Computerized Information Standards Enabling Innovation in Public Procurement of Buildings

Christian Koch and Kim Jacobsen

Chalmers University of Technology, Sweden
kochch@chalmers.se
K-Jacobsen A/S
kj@k-jacobsen.dk

Abstract. Computerized and standardized information enables innovation in processes, products and services. Where early research on the impact of standards tended to focus on barriers, more recent research advocates standardisation as enabler of innovation albeit in a stakeholder-oriented, flexible manner. This paper asks whether computerized information standards enable or constrain innovation in public procurement of buildings. In architectural and engineering design of public buildings handling of information involves interoperability problems that hamper innovation. Moreover the project based product development tends be done in constellations of firms in interorganisational contracting, which do not provide stability or room for innovation. A large hospital project was investigated through interviews, documents and observations. The effects of implementing building information standards are both inter- and intraorganisational. The building client claims to have saved money, through better structured building component data that gave considerable positive effects during tendering. The IT-suppliers develop IT-tools, preparing for new markets.

Keywords: information standards, innovation, hospital building, Denmark.

1 Introduction

Interoperability of building information continues to be a major challenge for the building industry [1], [2]. As the information get incorporated in Building Information Models (BIM) and used in design, production and operations processes of buildings, a swift, efficient and smoothless transfer between partners is crucial. Moreover using BIM in an interoperable manner is a central strategy for creating innovative solutions for new sustainable housing and to enable competitive innovations for Nordic building companies, enabling their prospering both locally and globally.

Many Nordic architects, consulting engineers, contractors (AEC) and real estate firms operate across the Nordic countries rather than in just one of them [3]. This requires common tools, standards and work methods. Moreover design, production and use of state-of-the-art sustainable buildings similarly requires a set of calculation, design and monitoring tools, which today remains national in their character in

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contrast to the demands of the market. At present international standards such as Eurocodes and Industry Foundation Classes (IFC) [4] and defacto standards such as DWG only partially cover the Nordic building processes, even if IFC is gradually developing as a global standard.

One such new standardisation tool is the Cuneco Classification System (CCS), [5], which at present is developed in a Danish context, but designed to be used in international building sectors. The standardisation of CCS target building informations as used in design, building and operation of buildings. CCS provide automated identification and classification, and enables smoothless data transfer between software packages which today are often not interoperable, be it heating ventilation and air condition (HVAC) design- and energy calculation- software, when combining sustainable design and indoor climate design. Also CCS would, through more integrated IT infrastructures, enable virtual collaboration and coordination which gain importance in and outside the Nordic region. CCS would thereby systematically overcome obstacles for innovation in building design, production and operation.

The aim of this paper is to analyze whether computerized information standards enable or constrain innovation in public procurement of hospital buildings and investigate under what circumstances information standards would have an improved impact on innovation.

The paper focuses on a concrete set of standards (CCS) but has the broader aim of documenting their innovation-enhancing effects in the Nordic building sector. The standards are presently under development and are partly implemented in a large Danish hospital project “the new hospital west” (DNV), which acted as a test field [6]. The classification is expected be avaible for use by 2014.

Standardisation can be driven and implemented through many channels. In building, the public player has often been change agent using procurement to generate standardisation and innovation. Recently EU has pointed to the public as spearhead for energy efficient buildings mitigating climate change [7]. Public procurement of buildings involves demands of use of IT, collaboration and quality tools. This context is therefore particularly interesting for studying links between standards and innovation.

CCS has four elements [5]: Classification of building information, property data of building components and rooms in the building, information levels to control the design and further processes, and rules for measuring building components (metrics). The standards and property data will be placed on a server accessible for all users in the building industry.

A literature review is used to develop five types of impacts that standards can have on innovation. This is thus the papers primary contribution to analyse how the envisaged standardisation with CCS enables innovation in procurement of hospitals and in building in general: First it is argued that standardisation of at least parts of products and processes *indirectly* provides resources for innovation as the standardised elements require less resources. Second standardisation can nurture efficient repetition across many customoers and at a time make space for the engineering of innovation for single customers i.e. enable a mass customisation strategy of product development [8]**.** Third standardisation stabilises processes in the volatile project based environment of building projects. Fourth improved interoperability and interfaces between subsystems enable product innovation [9] and fifth standardisation would after the first tests create larger markets for products.

The paper is structured in the following way. After a method presentation, a selective literature review is used to develop the five types of innovation enhancing effects of standardisation. Using this framework structures the case and discussion. The paper ends with a conclusion.

2 Method

The overall approach taken here for human computer studies is critical interpretivist [10] and a sociomaterial view on innovations and standards [11]. A literature review is carried out covering human-computer interaction, innovation studies, information systems and organisational approaches, adopting a sociomaterial approach as overall paradigm [11]. The review leads to a framework of understanding of the relation between computerbased standardized information and types of innovation.

More specifically the selected domain for studying effects of standards on innovation is architectural and engineering design of public buildings. Here handling of information gives rise to substantial interoperability issues that tends to hamper innovation. Moreover the project based production of products tends be done in constellations of firms in interorganisational contracting, which do not provide stability or room for innovation. The Architecture, Engineering and Construction industry is therefore often portrayed as innovation adversive.

A large hospital project is used as test field. Interviews, document analysis and observation through presence at meetings with the design team were carried out by the authors, one closely involved, the other at a distance.

The second author acted as project manager for a test project of CCS at the hospital. The first author acts as process evaluator for "Knowledge Center for increased Productivity and Digitalization in Construction" (Cuneco) [5], together with two colleagues from 2010-2015. By February 2014, seven short half-year process evaluation reports have been elaborated. As the entire center focuses on establishing an infrastructure through classification of building information and standardization, most of the material gathered is relevant to the research questions raised here. Data collection encompasses interviews (41), participant observation of events (17), document analysis (141 documents including more basic crosscutting documents and documents for each of the projects in the centre).

The limitations of the study are that the classification studied is not a long term stabilised one, but rather a prototypes under development. Many of the more indirect innovation types relating to business models and community [12] is more of a future potential for the time being. Moreover both authors are deeply involved in the development of CCS and one author has been project management for the hospital test project central is the paper. The closeness is however seen at a time as a strength and a weakness as it provides detailed insight in the processes of the case. The other author has acted as critical external vis a vis these indepth insights.

3 Literature Review

The review develops in three steps: first some general considerations of innovations, than review of studies of the relation innovation and standardisation and third the development of the five criteria.

The understanding of innovation as crucial for development of companies, industries and societies has expanded from mostly focusing on product innovation and secondary process innovation [13] into focusing on a broad range of renewals which is often argued being far more important to company survival and prosperity [13]. This broader range of innovation encompasses financial innovation, Business model innovation, management and organisational innovation, technological and IT innovation, innovation in networks, alliances and communities [12], [14], service innovations and customer relations innovations, such as channels and brands [13], [15]. Also a lot of interest has been allocated to involving users in innovation [12], [16-17]. This development complicates defining innovation and understanding how innovation impact on business development. [15] suggests the following definition:

"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." [15].

We adopt this innovation definition yet embed it in an understanding of innovation processes and innovations and standards as sociomaterial [11], Timmermans and Epstein 2010)

Early work on innovation and standardisation [19-20], often pointed at the constraints and dysfunctional effects of standardisation, where later works overwhelmingly advocate standardisation [21-23]. In these works most focus is implicitly on product or process innovation whereas the broader set of possible innovation are rarely treated.

Works on mass customization and modularity in product design [8-9], thus point at first the gains involved in standardising certain repeated elements of the product structure allowing the design to focus on the specific more customer oriented elements. Such a mass customisation strategy fits well with large complex building projects like hospitals that standardised interfaces between subsystems involve. Second modularity of the product design is equally well suited. Again here most focus is on product standardisation and secondary process standardisation, even if [8] do mention some of the organisational and managerial implications of creating products through mass customisation.

It should be noted that building information and its handling in projects tends to be highly volatile and hap hazard because of the large number of players, components and processes. [24] points at the losses related to poor interoperability amongst these players.

As a perspective the possibilities of establishing markets beyond single (unique) products and even mass markets would also involve standards as enabler for such market innovation [25].

However standardisation continues to involve barriers and pitfalls also in its involvement with innovation. [26] in their empirical study of standards in use, point at the danger of finitism – attempting to create standards covering all aspects of a domain, which risks "locking" the use processes and ultimately leading to non-use of standards because they indeed become perceived as barriers.

Summarising standards impact on innovation in the following ways.

1. Standardisation of product and process elements indirectly provides resources for innovation as the standardised elements require less resources [23]
2. Standardisation can nurture efficient repetition and the engineering of innovation for single customers (i.e. a mass customisation strategy of product development, [8])
3. Standardisation stabilises processes in a volatile project based environment [27]
4. Improved interoperability and interfaces between subsystems enable product innovation [9]
5. Standardisation creates larger markets for products [25]

Adding to this list but in a more secondary manner innovation in the business model in organisation, in management, in the financing might also be relevant

4 Case A Hospital Project

DNV-Gødstrup is one of the largest hospital building projects in Denmark. 130.000 new square meters are designed, constructed and erected over a decade and from 2020 the hospital will be able to make 47.000 operations per year.

By summer 2012, the first major test project of CCS commenced in this hospital project. The first prototypes and testing activities were developed during the autumn. In this context, the building client became allied with six software suppliers. Together, their six systems cover parts of the information flow from early conceptual design of a building (one system), over detailed design (two CAD-systems and a BIM system), cost and budget calculation (one system), and space management (one system). According to the project manager, the systems are able to identify building components, classify them and sort them. This also involves data flows supported by the chain of the six systems:

"At [the hospital] we are now at classification of rooms and about to classify building components. The six participating IT companies can actually all, almost all, classify. We have made an internal demo of an information flow: [list of the six systems]. The programs are capable of doing that. With CCS we can classify, sort, identify. The programs are further than I thought" (project manager, Nov. 2012).

The classification standard was implemented in six IT systems constituting a common infrastructure and covering important parts of early conceptual design and detailed design.

The central advantage of using CCS is that it integrate the four elements of 1. Classification of building information, 2.property data of building components and rooms in the building, 3. information levels to control the design and further processes, and 4. rules for measuring building components (metrics). It is one common system for handling building information in contrast to a normally completely fragmented building design context.

4.1 Standardisation with Indirect Impact

Implementation and use of standards in the building industry such as CCS implies that a more common terminology and structures are implemented, concerning products and processes. This also enabling commencing bridging between the many different IT-solutions that are in use across the companies participating in the project teams and enables smooth communication between the IT systems. A common structuring of buildings by designers is to perceive it as composed in rooms for various purposes, which therefore is one area of classification in CCS. Moreover it is also a demand that the standards should allow new innovative solutions, giving users a tool rather than a strict and detailed coding, that might create barriers for "thinking outside" the given frames, a recurrent initiator of innovation.

To do so CCS is in principle shaped as a collection of terms and concepts that can be brought together in different ways within the code structure. Users have a large room for manoeuvre to specify products and processes at the lower levels in the classification, while CCS also maintains a precise coding structure for specification at the first three to four levels, enabling IT-interpretation of the specification and exchance of data between it-systems.

A classification system is traditionally defined as a hierarchy of classes, and thus the number of classes of components or processes is fixed in the system. E.g. the classification system OmniClass has 211 different classes for doors, and the distinction of the classes primary are based of the properties of doors [28]. By it OmniClass actually determines the number of classes of components, which may exist for the user using this classification system. It can be right a challenge find the right class among the numerous types of classes or even to find a class which is adequate for a new innovative designed door component.

In contrast to traditional hierarchical classification systems like OmniClass, CCS has only one class for all types of door components. But CCS also allows you to add CCS-properties to the class (as many as you wish or need) thus you actually defined your own class-specification for your doors. CCS classification combined with CCS properties gives the users nearly an infinite numbers of combination possibilities to specify exactly the classes of building components needed. A well-defined syntax for code structure for specifying the created classes, act as a digital syntax for digital communication and exchange of the specification of the class.

The flexibility of CCS supports the users to be able to classify new solutions and at the same time be sure of, that the CCS code structure ensures that IT systems are able to interpret the specification og the class. Thus the implementation and the use of CCS indirect release resource from digital implementation to innovate.

The consultant unit of the hospital used CCS first to program rooms and later to organise building components preparing tendering documents. The room programming became more structured because all standard and special rooms entered the same structure enabling a move towards more standard rooms. Thereby the room programming became more efficient than usual for such large and complex building, here handling about 4000 rooms, whereof 80% became classified as standard rooms. This indirectly created resources for the design of the remaining unique rooms.

Here the envisaged flexibility of CCS was used and evaluated instrumental. The combination of the classification tables and codes worked. Property data however were not readily available and the design team therefore developed their own properties to enter in the CCS structure.

The client evaluates that better structured building component data has given considerable positive effects in the tendering of contractor contracts, where the design team of engineering and architects are enabled in several ways.

4.2 Standardisation Supporting a Mass Customisation Strategy

CCS is a structure for a digital platform for the building product and supports the notion of a product master [8]. The databased embedded product master, as the CCS server, supports the generic product properties and structures as well as the specific.

The hospital project involves a large amount of repeated components, building elements up to entire blocks of beds. The engineering and architectural design group work with room programming using CCS reduced the number of special rooms and increased the standard room to 80% of the 4000 rooms. The design of the last 20%, that could not be standardardised as they were unique special rooms. This reveals using mass customisation strategies with CCS for example design, function and equipment such as doors, windows, and HVAC equipment (and for example oxygen) has become more efficient than usual for such large and complex building.

4.3 Standardisation Stabilises Processes

It is considerably easier to develop new innovative digital solution in the building industry, when your work platform is bases on a well-known and stable production environment. A production environment which not sets any technical limitation, but supports you in creating new innovative solutions, is also more or less a necessity for a creative result.

To create a stable production environment, you need to stand on a standardised digital platform, where well-defined and structured building terms are implemented and where simple data operations, like data creation, search, sorting, exchange, can be executed seamless whiteout any it-specified knowledge for the users.

The purpose of CCS is to create a standard digital platform for the building industry, on which the different parties are able to create a stable digital productions environments. An environment from which they can create new innovative solutions for their building projects, whiteout worrying about whether the solutions can enter into a digital structure or can be communicated and be interpreted digital by other parties' it-systems.

To ensure a stable digital production environment you need to implement the CCS standard platform in your working methods and IT-systems, and surely also upgrade your employees competences in how the this new platform are able to support them in producing new innovative solution based on the ever ongoing demands for new solutions and progress.

At the hospital project CCS has first supported a systematic detailed planning of the design process, digital architecture and work method. This planning created stability as it afterwards had to be followed strictly. Moreover and second CCS supported ”data discipline” in all the sub activities. Also the enabled reuse of the CCS elements supported stabilisation. An important prerequisite for this was a systematic training effort of the members of the design team, especially those involved with Building Information Modelling (BIM).

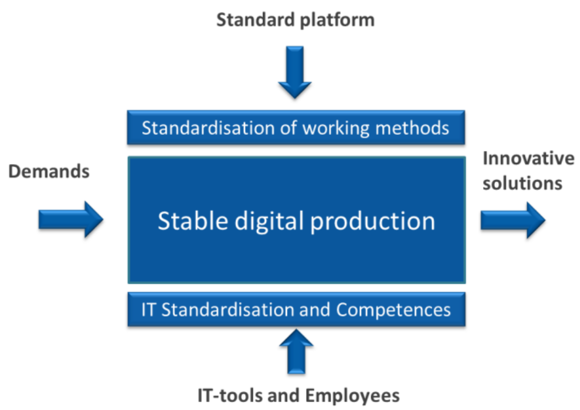

Fig. 1. Stable digital production of building [27]

4.4 Interoperability and Interfaces Enabling Product Innovation

Interoperability and interfaces within the product structure is an organised way to enable a number for players to contribute to product innovation through digital design collaboration and communication. In a somewhat similar vein as the well known apple i-phone platform, the CCS platform provides vast room for supplementary, enlarging innovations “as long” as they comply with the platform they can be taken onboard.

At the hospital project, CCS, enables handling of many types of digital objects, such as documents, BIMs, spreadsheets, data sets (in databases) and drawings. The classification codes enable automatic identification by distinguishing between the items. It is common in large complex buildings project to use considerable resources for coordination of the design activities, which is located in the many participating companies at numerous places and usually involving many different IT –systems and data structuring approaches. Here CCS supports interoperability also by standardising the interfaces between these systems.

4.5 Standardisation Creates Larger Markets for Products

Standardisation of design, production and operation processes is enabled by use of BIM. Process innovation through reuse and iterations are important new opportunities:

Reuse of parts of the sustainable design is enabled by well-structured data ordered as objects and more feasible if one encounter a (larger) Nordic market and markets beyond that.

IT suppliers participating in the hospital project have used their experiences with CCS to incorporate the classification in their IT-systems. They are currently marketing that in the Nordic and Baltic region. More in general there is a large global market for hospital design providers, where experiences of CCS can be transformed into design service offerings globally. Here it is likely however that competing standards will create future market condition [29].

5 Discussion

In the following the five innovation –standard relation types is discussed. First the standardisation is expected to indirectly provide resources for innovation. The case shows how standardisation in the tendering process prepares for cost reductions that indirectly can provide more space for innovative solutions developed in the products. The client thus claims to have saved 20 mio DKr like that [6]. The communicated tendering material is easier to access, better structured, and more homogenous, which in turn generate more comparable and cost efficient tenders. However the implementation and co-testing of the standards with the development organisation also required substantial investment in terms of hours and human resources. One issue being that the testing of the standard commenced before the standard was fully developed, i.e. a beta version was provided in the beginning and later improved. Second standardisation can promote efficient repetition and the engineering of innovation for single customers (i.e. a mass customisation). The room programming and the standardisation of it gave considerable result enabling innovation both on the standard side and the customer specific side. Third standardisation is expected to stabilises processes. In the hospital project this occurred as improved planning and also a relatively strict practice of following these plans providing stabilisation. It was carried out in a manner that demanded systematic change management, provided through training. Fourth an improved interoperability and interfaces between subsystems enable product innovation. The classification enabled handling of many types of digital objects, and supported interoperability also by standardising the interfaces between these involved systems. Fifth standardisation is expected to create larger markets for products, which in the hospital project both occurred as marketing of new solution and a still unexploited potential for offering new services. The IT-suppliers were provided with competences after having developed relevant IT-tools, which enable them diffusing the standard. More specifically the public building client evaluates that better structured data on building component give considerable positive effect in the tendering of contractor contracts, where the design team of engineering and architects are enabled i several ways by the computerized information standard. As a final note the range of possible future innovation directly and indirectly innovation involve financial, organisational and managerial innovations as well as community innovation once the hospital is build [12].

6 Conclusion

The effects of implementing building information standards for innovation is both inter- and intraorganisational and contradictory. Where the building client claims to have saved money, the IT-suppliers and design companies is provided with competences. More specifically the public building client evaluates that better structured data on building component give considerable positive effect in the tendering of contractor contracts, where the design team of engineering and architects are enabled in several ways by the computerized information standard. We have found that the standardized building information provide cost reduction and stabilised processes that indirectly opens for innovation, but also that the standardisation of rooms led to more direct innovation in the design of rooms both in the standardised and in the unique rooms, in line with a mass customisation strategy. Moreover the use of one common standard enables a far better coordination than previously. Finally we currently witness IT-suppliers using their experience with classification in providing new solutions and marketing then on a Nordic market, whereas we still have to see the event of the design companies following the same path of providing new services.

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