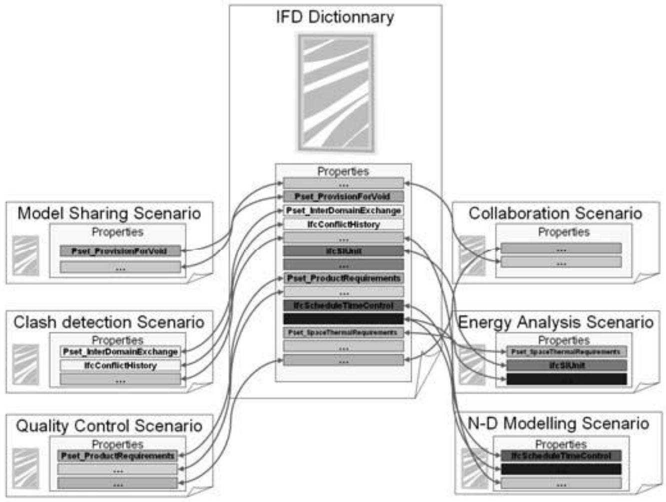

Figure 3: The IFD context mechanism to support different views of an IFC object

3.4 *Towards Collaboration*

In front of all gaps “tagged” as “standards” or “User Requirements” (see description of categories in table 1) we have made standard based propositions and shows that most of them could be solved by using existing appropriate mechanisms of the IFC. Some issues are out of the scope of this study (for instance, the management of the GUID tackled by the use of the PLCS standard).

The collaborative approach shows the need to change the current way of working and the current way of exchanging data among partners.

IFC has to be considered as a robust and mature exchange format only. Our analysis shows that in most cases, it is not necessary to create a new basic object to bridge a gap. The basic blocks are there. It is just necessary to come with more “high level objects” that are well suited for identified processes. As a consequence, there is a need to define explicitly a priori exchange protocols adapted to the identified cases (e.g. our KPs).

This need could be satisfied from the technical point of view by using / defining adapted Proxies and Property and from a collaborative point of view also by using / applying methods facilitating the formal description of the whole process (IDM). IFD provides an open mechanism to support the multi-facet aspect of IFC objects (see illustration Figure 3 above). IFD makes also the semantic link between client requirements often expressed by qualitative indicators (common words) and technical specifications expressed by values and physical units.

It is necessary to well identify and differentiate functions/functionalities dedicated to collaborative work and those technical which should be supported by the IFC. On that particular point, we have reported that the implementation of the IfcOwnerHistory is not satisfactory. The new way of working imposed by a collaborative approach leads to develop new and enhanced ways for tracking changes by using the PLCS standard. This point has been particularly tackled in a deliverable available on the InPro project web-site (Overview of Information Management Applications, Including Object-Based Version Management – M.Nour et Al) and the usage of PLCS for adding the data management aspect to IFC will be demonstrate in the final InPro demonstrations.

4 CONCLUSION

The work performed in this task concentrated on the analysis of the key processes against the InPro's new way of working based on a collaborative approach relying on the use of a so-called OIE. Compared to the current way of working, this new integrated and collaborative approach needs improvements at different levels. We look as well to the changes in the process and information flow as to the changes of the information itself. This was the main outcome of the key processes analysis. The main output of this analysis is that IFC holds most of the necessary objects needed to fix the gap list items. What is necessary is to add more semantics to the relatively abstract terms available in IFC and describe the process around them; this could be done making use of IFD and IDM standards. When it comes to share data (collaboration), the PLCS standard is used for the management, the consolidation and coordination process aspects

5 ACKNOWLEDGEMENT

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7 ACRONYMS

BIM: Building Information Model / Building Information Modelling

IDM: Information delivery Manual

IFC: Industrial Foundation Classes

IFD: International Framework for Dictionaries

InPro: Open Information Environment for Knowledge-Based Collaborative Processes throughout the Lifecycle of a Building

GUID: Global Unique Identifier

KP: Key process [InPro]

OIE: Open Information Environment [InPro]

PLCS: Product Life Cycle Support [ISO]