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Information delivery manuals to integrate building product information into design

Berard, Ole Bengt; Karlshøj, Jan

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Prof Charles M. Eastman
Director, Digital Building Laboratory
School of Architecture
Georgia Tech
Atlanta GA, 30332-0155
USA

FOREWORD

The Architecture, Engineering, Construction and Operations (AECO) community is moving from a planning and documentation process that has been enabled manually by people (as a manual craft) to a digital process that supports automation, and to digital craftsmanship. The path of that transformation, in thinking, new processes and supporting technologies, has only begun. But as late starters, we have the advantage of learning from the other fields that have adopted digital representations, from obvious analogies such as aerospace, to more subtle ones, like the mass customization now practiced in digital dentistry.

An important dimension learned from these earlier developers is the central importance of process. Processes are the complement of a product, a project is the synergistic integration of both product – what a designer defines - and the process required to realize it. Digital models allow the integration of new automated processes in place of manual ones. These range from communicating a part of a design in a digital format, to checking of the design using rule-based systems, for example in terms of spatial conflicts, to describing an assembly process for the realization of the design – to a robot. Development of the criteria needed to define processes, not to just document them, but rather to re-define them and improve them, is a new and important capability that the following paper begins to address. What are the criteria needed to specify processes, to map them into implementable plans, the uniqueness of processes in construction, both in their individual steps and in their larger structure – these questions are well raised in the paper by Berard and Karlshoej. We need to develop lines of work that build upon one another that resolve one level and proceed to the next. For example, I hope the authors' work can be critiqued and improved, resulting in deeper understanding of the role of processes in the built environment.

Chuck Eastman

Georgia Institute of Technology

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INFORMATION DELIVERY MANUALS TO INTEGRATE BUILDING PRODUCT INFORMATION INTO DESIGN

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Ole Berard, Industrial PhD Student,
Department for Civil Engineering, Technical University of Denmark (DTU), Lyngby, Denmark
MT Højgaard, Soeborg, Denmark;
olbe@byg.dtu.dk

Jan Karlshoej, Associate Professor,
Department for Civil Engineering, Technical University of Denmark (DTU), Lyngby, Denmark;
jak@byg.dtu.dk

SUMMARY: *Despite continuing BIM progress, professionals in the AEC industry often lack the information they need to perform their work. Although this problem could be alleviated by information systems similar to those in other industries, companies struggle to model processes and information needs in the manner necessary to develop information systems that support digital collaboration, workflows, and information exchange. Processes for information systems can be described from four perspectives: task sequence, information need, organizational interaction, and required logic for the specific task. Traditional business process modeling languages often fail to completely cover all four perspectives. BuildingSMART has proposed Information Delivery Manuals (IDMs) to model and re-engineer processes that address the four perspectives through a collaborative methodology in order to standardize and implement them in information systems. BIM implies that objects are bearers of information and logic. The present study has three main aims: (1) to explore IDMs capability to capture all four perspectives, (2) to determine whether an IDM's collaborative methodology is valid for developing standardized processes, and (3) to ascertain whether IDM's business rules can support the development of information and logic-bearing BIM objects. The research is based on a case study of re-engineering the bidding process for a design-build project to integrate building product manufacturers, subcontractors and their knowledge about costs, construction methods, and products, with the intention of minimizing the time spent on non-value-adding tasks and reducing design errors.*

KEYWORDS: *BIM, Building Products, Design Management, Information Delivery Manual.*

REFERENCE: *Ole Berard, Jan Karlshoej (2012) Information delivery manuals to integrate building product information into design, Journal of Information Technology in Construction (ITcon), Vol. 17, pg. 64-74, http://www.itcon.org/2012/4*

1. INTRODUCTION

Building Information Modeling (BIM) has become increasingly popular in the architectural, engineering, and construction (AEC) industry. One of the perceived benefits of BIM is the organized and visual information it provides (McGraw-Hill 2009). However, it is costly for professionals due to information overload or the lack of high-value information (Tang et al. 2008) to access the information these professionals require. BIM constitutes a pool of digital information that could become an information system used to support design and construction processes. Manufacturing industries have acquired great benefits from implementing information systems to manage collaborative standardized processes and share information (Banker et al. 2006).

Information is related to processes because information needs are task- or process-specific (Eastman et al. 2010). Construction companies struggle to model and re-engineer processes in order to develop information systems for collaborative processes. One explanation for this is that products (that is, buildings) and organizations are perceived to be unique on every project, which necessitates the need to also adapt the processes and information (Hartmann, Fischer and Haymaker 2009). Becoming aware of information needs and making information requirements of other actors could help develop information systems, but also enhance collaboration in general.

1.1 Information Delivery Manual

The four following perspectives can be used to describe business processes for information systems: *functional* (i.e., business rules), *behavioral* (i.e., sequencing), *organizational* (i.e., actors), and *informational* (i.e., information elements) (Curtis, Kellner and Over 1992). According to a review by List and Korherr (2006) of seven business process modeling languages (including UML 2.0, IDEF3, and BPMN), all have shortcomings in terms of the organizational and informational perspective, whilst the functional and behavioral perspectives are generally well implemented.

The Information Delivery Manual (IDM; ISO 2010a) is a business process modeling language that has been proposed to address the issues described above. The IDM is both a *product* to document information that needs to be exchanged to perform a task in a process, and also a *methodology* to model and re-engineer the process. As a *product,* the IDM extends Business Process Modeling Notation (BPMN) (White and Miers 2008). Unlike other methods for process modeling languages, the IDM does not focus on information products (that is, documents) but on in-depth descriptions of information elements (such as attributes) and their exchange through object-oriented models. The IDM consists of a process map (behavioral), narratives (organizational), exchange requirements (informational), and a narrative of business rules (functional) (Karlshoej 2011). The IDM as a *methodology* utilizes collaborative process re-engineering by involving multiple competencies (such as domain and software experts), as well as knowledge about BIM and the IDM to model or engineer cross-functional processes.

The IDM is part of the Information Exchange Framework for certifying IFC software (Wix and Karlshoej 2010). Other parts are Model View Definitions (MVD) (Hietanen 2008), which translate IDM into a document for software development, and Industry Foundation Classes (ISO 2010b), which provide the data structure. Although the three standards are closely affiliated, they are not inherently interconnected, either by ISO/AWI 16739 (ISO 2010a) or the US National BIM Standard (NBIMS) (NIBS 2007). On the contrary, the value of the IDM is beyond IFC certification and an IDM may become a legal agreement (NIBS 2007) between multiple parties for the purpose of enhancing their digital collaboration. The notion of *exchange objects* (Eastman et al. 2010, Aram et al. 2010) is used to explicitly decouple the IDM from IFC, rather than *exchange requirements,* as binding of data sets to a data structure should happen on the software development side (that is, MVD). BuildingSMART recently suggested keeping the IDM free of IFC bindings.

The IDM is gaining popularity in industry and research as a way of re-engineering and modeling processes and information flows. BuildingSMART lists 98 IDMs that are currently being developed (four of which are approved) (Karlshoej 2011). In the research literature, the IDM has been applied to pre-cast concrete (Jeong et al. 2009, Panushev et al. 2010), while suggestions have been made for implementation (Eastman et al. 2010) and improvement (Aram et al. 2010).

1.2 Knowledge in Digital Product Models

BIM implies that information is exchanged through product models consisting of CAD smart objects, so-called BIM objects (Ibrahim and Krawczyk 2003), digital components of parametric or static geometry, and information describing the state (for example, materials, dimensions) and behavior (for example, energy performance, price), that are aware of their relations to other objects, possibly implementing simple logic. In manufacturing industries (such as the automotive and aerospace industries), the integration of production knowledge in to object-oriented product models for the benefit of design and production is an established topic of research (Hvam 1999, Yang et al. 2008) and practice.

Fischer (2006) described how formalized construction knowledge can lead to self-aware *virtual elements* that "know" what affects their design and behavior and are able to react to it. Fischer argued that construction knowledge has not been formalized to a degree that supports this. Even though construction knowledge has not yet been formalized, atomic parts of it can be programmed into existing objects and provide value. Lee et al. (2006) suggested that the building object behavior (BOB) notion describes knowledge embedded into BIM objects. The logic programming in BIM authoring tools provides a practicable point of origin with which to illustrate the potential, and it could be used to implement simple design and production rules. It is not yet possible to exchange BIM objects comprehensively through open standards (such as IFC), but Wei et al. (2010) did conduct research on this topic. This research relies on a commercial and proprietary format (Autodesk's Revit 2010 Families).

1.3 Background for the Case

The IDM claims to be a new methodology with which to model processes that address some shortcomings of other languages. An underlying assumption of the IDM is that processes must be standardized if they are to be implemented in information systems. Apart from the *behavioral*, *organizational*, and *informational* perspective, the IDM encourages description of constraints and logic in business rules, which relate to the feature of BIM object to implement simple logic. This is the motivation for the present study's evaluation of (1) the IDM's capability to capture task sequence, information needs, organizational interaction, and required logic; (2) whether the IDM's collaborative methodology is valid for developing standardized processes; and (3) whether business rules identified by the IDM can supplement the development of information and logic-bearing BIM objects. Since the IDM is task-specific, the evaluation is based on a case process: *the bidding process for a design-build project*.

The influence on and inclusion of contractors into design increases in new contract forms (e.g. design-build and Integrated Project Delivery (IPD) (AIA 2007)). This is important for contractors and building product manufacturers, since they can receive orders based on their expertise in building solutions. The bidding phase of design-build projects is short and pressurized since the output is a complete design including planning and cost. The focus in this phase is on construction costs; however, as sustainability becomes an issue, life cycle costs and product quality become increasingly important.

Errors induced by the design are a significant source of errors during construction (30 percent of all errors) and maintenance (55 percent), many of which are caused by a lack of knowledge (44 percent), information (18 percent), or motivation (35 percent) (Josephson and Hammarlund 1999).

Research and practice have shown that sub-contractors and manufacturers can contribute to the optimization of design and construction (Gil et al. 2001) through better options for client customization and enhanced ease of off-site manufacturing (Elliman and Orange 2003), review and verification of constructability (Arditi et al. 2002, Pocock et al. 2006), better cost control by choosing the right product and production method (Slaughter 1993), fewer design errors due to thorough feedback (Johansson and Granath 2010), and exhaustive product data from the supply chain. Nonetheless, the design and the construction of a building are currently clearly separated tasks (Vrijhoef and Koskela 2000). Although rework costs do not vary significantly among procurement methods and project types (Love 2002), there seems to be a causal link between the project costs and good collaboration of the design and construction team (Love et al. 1999). New contracts, such as IPD, address this issue from an organizational perspective. The present study intends to address it from a behavioral perspective. This is the why re-engineered bidding process for a design-build project must *free up time*, *reduce design errors*, and *integrate* sub contractors and manufacturers with the design.

2. RESEARCH METHODOLOGY

In this research the researcher becomes actively involved by facilitating the social situation that is being researched; this is referred to as action research (Hartmann et al. 2009, Somekh 1995). This type of research makes it necessary to distinguish between research methodology and development methodology (that is, the IDM). Action research is pragmatic and feeds the findings directly back to the practitioners. The challenge of action research lies in the rigor of the data collection. This collection is impossible without prior knowledge and is based on qualitative methods (such as unstructured and semi-structured interviews, notes, analytical memos and observations, development documents, workshops and discussions) and constantly challenging and following up on the development process. The view of technology in this research is inspired by the social construction of technology (SCOT; Bijker 1995). Technology, particularly BIM, is shaped by the struggle of different social groups. BIM has a high degree of interpretative flexibility, since different social groups have different applications for it. Architects consider BIM as a tool for outstanding design, as contractors would like to improve their productivity. These different views are not necessarily contradictory, they just illustrate that the technology is not stable and that closure has not been reached. Design methodologies that include the social groups in the development of the technology reach stable technology at a faster pace according to SCOT.

3. THE DEVELOPMENT OF THE INFORMATION DELIVERY MANUAL

3.1 Development Methodology

The working group consists of a contractor (responsible for estimation, procurement, project management and design management), two BIM consultants, seven building product manufacturers (responsible for knowledge about products, estimation and sales; see Table 1), a software vendor (construction estimation), and the Technical University of Denmark (DTU – IDM expertise and academic monitoring). The manufacturers are categorized by terms from Supply Chain Management theory: *Made to Stock* (MTS) for off-the-shelf products (e.g., drywall), *Made to Order* (MTO) for products manufactured on order (e.g., windows), and *Engineered to Order* (ETO) for products that involve design (e.g., prefabricated concrete).

TABLE 1: Building product manufacturers, products by production category, and whether they just sell the product or also install it (service).

Production Category	Company	Product	Service/Product
MTS	Drywall Inc.	Drywall, ceilings	Product
MTS	Energy Efficiency Corp.	Insulation	Product
MTO	Up and Down Ltd.	Elevators	Product, Service
MTO	Clear View LLC.	Windows, doors	Product
MTO	Outer Shell Corp.	Façades	Product, Service
ETO	Light Concrete Inc.	Prefab Concrete	Product, Service
ETO	PreFab Ltd.	Prefab Concrete	Product, Service

Twelve manufacturers were invited to the initial workshop, six of which accepted (one joined later because of expertise in BIM). Invitation criteria included the variety of building products and production categories, avoiding competition, good collaboration with the contractor, and evaluation of their innovativeness. Based on a self-assessment by the manufacturer [1] of BIM needs (see Fig. 1), the contractor and the individual manufacturers choose the products, attributes (see Section 3.3), and knowledge to be developed as BIM objects [2] (i.e., Autodesk Revit 2010 Families). The focus was on simple geometry, only necessary attributes, and simple rules to solve known design issues. Quality assurance of the BIM objects took place at the universities BIM laboratory (DTU BIMlab) where the BIM objects were used in software for different purposes [4]. The process was analyzed and modeled [5] collaboratively by an expert committee (see Fig. 2) and a sub-group of the working group, and then validated [6] through a test case and follow-up interviews.

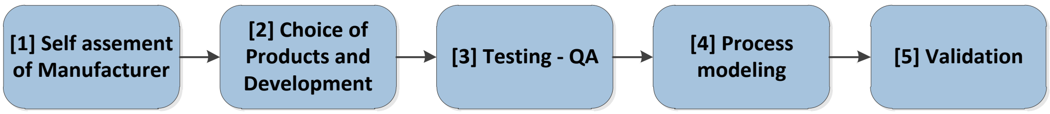

FIG. 1: Schematic representation of the development process.

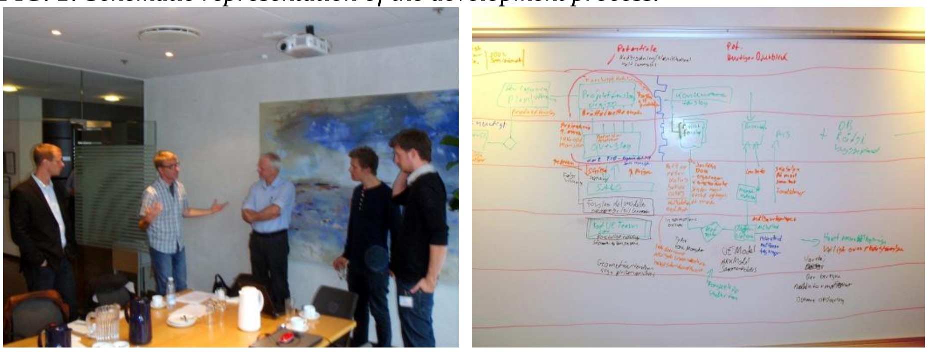

FIG 2: The expert group workshop

3.2 The Business Process

The existing process is typically sequential – starting with *design*, then *procurement*, and finally *compiling* the documents – with little opportunity for feedback between the main sequences. The *design* stage is more agile and runs in iterations that are not necessarily synchronized. Two main loops have been identified: the *program requirements* (placement of the building, aesthetic design, and performance requirements) and the *conceptual design* (the structural system, main routes for MEP, and choice of products and materials). The process is a compact version of the design and procurement of a traditional project and takes typically 4 to 6 weeks.

During design, the estimator keeps track of the costs (two or three complete estimates). Before placing the bid, the prices needed to be covered by subcontractors or manufacturers. Communication is increasingly unstructured (for example, telephone conversations, emails, and file sharing). Designers lack knowledge about cost and constructability and want feedback on multiple design alternatives. Sub-contractors and manufacturers are rarely invited into the design, but often based on personal preferences and experiences or through the sales function of the manufacturer. Engineered-to-Order companies are more likely to be part of the design process, but not necessarily at the bidding stage. When Made-to-Order companies are involved, they often have to spend time adjusting products or design with each other. Involvement of Made-to-Stock products is limited to a quantity take-off.

For *procurement*, the sub-contractors and manufacturers receive a closed design without the opportunity or incentive to change it. In this context, their main challenge is the effort spent on information management (*"Sometimes we get 80 drawings; how do we find the right one?"*) and quantity take-off (*"Mostly we cannot even get a DWG drawing, which is easier to take measures from!"*). The output is a bid, including a specification of the costs and products. The last sequence is *"the time where the project manager does not sleep"*, compiling documents, prices, and presentation into a bidding document.

The improved process (see Fig. 2), which integrates sub-contractors and manufacturers, can lead to a more cost-efficient design with fewer design errors. This has been shown in the literature and in practice, and has also been identified by participants. The improved process is built on *direct* participation, whereby knowledge is communicated by humans, and *indirect* participation, in which knowledge is communicated by computers through logic.

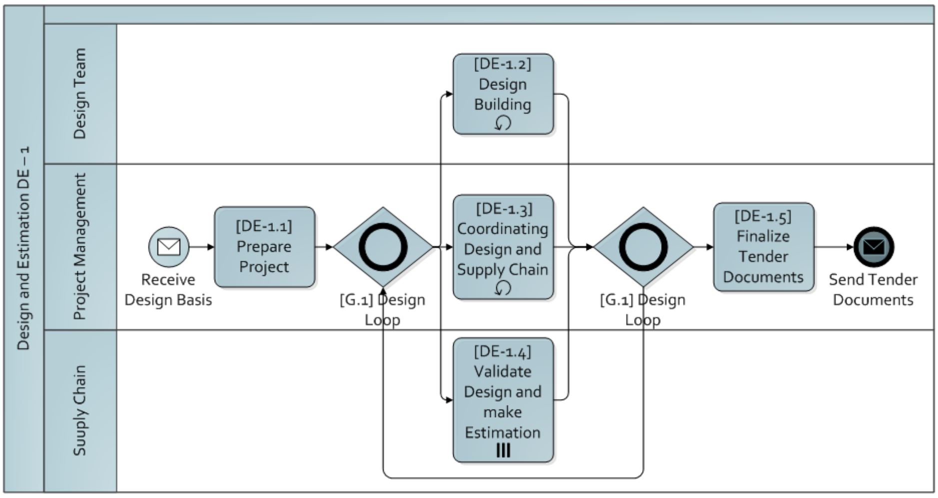

FIG. 2: Overview of IDM process

The design team makes a product model of the conceptual design using product-specific objects that have been developed and maintained by the manufacturers, instead of using generic objects. These objects are loaded to a BIM authoring tool (see Fig. 3) and equipped with simple rules (see Business Rules) to validate the design (for example, windows come in certain sizes); if the requirements are not fulfilled, the designer is notified. Information that a designer would previously have had to find by searching in a product information sheet or by contacting the manufacturer is integrated into the object. In this way, the manufacturer participates *indirectly* in the design. Afterwards, the product model is shared and can be accessed by the other designers, contractors, and manufacturers. In order to provide input that cannot be coded into the objects and for cost estimations, it is still necessary to involve the sub-contractors and manufacturers who participate *directly* in the design. Cost cannot be coded into the objects because product and labor costs depend on external factors, such as the volume of orders.

Ideally, project management can focus on coordination; forwarding the design to the sub-contractors and manufacturers and, vice versa, the design feedback and cost estimation to the design team. The product-specific objects also enable manufacturers to identify their part of the design and the IDM ensures that the necessary information is in the object (see Section 3.3). This enables the manufacturers to perform their tasks (estimation) with less effort spent on information management and quantity take-off. This frees up time that can be used to analyze design alternatives and provide valuable feedback to the design team beyond costs.

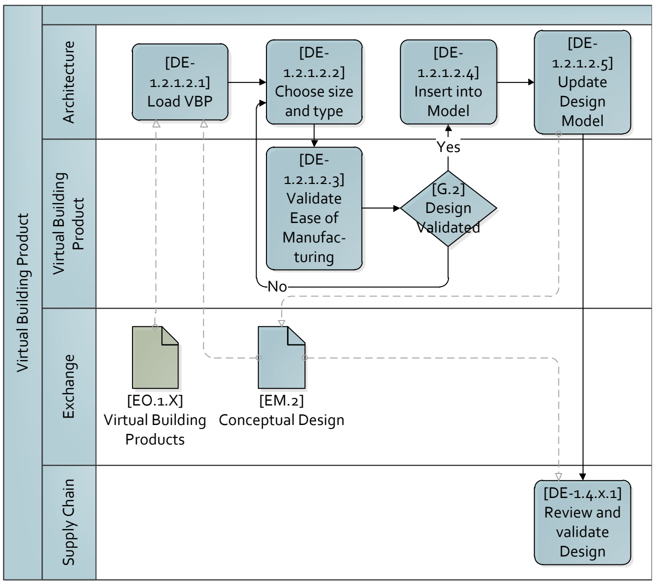

FIG. 3: Working with the Virtual Building Product

3.3 The Exchange Objects

All types of products (ETO, MTO, and MTS) have the same basic information (see Table 2). ETO products that the manufacturer designs (that is, pre-cast concrete and lightweight pre-cast concrete) require additional information from the designers, such as structural system, load, and principal details. Traditionally, some of this information has not been communicated through CAD and requires additional documents, such as the structural load analysis.

Passenger elevators (MTO) are highly standardized and do not require a lot of geometrical and other information. More important are the business rules, to ensure that the elevator fits the shaft designed. For windows, doors, and façades (MTO) the space defines the requirements for the object (e.g., solar shading, noise reduction, safety, security, and fire). Manufacturers are also interested in the energy performance analysis to optimize the product choice. MTS products (insulation, drywall, ceiling, and floor) also need attributes that are derived from space (such as fire rating, noise reduction, robustness, and applicable surface requirements).

TABLE 2: Common information in all exchange objects.

Attribute	Data Type	Actor supplying	Documentation
Object Type	String	BPM	The type of building product
Manufacturer Name	String	BPM	Name of the manufacturing company
Model Number	String	BPM	Manufacturer's name/number of the product
Weight	Number	BPM	The lifting weight of the product (in kg)
U-Value	Number	BPM	Heat transfer coefficient of building element.
Links	hyperlink	BPM	Link to installation documentation
Material	Object	BPM	Name, quality, strength
Geometry	Numbers	BPM	Geometry that allows measures to be taken
Dimensions	Numbers	BPM	Dimensions that allows measures to be taken

3.4 The Business Rules

An important and obvious business rule is that objects can only have sizes and dimensions that are available for order. By way of example, two such business rules are explained in detail. The first issue is related to windows. According to the manufacturer and the contractor, the size of the opening (that is, a hole in a wall) must be the same size as the window including caulking. Normally a window has 12.5 mm caulking on each vertical side. However, when two windows or doors are adjacent the caulking must be 10 mm (see Fig. 4).

The second example is passenger elevators. In addition to the lifting shaft, an elevator requires an overhead on top and an elevator pit in the bottom for the lift system and other technical installation. The size of these depends on the model and make of the elevator. According to the manufacturer, a common issue is that the chosen elevator does not fit the shaft, either in depth or width, or that there is not enough room for the pit or overhead. This can be costly if it is discovered after the precast concrete elements are manufactured. Thus, one business rule for the elevator ensures that the width and height of the shaft is adjusted with the elevator design.

[BR-3] Window/Door Width

Type	Business Rule
Name	Window/Door Width
Documentation	It is mandatory that the width of an window/door is equal to the width of the opening subtracted 10 mm for each vertical side adjacent to another window/door and subtracted 12,5 mm for each vertical side not adjacent to a window/door.
Related to Concepts:	• [VBP-2.1.1] Window • [VBP-2.1.2] Glass Door

FIG. 4: Example of a Business Rule

3.5 Validation

The IDM and the BIM objects were validated in three stages: a test project, follow-up discussions with participants in the working group, and interviews with a wider group of supply chain actors. The test case was based on a minor residential project designed by an architect. The BIM objects were loaded in the model after the design was finished to simulate real life conditions; it cannot be presumed that the architect will use the product-specific objects. This led to an unanticipated proof of the value: the elevator designed by the architect was too small (see Fig. 5). The design was shared with the manufacturers in three formats: Revit, a Solibri Model Checker Information Take-Off highlighting the necessary attributes, and a DWF file for viewing purposes. The manufacturers were asked to review the design and give feedback on cost, design improvements, and specifications. Finally, the IDM was presented in an interview to a separate group of sub-contractors.

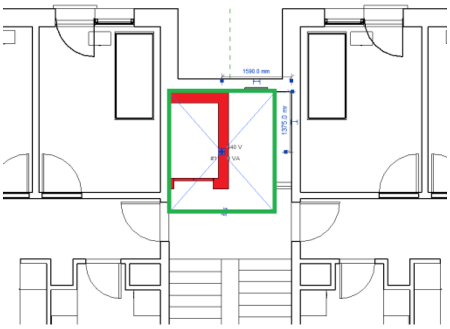

FIG. 5: The elevator as designed (red) and as ordered (green)

4. RESULTS

The IDM builds on the BPMN to model process, as an established modeling language; it is able to capture the sequence and interdependence of tasks. Furthermore, the swim lanes (that is, actors or organization) address *who does what*, meaning that, supplemented with narratives, the organization can be well described. It can become trivial to describe the organizations and actors, since many roles in a construction project are well defined. References to definitions provided by other sources (such as OmniClass) could help.

IDM distinguishes itself from other process modeling languages in the way it addresses information. The Exchange Objects enable the detailed specification of information requirements to perform a task, rather than just addressing documents, the content of which might remain a black box in other approaches. This study used the IDM to describe information requirements to a proprietary format (Revit) and to define the *set of information* that needed to be exchanged independent of the *data structure*. The set of information could be exchanged in different *structures*, such as IFC, Revit files, and even in unstructured documents. To professionals, it is more important to communicate the necessary information (for example, "*I need to know the size of the window by Monday*") than whether that piece of information comes in an IFC model, a Revit file, an e-mail, or a phone conversation (although other considerations, such as traceability, could cause one to be preferred over the other). Mapping the information set to a data structure is the responsibility of the systems developer. This is why the IDM needs to be free of IFC bindings. The information, however, should be collected as data sets representing building products, to also support the way users think about information.

The IDM's business rules are a container for design knowledge, functionality, constraints, and transformation of information. The project used narratives to communicate business rules as suggested by the IDM. Narratives are ambiguous and can take a long time to capture the essence. A precise modeling language is beneficial for the brief communication of business rules, and it also ensures that the business rules are universally understood. The Production Rule Representation (PRR) of the Object Management Group (OMG 2009) provides a standard to express rules as syntax similar to programming languages (see Fig. 6).

```
rule: Not Adjacent to Window or Door
ruleVariable:
    side : Side = window.Sides->any()
condition:
    side.IsVertical()
    and
        not side.IsAdjacentTo(typeOf(Window))
            or
        not side.IsAdjacentTo(typeOf(Wall))
action:
    window.Width -= 12.5 mm
```

FIG. 6: Example of Production Rule Representation of the window width rule

IDM enforces the analysis and description of multiple perspectives of a process, and its context, which is necessary for developing an information system. To this end, IDM is a *check list* to ensure exhaustiveness. Unfortunately, this exhaustiveness is also the greatest disadvantage, since an IDM is not concise; most IDMs cover 50, 60, or more pages. This makes the methodology more suited than the product to make requirements to building product manufacturers and their BIM objects.

Construction project processes are highly flexible and, in today's practice, it is cumbersome to model a process in great detail in order to standardize it. Not only is the order of task execution different from project to project, but the interaction between organizations can also differ within a single project. A progressive window manufacturer may want to get involved in the design, while a more conservative one wants a list of his deliveries. The real world can turn out to be very different from the model, depending on the context, and it is counterproductive to trust a detailed model that has been made for the wrong purpose. Trying to map the sequence in these processes is a huge effort and it can be very time-consuming to collect the input from multiple sources. In addition, professionals can rarely recognize and accept the same processes, because they perform them differently. The challenge is to keep the processes general enough to suit different needs and specific enough to remain relevant. The result of a generic work-flow is not necessarily applicable in specific project. This is why modeling the process by tasks sequence has a low priority and must be high order and flexible; this also reduces the chances of getting lost in modeling process and *over-modeling*.

If it is not possible to standardize processes on construction projects, since they are unique and ever-changing, information systems need to support this. IDMs could contribute as a standardized way to communicate processes on construction projects. If construction projects documented their processes and information needs in a unified way, overtime processes could be combined and reused on projects and, finally, researchers could analyze processes for effectiveness and efficiency leading to improvement. In order to become functional on a project basis, IDMs lack the ability to address points in time. While they provide the sequence, they fail to address the actual date when a task needs to be performed and information needs to be exchanged. In the context of a project, the collaborative modeling and re-engineering of a workflow could define what information is needed to perform a workflow, ideally pulling the information from the previous actor. A simplified IDM could provide the methodology and the modeling language to make this work uniform.

Business rules can capture atomic parts of the workflows, which are so small and simple that they are part of many projects and so time-consuming that automation becomes relevant. An example is the business rule that provides the window size. It is a regular problem that is simple to implement in existing BIM software and it can prevent costly erroneous orders. Information needs can be so general that they are easily implemented as attributes into BIM objects. IDMs, on a project basis, can provide a lead and help identify business rules and attributes. However, to provide requirement specifications for companies developing BIM objects, the business rules and attributes must be compiled to a much simpler format to avoid overburdening the developers.

5. CONCLUSION

The Information Delivery Manual encourages consideration of information in terms of informational elements or objects and attributes rather than informational products (that is, documents), thereby enabling actors to analyze their information needs in detail. The collaborative method helps achieve multiple inputs for modeling the workflow, although this implies a great effort. The exhaustiveness of an IDM is also its greatest disadvantage; it is time-consuming to develop and communicate on projects. Rather than being a methodology to identify informational need on an industry basis, the IDM could be applied to identify processes and information needs in projects. Over time, the collection of these processes will enable professionals to choose processes. The main focus will not be to develop an information system, but to adjust the information exchange to suit the needs of the actors. In order to be applied to projects, the IDM must be able to handle time as points in time rather than sequences. Furthermore, the IDM needs a more concise terminology, a clear selection of detail level, and a strict de-selection of trivia. The IDM cannot be applied as requirement specifications for the development of BIM objects, because of its extent, but can form the basis upon which to compile the same.

This leads to the following suggestions related to the implementation of the IDM on a project basis: (1) Task sequence should be modeled at a high order; (2) the IDM must handle points in time; (3) The narrative description must be reduced by not requiring descriptions of well established roles; (4) the IDM should be completely independent of data structures; and (5) Business rules must be communicated unambiguously; for example, by a business rule modeling language such as PRR (OMG 2009).

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