Case study Sweden - Karlskrona hospital building project

Investigating the use of standards and their impact on innovation

Case report in the BISI project

Building Information Standards and Innovation

Sjouke Beemsterboer

Christian Koch

Chalmers University of Technology

2017

K-Jacobsen **Astacus** **NTNU** **Projectspine** **Chalmers**

Contents

The designed building 02 46 at the Karlskrona Hospital (source Blekinge Landsting 2017)

1 Executive Summary

This case report covers the design of a new building on the Karlskrona campus hospital in Blekinge Landsting (county council). The case report is part of the Building Information Standards and Innovation project financed by Nordic Innovation and the participants.

The process followed is from early 2015 to june 2017. Detailed design is still ongoing, preparing for tendering to contractors at the time of reporting.

The BISI project has been limited in resources in studying this process. The method is a combination of interviews and documents study complemented with minor on site interaction.

The constellation of IT systems and way of working in the Karlskrona project is characterised by the use of three different CAD system; MagiCad, Revit, and Autocad. A document system, byggnett were also central. The way of working is a mixed IT-paper method where also several less interoperable IT systems have been involved. To transform 3D BIM models to 2D pdfs has involved considerable extra work in the process.

Several standards has been used in the process Bleking Landsting room classification, Fi2, BSAB 96 (AMA), PTS and IFC standards. Also the CCS building component standard have been offered yet it differs from the others in that it is less visible. It supports a BSAB coding that can be entered in Revit models. The more visible expression of the CCS standard is the Spine software package. In six out of eight main design areas the use of Magicad made the Spine/CCS function suboptimal as they are interoperable unless IFC is used. Clearly, this limits the extent to which the classification BSAB/CCS can drive innovation in the present project.

The limited use of BIM and limited attempts to integrate the IT architecture have multiple explanations. However, a central is the clients lacking demands of integrated BIM in the design. This has been exhibited through a low priority of IT demands in contracting and low priority of strategic management as well as project management of BIM. No IT agreement has been accorded upon. Adding to this, large parts of the consultancy team in the design operated under a low level of BIM integration. These characteristics in turn created barriers for integration of classifications and standardisations beyond the above mentioned standards (Blekinge Landstings own room classification, Fi2, and AMA). IFC *was* used to assure occasional coordination of models, roughly once a month during detailed design. But in this context, the Spine/CCS implementation support could not overcome these barriers.

The analysis of innovations in the project showed that there is few examples of actual innovation and they are not related to the use of classification standards. However, benefits such as improved coordination, increased knowledge capacity and indirect efficiency gain may contribute to more innovation in the hospital project. It is important to emphasize that no causal relation between these concepts and innovation has been established in this case study. On the other hand, it can also not be denied that innovation will take place due to standardisation. The concept of ”new” in innovation is a relative concept, for the actors involved in a context. This makes it difficult to judge, as clearly the new hospital building is different from the old one, but whether it is innovative in a broader context i.e. compared to other hospitals is beyond our methodological reach here, let alone the impact of the standard in this respect.

2 Introduction

This case report is part of the Nordic Innovation project "Building Information Standards for Innovation in Public Procurement of Buildings" (BISI). Below we will go through objectives, central definitions, timeline, terms and partners.

Objectives for the BISI project

The BISI project is a response to a call for research from Nordic Innovation. Nordic Innovation asked for studies of standards as a tool for business success, and for contributions to our understanding of the links between standards and innovation. The purpose of the Nordic Innovation call was also to develop concrete initiatives that show how standards contribute to innovation. And to study how new standards are created or implemented as a main driver for innovation within a specific sector. Scoping this to how standards are created or implemented as a platform for radical innovation or to drive incremental innovation. And documenting the innovation-enhancing effects, through studies in specific sectors and based on a concrete standard or a set of standards. Finally, the call also communicated that Nordic initiatives with a European and international perspective was interesting.

On this background the BISI project was formulated with a point of departure in the recent new classification cuneco classification system developed in the Danish building sector context. The goals of BISI have developed from only focusing on one classification to looking at a constellation of standards active in the Nordic building sectors. The BISI goals are therefore

Aims of BISI project:

- Mapping and analysing the impact of building information classification on innovation processes in the building sector in Denmark, Norway and Sweden.
- Mapping and analysing changes in innovative direction in public procurement of buildings enabled by building information classification in Denmark, Norway and Sweden.
- Comparing the use of standards and classification in public procurement in Denmark, Norway and Sweden.
- To support the classification of the hospital through the implementation of Spine -software, (Spine is Standard Project Information Network Exchange)

Answering to these aim is done through BISI methods. These are described in appendix 1 in section 10. The interview minutes are used extensively throughout the report and referenced as shown in appendix 10 with a "#" and a number.

What is a building information standard?

The aim of building information classification is to standardise use of information by creating similarity, homogeneity and consistency across time, space and participating actors.

Some building information standards cover both build products and building processes. This is for example the case of cuneco classification system (CCS). CCS and other standards can moreover be characterized as "suites" of many related standards, like the NS or BSAB standards. Many standards refer to the ISO standard ISO 12006-2, which is a standard for standards of building information (Ekholm and Häggström 2013).

Building component standards would usually encompass attachment of properties be it physical, functional, aesthical, cost, shape, or time.

For the purpose of this project the Spine software was equipped with a mapping of BSAB 96, enabling the user interface to show BSAB categories, while the internal engine would code in CCS.

In the present study the understanding of classification and standards have on purpose been broad to allow for actors in the project to voice their understandings.

What is innovation?

"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." (OECD 2005).

It derives from the definition that innovation can occur in many aspects of a business as well as in a building project studied here. It is thus common to relate newness to the particular context and understand innovation as anything new in the context. Here however it will also be evaluated whether innovations in the project are new in a broader context.

Timeline and terms

Below is indicated the main timeline and some of the main processual/phase terms of the project

Table 1: Identification of the different phases in the hospital building project, and English translation

Olika skeden i byggprocessen (generell)	Different phases in the building process (general)	Actual process of the project
1. Behovsanalys	1. Analysis of needs	
2. Förstudie	2. Pre-study	Maj-June 2015
3. Program	3. Programming	May –June 2015
4. Systemhandling	4. System design	August- December 2015
5. Projektering	5. Detailed design	January 2016 – (ongoing june 2017)
6. Förfrågningsgrundlag	6. Tender preparation	
7. Utlysning/Upphandling	7. Tender	Expected January 2018
8. ByggProduktion	8. Production / Building	Expected 2018-2019
9. Överlämning	9. Handover	Expected 2020
10. Förvaltning	10. Operations	Expected 2020

Source: own translation based on phases from (byggepedia 2016, document analysis, PTS forum, 2016)

More terms are included in the glossary in the appendix 2, section 11. Many hospital context terms are translated from Danish using NHS (UK) reference terms see the glossary, section 11.

Partners in BISI

- Chalmers University of Technology
- Norwegian University of Science and Technology
- K-Jacobsen A/S
- Projectspine A/S (previously Betech)
- Central Region Denmark (Region Midtjylland) DNV-Gødstrup

- Helse Nord Øst, Universitetssykehuset i Tromsø
- Landstinget Blekinge, Sjukhuset I Karlskrona
- Astacus AB, Motala

Enjoy!

3 The project

The studied building project consist of an extension of the Blekinge hospital in Karlskrona. The building extension will add an additional 11.000m^2 to the hospital complex. The hospital in Karlskrona is one of two hospitals to serve the Blekinge region and its population of 156.000 inhabitants (Blekinge, 2016). The other hospital lies in Karlshamn and both are located roughly 55 kilometer apart from one another. The existing buildings of the hospital stem from 1922 and 1978 and need extension for a modern and efficient operation of the Blekinge hospital. A pre study showed that the renovation required for a necessary relocation of medicine technology, microbiology and a number of other departments within the existing building structure was very costly. As a result, the option of a new built extension to the existing hospital buildings gained preference (UULAS, 2015).

The new hospital building labelled 02 46 consists of seven floors, including one underground floor. The building is planned and designed to host a nephrology centre, a breast centre, pathology-, cytology- and microbiology laboratories, a morgue, an autopsy department, training facilities and a series of technical facilities.

4 Actors

A building project of this size involves necessarily a large amount of different actors. This section will introduce the actors that were judged by the researchers to be most relevant for building information standards and innovation in public procurement of buildings during the phases of the building project under study.

4.1 Client

The building client (B) for the Karlskrona hospital project is Landstinget Blekinge, department Landstingsservice, Affärsområde Fastighet, byggprojektkontoret and Avdelning för Fastighetsförvaltning. In the building project, the client has chosen to require the companies (#2) involved to use the Cuneco Classification System (CCS) in the delivery of 3D building information models, with help of the Spine software [#2]. The project director for the building client is Lennarth Ohlsson (LO). As acting project director, LO is responsible to see that the project progresses in due time and within the budget available. On a daily basis this requires much coordination and many management tasks to be fulfilled [#1]. In addition to the position of project director LO is also construction project manager for electricity. In the interview, LO presents a pragmatic and moderately positive opinion on standardisation:

> *"…very many standardisations are good, if standardisation leads to a better product then it is good. It eases the work." #1*

> *"It should not become complicated, it may not be such that you introduce something, a system, or a standard, and that the standard makes it take longer and become more expensive." #1*

Information coordinator for the building client is Anders Johansson (AJ). AJ is involved in the BIM coordination [#1], and as such also closely involved in the use of CCS and other classification tools in the project.

4.2 Companies

This sub-section introduces to the reader a number of relevant companies involved in the design phase of the building project. The focus here is on the organisations that have responsibility for different key parts of the building design – i.e. architecture (A), construction (K), electricity (El) heating, ventilation and sanitation (VVS). In addition, employees that were interviewed within the respective companies will be introduced.

Tengbomgruppen AB is the architect (A) involved in the system- and detailed design phases as well as tender preparation (förfrågningsfas) of the building project. Tengbomgruppen AB is a Swedish architecture company with around 570 employees (Tengbom, 2016). In Tengbom Helena Beckman [#10] is design project manager and Christel Dell'Aquilla is BIM coordinator [#9]. Tengbom has the coordinating role in the project. Being in close interaction with K, El and VVS, the architect connects all these [#6]. Tengbom won a call for tender of the architectural design of the building in 2015.

ÅF-infrastructure AB is an engineering consultancy which is responsible for the design of the heating, ventilation and sanitation (VVS) in the building project. ÅF is a large Swedish engineering and consulting company with around 8500 employees focusing on energy, industry and infrastructure (ÅF, 2015). The size of the organisation, and the accompanying depth and breadth in competences is described as a strength of ÅF. Competences relevant for the project include but are not limited to piping, ventilation, sprinklers, control and monitoring installations, lighting, sound, and vibration [#2]. The group within ÅF involved in the project responsible for VVS describes to have many years of experience with extensive 3D modelling. At the same time, the scale of information that is included in the Karlskrona hospital project is larger than the involved actors have experience with [#2]. ÅF has a framework agreement on engineering consultancy services with Blekinge Landsting.

Within ÅF-infrastructure Robin Cederqvist (RC) is assignment manager [/project leader] VVS and sprinklers for the hospital project. In this position, RC gives leadership to the individual administrators for piping, ventilation, and sprinkler [#2]. Next to this, RC is as installations coordinator responsible for 3D coordination ad collision control for the installations in the building from early 2015. This includes ensuring that the building information models are classified with the right properties, collision control, and interaction with the building client to agree on the type of information that is desired in the building [#2]. Much of the interaction with the building client is described to be with Anders Johansson, who is BIM coordinator at the client [#2]. As administrator of piping, Krister Hansson (KH) is responsible to collect the necessary information for the system- and detailed design of the hospital project. This requires a degree of coordination with other actors in the project such as El, but also supervision of the person within ÅF who does the actual drawing of the piping elements [#3]. Similarly, Anders Nilsson (AN) is administrator for ventilation [#4], and Andreas Thomory (AT) for sprinkler installations.

Gudmund Israelsson Ingenjörsbyrå AB is responsible for the structural engineering (K) in the design phases of the hospital project and has been active as such since late 2015. Gudmund Israelsson's is a small structural engineering consultancy, with a subsidiary architecture division (Israelsson, 2015).

Kent Pung (KP) and Johan Hammarback (JH) are the structural engineers involved in the project. In addition, KP also acts as coordinator from the K side. The engineers describe an interest and perceived strength in finding more flexible and creative solutions [#6] that simplify the structural design [#5]. In line with this, the designs for the hospital project are custom made instead of standardised protocol [#6].

> *"Everything we do is especially designed for this specific case. So if we make a villa or a house, everything is just designed for that one. All this stuff we have in this hospital, the concrete, is not premade, we are going to do it there. So what happens, the difference is that it is much more flexible, the whole building." [#6]*

> *"… the fun stuff is to find which beam layers will be weight bearing or where the pillars will stand." [#5]*

Gudmund Israelsson has a framework agreement on engineering consultancy services with Blekinge Landsting.

Amhold AS is a Tallin based multidisciplinary engineering and architectural consultancy firm (Amhold, 2016), responsible for electricity in the design of Karlskrona hospital project. Within the project Uve Matson is project leader for Amhold. Amhold has a framework agreement on engineering consultancy services with Blekinge Landsting.

5 Organisation

This section presents some characteristics of the organisation of the project, the IT organisation in particular and the different phases of the project.

5.1 Overall organisation

Generally, the building client considers the interaction within the project organisation as good and important for the success of the building project [#1]. Within the design phases, the building client collaborates closely with A, K, El, and VVS (and more consultants such as those on fire and noise). Interaction in the design phase of the building project follows roughly the following lines. The architect delivers the overall drawings of how the building is intended to look like to the persons involved in structural engineering (K), electricity (El) and heating, ventilation and sanitation (VVS). Based on the drawings of the architect, the other actors attempt to design their own areas. Coordination and mutual adjustment between these activities ensures that everything will fit in designed hospital building. The contact between the project group actors within the same phase goes direct, whereas contacts with the client's users go through the formal client representative. Demands from project group actors involved in other phases are primarily communicated through the building client [#3].

Next to the general organisation, two specific aspects will be highlighted in this sub-section. Interaction between the structural engineer (K) and the architect (A) will be used to illustrate organisation within a single phase. Interaction between the system design phase and the detailed design phase presents an example of organisation between phases.

5.1.1 Interaction between K & A in the system design phase

In the forerunner phase the architects made a programme for the building, which in this case was relatively detailed. In the system design phases the architect first interprete the program made and then commence making sketches and CAD drawings of what the building is intended to look like. As the architectural design gradually emerges, the structural engineer can commence making concepts for the structure (#7) Subsequently, the architectural drawings and BIM models are handed over to the structural engineer, who designs the skeleton that carries the building. Practically, this requires the structural engineer to balance the demands of the architect with structural demands, and if possible those of electricity and VVS, which arrive later. An example where such conflicting demands may be observed is the placement of the rooms in between the placement of bearing pillars.

> *"Usually we want columns in the whole room, so they all come just above each other […] the column needs to go through everything. This effects the architecture space for designing rooms […] so we have to co-work together to make the sketch of the architect possible. [#6]*

> *"…the ones who have to make the drawings have to fit it in the architectural design, at the same time it has to fit with the calculation model." [#6]*

> *"One good example would be, we have every column away from each other, let's say five meters, but each room the architect has drawn is seven meters. How do we make that possible or is it impossible to do that? This communication I do with architecture and the one that calculates, and in the end I tell the guy to make the physical model of it and how the result is […] Mostly the architect changes the way to make it fit. It is not always that the span [between pillars] has to be this big, they can also change the wall […] in some parts we made the span smaller and the columns thinner so that they fit into the wall." [#6]*

In short, for the structural stability of the building it is deemed important that the pillars are placed right above each other. Yet, this may conflict with the design and placement of the rooms by the architect. Mutual adjustment between architect and structural engineer is observed, through re-designed of the room placement, adjustments of the structural design, or both. The collision control using the BIM models of A and K is also an important tool. In this case, during the system phase collision controls between A and K was carried out once in March 2016 and twice in April 2016. For example in March the collision control tracked more than 100 collisions, whereas 65 was verified to take action on.

5.1.2 Interaction between system design phase and detailed design phase

During the spring of 2016 many of the engineering actors involved in the project were finishing up the more general system design phase, which was audited and approved by the client before the project actors started slowly to work into the detailed design phase. The end of the system design phase was characterised by an increase in review and coordination work to ensure that no collisions are taken from the system design phase into the detailed design phase when fixing them would become more expensive. The responsible for review and collision control in the system design phase considers this process to have went very well [#2].

> *"We have drawn all the corridors and all sections, the basic sections. So all the pathways and everything that we going to limit rooms with at the room level, that we have developed and coordinated fully, together with the architect, the*

structural engineer, electricity and VVS. So basically, the systems design phase is set very well I think, before we go in the detailed design phase at room level. So pretty traditional, as it was done before." [#2]

Collision control was carried out between all disciplines from end of April 2016 through to September with regular intervals. For example, the first "full" collision control in April identified 125 action points out of roughly 170 tracked. The later collision controls in this periods are more clearly part of the detailed design phase

At the same time, it is recognised that there is a little delay in the project. It is unclear who or what causes the delay. In the interview, different explanations are given [#1, #2, #6]. Explanations include unexpected demands for the protection of endangered species, the structural and architectural system design, and a collision with one of the installations [SB: check the last one]. At the moment of writing, it is not clear whether there are multiple delays, or one delay with different explanations by project members. Also, it is unclear yet what the consequences of this delay will be for the detailed design phase.

5.2 The IT-organisation

The hospital project has its own IT organisation, that intersect with the companies' IT organisations. The IT- group met once in early autumn 2015 , but started meeting regularly from January 2016. There are nine members: Christel Dell 'Aquila (Tengbom) ; Anders Johansson (Blekinge Landsting); Robin Cederqvist (ÅF): Emil Söderström (Tegnbom) Kent Phung (Gudmun Israelsson) ; Johan Hammarbäck (Gudmund Israelsson) Joakim Persson (BL); Linnea Hervén (BL); Anders Tovesson (BL);

Several of the company members also act a BIM coordinators on the project in their parent organisation.

A PTS file exchange and project portal plays a central role in the IT-organisation of the Karlskrona hospital project. It is the building client who mainly administrates the portal, but all involved actors are able to upload and exchange documents through the portal. The project portal is mainly used to exchange drawings, DWG formatted BIM models, pdf documents and other relevant information, such as meeting notes [#1, #,4 document analysis]. For example, the installation actors involved in the hospital design use the project portal to receive the drawings and models that the architect makes together with the structural engineer [#4]. The project portal is intended to be easy to use.

"It is quite easy to makes change in, for example, you have notes in the protocols. You create it just like in [Microsoft] Outlook." [#1]

From an organisational point, information interaction is being facilitated by the building client's BIM coordinator. Furthermore, the consultant responsible for VVS and sprinklers also acts as a reviewer of the models that are being sent and communicates the results back to the involved actors by document [#5]. The reviewer makes sure the drawings include the right properties asked for by the client [#2].

The building client has demanded that the interviewed actors use a common classification system. The goal of such a common system is to improve interoperability of building information between actors and between different phases. Such client demands on information and classification may be considered a typical part of the normal way of working.

"Not more than another client. It is almost more how you name a component. Some want that you call a cup for a glass in the drawings. They have their own terms then, but besides that it is all normal. They have different systems for how they want it to be named." [#3]

More details about the use of classification systems such as CCS will be presented in section 8.2. For now, it can be noted that there is quite some uncertainty about the ways in which the building information is used in later phases [#2, #5]. Interviewees understand that the building information that is being generated is intended to be used in later phases, in particular the building and the operation management phase [#2, #3, #5], but are unsure about the extend or ways in which it will be used [#2, #5].

"If we are not involved in some role in the production phase, then we do not really know if it is being used or not. Often it is so that you leave the project more or less when it is proclaimed to a construction document. Then there comes a few questions during the production phase, but then you are not always with [the project] fully." [#2]

In this section, some observations of the interviewees on organisation and IT organisation have been presented. The next section will describe the specific IT systems in use by the companies interviewed.

6 IT architecture

In this section the different IT systems in use by the companies in the project will be briefly discussed.

On a general level, the building clients demands that 3D modelling software is used by the involved actor [#1, #5]. For the building client, this is the first time that they do this fully in a building project [#1]. For the most part this is not mentioned to give any problems. A small issue to mention here is that not all domains do 3D, for example, detailed El drawings and the information to be used by the building contractor are still mostly 2D [#1]. However, this is not considered a problem by the building client [#1].

Autodesk Revit, Autocad and MagiCAD are the three main software programmes being used during the system design and detailed design phase. Revit is used by the structural engineer and architect, [#3, #5, #6], whereas MagiCAD is used by the consultants responsible for Electrity (El), Ventilation, Piping, Heating, and Sprinkler [#2, #6]. Autocad is used for geotechnics and landscape.

In the beginning of the systems design phase the architectural design was carried out in Revit and was largely delivered by Christmas 2015 in one 3D-model. From then one the structural engineering model was developed and later the other engineering models. The table gives a snapshot BIMmodels in use in the spring of 2016 in the detailed design phase:

Table: BIM models in use

Actor	Focus of model	Software
Architect	Façade, indoor layout	Revit

Engineers	Structural	Revit
	Electricity 1	Magicad
	Electricity 2	Magicad
	Heating	Magicad
	Ventilation	Magicad
	VVS	Magicad
	Sprinkler	Magicad

At a later stage (2017) geotechnics and landscape architects started working at the project. These areas used Autocad.

Spine translation software plays a central role in this research project as it is the add-on to the drawing programmes that allows common classification using the CCS standard. It is noted that Spine not well adjusted for MagiCAD.

At the same time, there seems to be some misunderstanding and lack of knowledge about what Spine is intended to contribute or be used for in the project. Spine is new for the actors involved in the project [#2, #5, #6]. A VVS consultant mentioned that Spine will be used while classing with BSAB codes [#2]. The structural engineers mentioned to have no experience with Spine and are curious and uncertain about what it should be used for [#5, #6].

PTS stands for Program for Technical Standard. The PTS is developed by a group of county councils, including the Blekinge county council (building client). The standard builds on experiences from earlier hospital building projects to ensure that best practices and experiences are taken into account (PTSfurom, 2016). Part of the standard is the PTS file exchange and project portal is used in the hospital project.

Solibri Model Checker is used as a coordination tool to check the drawings and models for collisions [#2].

Other IT infrastructure element in use include a project web system “byggnet”. This is operated as a document and BIM model administration system. The folder structure follows the phases of the project and the actors active in each phase. By June 2017 (close to the design being finished) the system contained around 650 folders and 10.000 files amounting to 32 Gbyte stored data.

The architects used an internal object family for hospital design and BIMeye to support the administration of their objects. The Karlskrona hospital uses the facilities management system “Landlord”. The structural engineers use a calculation program for structural design and safety. This software is however not interoperable with Revit as reflected here:

interoperability issues between Revit and the underlying calculation software is another practical issue mentioned.

> *“The thing what I want really [Revit] to do is from there to transfer into the calculation model. That would be very useful for us. But it does not. […] We make a new drawing in the calculation program. We redraw everything, literally everything we have into Revit, into the calculation program” [#6]*

IT-based "help" tools for classification included the PTS and Fi2 websites as well as the SPINE plugin for Revit. The Spine version used in the project, supports BSAB through a mapping to CCS. IFC version 2x3 has been used for creating interoperable models for collision control (see section 8.1.2)

The IT-architecture and way of working is thus characterised as a mixed IT-paper method where also several less interoperable IT systems have been involved. To transform 3D BIM models to 2D pdfs has involved considerable extra work in the process.

7 Timeline

2014

- September 2014 Municipal elections in Karlskrona.
- UULAs pre-study and program. Key issues include coupling the new and old building, a room function concept, and a design of façade.

2015

- January 2015 first project meeting [involving Chalmers and other BISI actors] Hospital management appoints a new project manager and a BIM coordinator.
- Room programming commences in Blekinge Landsting's clients organisation
- March the BSAB- CCS mapping in Spine is commenced
- May-June UULAs pre-study is finalised.
- August 2015 Building client selects companies for system and detailed design phases of the building project based on a purchasing agreement. The agreement separates architect and engineering services.
- Kick off meeting design organisation includes introduction to Spine
- August – December 2015 Conceptual Architectural (Systems) design include
  - redesign of façade to create a more harmonious building
  - Redesign of staircases and other gestalt elements to enable daylight access

  Design of 29 standard rooms (typrum), Design of floor plans (continual numbering used)
- November 2015 Structural Design commence

2016

- January 2016 HVAC (VVS, Ventilation) design commence at ÅF
- January Audit of Architectural Design with client
- January 2016 BIM coordination meeting
- Januar 12 Spine implementation meeting
- January 26-27 two day training seminar on Spine and 3D.

- March BIM coordination: Collision control Architectural-Structural models
- April BIM coordination: First joint collision control all disciplines
- April Architects design sub roofs and rooms
- Spring 2016 Stock taking of protected species at the building site #1
- May 2016 Room functions have been determined for the most part(through detailed design)
- May 2016 System documentation phase is ongoing #1, only ongoing for K and A #2
- May 2016 Start of detailed engineering design phase, system design phase has been closed for VVS #2
- May 2016 Electrical design ongoing

- August 2016 Start of detailed designed phase overall postponed. The ventilation installation is said to need extra time due to changes in the building design and room layout #6
- October many engineering design areas submit detailed design material
- Fall 2016 Originally expected closing of the engineering detailed design phase delayed #1
- Fall 2016 Originally expected shift to the tender preparation phase (förfrågningsfas) delayed

2017

- January 2017 Originally expected earliest closing of the detailed design phase delayed #5

- Spring 2017 Continued detailed design including geotechnics and landscape
- May Commencing the preparation of tendering (förfrågningsunderlag). Four contracts is prepared, each as a coordinated general build contract (samordnad generalentreprenad). The areas being general building, piping, aircondition and electricity.
- December 2017 Political decision on building 02-42 #1
- December 2017 Expected call for tenders to contractors #1

2018

- January 2018 Contracting finished #1
- Spring 2018 Expected commencing of the building phase #1

2010

- Beginning 2020 Hospital building is expected to be in operation, beginning of the operation management phase #1

8 Analysis

This section contains the analysis of the Karlskrona hospital building project. The analysis consists of three main parts: the project in general, the classifications in use, and innovations in the project. Furthermore, sub-section on the project in general and classifications in use are structured around a themes that came up from an analysis of the interviews.. In the sub-section on innovation, results from the literature review were used to structure the analysis.

8.1 The project in general

8.1.1 Room function program / room classification

A returning theme in both programming, and early design phases of the hospital project is the distribution and function of the rooms in the building, and the design and organisation of the functions that each room should have. The building client's demands for designing the rooms in the hospital is communicated mainly through the 'room function program' (RFP) developed during summer 2015 on Blekinge Landsting's own standard and later translated to the Fi2 standard (BIM alliance 2016) for further development of rooms. The RFP gives prescriptive guidelines for which components should be in each room. For example, patient rooms are explained to require patient accessible points for washing and sanitation equipment, a ceiling rail for a patient lift, and lighting fixtures; a laboratory room may require a specific mixer type positioned. To generate these demands, the building client has performed a stakeholder analysis. Through a stakeholder analysis the client can include in the RFP the wishes and needs of various people that are using the building, such as patients, people with various disabilities, cleaning staff, those involved in transportation and repair of the building. [#1]

Unsurprisingly perhaps, the guidelines are not always experienced to be straightforward. The building client explains that the RFP does not go very deep into detail, and is instead intended to be a reference to help guide the design [#1]. It may at times give diverging instructions. However, importantly, it is recognised that the RFP can be open for interpretation [#3].

> *"They develop the room function program, but they can be open for interpretation also. For example, there was a formulation that the laboratory taps should not be too high and they should be designed in a way that they do not leak. [interviewee laughs]. But what is not too high? Amongst others, will we go there tomorrow and meet the responsible for the operations, perhaps straighten out such a question. […] But like this are there also other components such as a fume cabinet or an air bench" [#3)*

From the perspective of the structural engineer, the architect plays a key role in interpreting the demands of the building clients, through the RFP.

> *"What they [the building client] do, they interact with the architect. They say, I want five rooms, in group rooms, one tv room, and the architect makes it possible. Let's say, they say I need 100m2 of storage, then the architect makes it, but how they [the architect] make it and how big the rooms is, how they put it, and how the shape of the room is, that is the architect's work." [#6]*

The systems design of the architects of floor plans, and rooms were carried classifying rooms through running number and a functional naming.

The distribution of the rooms was in turn not considered a big impact on the structural design of the building, that commence subsequently, with the exception of heavy equipment that needed to be placed in the building or dangerous chemical or explosive activities will go on [#6].

The room function program, and the design of rooms was almost finished by May 2016. All rooms were classified by the coordinator and controlled using Solibri Model Checker [#2] However, changes in the environment of the building client, have affected room function program and subsequently the design process.

> *"In the beginning there were five floors, and then came, we live in a politically steered organisation, then came here before Christmas, November last year [2015], came that we will have kidney medicine in this floor also, and a breast centrum on a floor also. And then we had not started working with it … and making such a room function program useful that is a type of maturing process. To plan a building is a maturing process, and that is why it takes a little longer." [#1].*

To balance the need for adjustment emphasized in this subsection, it should be added that many aspects of the rooms are considered standardised. To stick with the kidney example:

> *The Dialysis room will be designed, then there are here [in the RFP] a bunch of functions which will be in the room. You may change it, but the most is the same standard in the room." [#1]*

8.1.2 Collision control

Another prominent activity in the design of the building project is collision control between the different BIM models for A, K, VVS, and El. This commenced in spring 2016. One of the great benefits of integrated 3D models, is that it becomes better possible to check already in the design process whether the designed elements of a building do not collide when put together in a building. This is expected to prevent costly changes and delays later on in the construction phase [#1, #4]. In the hospital project, the ÅF project leader for VVS acts as coordinator for collision control in the detail design phase

> *"we control the whole time that they insert rightly, right properties based on what the client wants to have. And you control in Solibri then, it is a tool we have for coordination […]. Practically you can say that they deliver an IFC file, all disciplines deliver IFC files. There I retrieve them as coordinator, merge them in a single BIM model in Solibri and through these IFC files I get all information. I am collision controller, controller for classification, so that they have classified all the objects with the right type of codes. Is it a structural element then it should be classified as a bearing element. I check much so that it has the right affiliation to the floor it is and so one, so that the builders in the next phase, in the production phase will be able to use this model to mix, for example, how much concrete will they have [...] in floor two for example, how many inner doors of a certain type will there be on a floor, you can get that kind of information on Solibri." [#2]*

In the system design phase of the project, the control brought to light a number of collisions between the architect and the structural engineer. This influenced the floor plan, and pillar- and beam placement [#2]. Other collisions that emerged were those between El and piping [#1, #3]

Similarly, a number of collision was found during the detail design phase where collisions control carried out every three weeks frequently found more than 100 collisions (document analysis).

8.1.3 Risks

Although, this was not emphasised much, the building client expressed a concern about increasing costs involved in the 3D models. According to the client the inclusion of BIM in a building project increases the costs during the design phases with the intention to benefit more during the building and operation phases. As the project is still in the design phase, the building client faces increased costs as the BIM design is paid for by running accounts. This includes any time required for the engineers to learn the things they need to know for the BIM design [#1]. Future benefit is generally expected, but does at the same time not become a reality for the building client until later phases. This opinion of the client stands in contrast to the position of the architects which posited that working in Autocad (DWG) and PDF formats would take the double time for them compared to working in BIM (Revit) because of the many extra documents that needs to be created when working in more tradition 2D CAD.

8.2 The Classifications in use

8.2.1 Early Classifications

After the programming report was delivered from UULAS architects and the overall conceptual design appeared to be in place, the rooms planners of the client commences specifying the rooms in the planned building. Here the classification of Blekinge Landsting was used. Later in the early systems design phase the architects used function names and running numbers in their design.

Similarly, the Structural engineers commencec their design using very simple numbering systems for beams, slabs etc.

8.2.2 Spine / BSAB/CCS

The use of Spine as a tool to help classify was a demand from the building client [#2]. The information put in Spine is coded according to BSAB and translated to the CCS standard inside the engine of Spine., even though this appears not clear for all [#6], possibly because the embedding of CCS renders it invisible. Spine is designed to be interoperable with Revit, but not MagiCAD which was used by most of the engineering disciplines. This created a barrier for a more active close integration between design areas and a "workaround" needed to coordinate models and classify using Spine when working in MagiCAD. As described by a project manager:

.

> *"We work in different software programmes, and Spine is really only adjusted to work in Revit. So we who work in AutoCAD, MagiCAD, we get a bit of a problem there [...] we must export an IFC file from MagiCAD and then open it in Revit, and then with help of Spine, as an add-on program in Revit make those classifications, and the problem is that then we cannot import the information back from the IFC file to MagiCAD. So our files remain still dumb. Like I see it we could just as well do the classification when we are ready with the project, and deliver an IFC file which has been classified so that we do not have to do it multiple times, or find an alternative way to classify MagiCAD models." [#2]*
>
> *"Export the IFC file, open it in another program in Revit, and then via Spine in Revit do the classifications, and then put it back in the coordination program Solibri. ... That costs time [...] At the [VVS] installations side have we not yet done any classification at present in the models. .... But I expect or more less that we will get a solution for how we will be able to classify our models in a way which is sustainable. Because our files will still not be classified via Spine then. It will be the right product and everything in our files but the BSAB classification for the [VVS] installation side is not done then. So we continue to discuss with the building client [...] how we will do the installation side with classification. The way I see it now, we can just as well wait until the end of the detailed design phase and classify our files fully, with Spine then. And then deliver a classification IFC to the building client which they can use in their building information systems."* [#2]

These quotes from May 2016 during the detailed design phase show that the use of Spine to classify is understood as a rocky process even for the engineer most closely involved in the building information model – i.e. engineer #2 is 3D coordinator, responsible for review of the drawings and connected information, and collision control. The engineering part of the design organisation thus was inclined to find other ways of classifying using BSAB directly. Second ex-post or reactive classification was viewed as a legitimate and efficient option.

In principle classification, can be done in a proactive or reactive manner. The proactive manner implies that the coding is embedded as soon as design work implies use of room classification, building components, information levels and later metrics. The reactive manner in contrast focus on making sure that the delivered documents and designs are coded with classification as late as possible to meet the clients demand. It is not obvious that coding is needed when developing the systems design. The companies chose to wait with the classification and it entered the detailed design of the hospital building in 2016.

The classification, especially of building components with BSAB (in AMA) was thus done predominantly in a reactive manner, in due time before it was to be used by the clients and less in a proactive manner in the internal process. However other more hidden classification were done in a proactive manner, such as the use of MagiCAD and Revit internal ordering functions.

The use of Spine and the combined BSAB/CCS classification system was left for the architects and structural engineers as they used Revit. But here Spine ran into other typed of scepticism. .

The structural engineers voiced this scepticisms:

> *"I did not really understand the Spine program, since when we transfer all our information from Revit into IFC model, all this information is already there that the Spine provides us with. So for us it is kind of the information we have in Revit format, we just change it or add a new one in Spine. For us, it does not make it easier our work. So far it has not helped us anything yet, but maybe later." [#6]*

> *"… before Revit did not do this kind of [classification] […] but now it does. Before, for a couple of years ago, this Spine would be good, but now I do not see it. […] They say that you can specify everything in very small level, until very specific. You can do it in Revit as well if you want to do it, I would say it is even less work if I do it in Revit than if I do it in Spine." [#6]*

Interaction between actors in the design phase was not viewed as in for much change because of Spine.

> *"I do not think it will change anything. We have had collaboration without Spine in the other project and it worked out fine, if I put in more information in Spine that in my Revit model, maybe then it will make a difference, but I am not going to do that, otherwise I would do it in my Revit model as well, it is not more information in Spine than in my Revit model, maybe even less." [#6]*

In May 2016 the designers did not actively use Spine, but appeared to treat it as an obligatory exercise towards the end of the design phase (denoted reactive classification above). But beyond that the attitude to classification and particular software tools to support it is perhaps best summed up in this quote

> *"…if it is required in some project, yeah, than we can do it." [#6]*

In other words classification and constellation of IT tools is viewed as a project issue rather than a business issue, making project members follow what the client might ask for.

Going back to issues related to the overall mixed IT infrastructure, the interoperability problems may continue as observed here in the future hampering the possibilities of a classified set of BIM models used for facilities management and future redesign. As noted by the project manager for engineering:.

> *"If you cannot import back information in our model files, so will the building client not have these classifications from Spine in MagicCAD files, they will only*

have it in IFC files. Then they must [...] every time you do a small project in the building, then you must also classify it again in the IFC files [...] If another consult comes in, four room will be building at the fourth floor, then they have to do a classification of the whole house. And that is a problem." [#2]

8.2.3 PTS database – standard

A key standard used in the design of the hospital project, is the Program for Technical Standard (PTS). The standard builds on experiences from earlier hospital building projects to ensure that best practices and experiences are taken into account. The standards set demands guidelines for the designers to follow. The development of guidelines for standard rooms is a good example of the PTS in action. Here the PTS contains demands related to interior equipment, functional requirements, and visualisation of the rooms (PTSforum, 2016). Consequently, the PTS also creates a certain level of similarity between the different hospital projects.

"If you takes a nurse from Gothenburg, and the person moves here, or vice versa, then I should think that it is quite similar, if the person works at a similar type of department." [#1]

The building client meets every other month with the representatives of the other county councils to share experiences and update the standard if needed. These meetings also ensure that the standard remains flexible and able to adjust to expected technological developments or specific requirements of the building design [#1, #2, #3]. Furthermore, the PTS standard has been described as relatively easy to use [#2].

8.2.4 Type of building information in use

When describing the types of building information in use, the engineering interviewees referred mostly to a limited number of physical building properties of the designed element. These relate to size and weight and amount of the individual components [#1, #6], to ensure that there is enough space for everything [#2, #3], and to allow the constructor to build the building.

Property information about the building components that are used in the BIM models [may] come directly from the producer. Such information is often standardised differently than the firms or a project would do and are dependent on the practices of the company that provides the component information [#6]. Such property information may be used as an add-on in Revit, [#6].

Perceived but not (yet) used building information includes costs of materials [#1, #2,], (minimum) quality of the material to be used [#5, #6], function of components in the building [#5] energy properties such as insulation characteristics [#6].

For long the depth of classifying was uncertain to many actors, such as structural engingeering expressed in may 2016:

"I am a bit unsure really about what we will classify […] perhaps it is only supporting and non-supporting [pillars] […] I am not sure if they go so much deeper, 400 pillars in concrete, which have a strength class of C30-37 in strength, I do not know if they go more substantial." [#5]

This can be interpreted as a consequence of the approach of project wise following the demands of the clients. If the client as in this case are uncertain or less engaged in classification issues the unprecise classification might linger on for some time in a design projects. Moreover it is expressed that correct classification is important for future additions in building information, such as costs, to be effective [#2]. This proactive view should have led to earlier project decisions. At the end of the design phase the issue was solved by complying to AMA/BSAB coding.

8.2.5 Information levels

The level of detail needs to be appropriate for use in later phases. The interviewees identified the construction phase and operation management as relevant phases to use the information. However, these phases do have different practices and systems. There is concern with regard to the extent that the building information can actually be used, and to whether too much detail in the information actually accomplishes anything later on.

Detail in information that is being coded

> *”In particular, I think that in the system design phase, you have to keep it at the right level. […] You look forward, that you really get time and ensure that you get place for the installations, the large installations in the large pathways and shafts throughout the whole building we have adjusted more or less in detail in the system design phase, [pause] so that there will be no surprises that we need to have large shafts, or more shafts in the whole house. [#2]*

> *“If we classify for example an air supply valve in a room with a BSAB code, then we classify it with the code air supply valve, but then you can break it down in x amounts of levels, that it is a square air supply valve with a connection box for example. But you keep it that it is an air supply valve.” [#2]*

At the same time, it is a task not to go too detailed in the design either. For the building structure, an appropriate level of detail is weather a wall is bearing or non-bearing, or with steel pillars. Even if you can go much deeper, by for example focussing on type of material, or strength of the material, this is not directly necessary for the project [#5]. Use for the building client and building project guide the level of coding.

> *”If it is a dressing room, we use the code for dressing room. We will keep the level quite high, you can go very much in detail – e.g. level of bolts), but it should be useful for the client. So, that they do not need to pay for something they will never make use of.” [#2]*

> *“In the same way, the client, keeps a list where they will say in more detail which information they want that we will connect to the model, so we have that in print. So, that we get it at the right level. Their property models are not based on BIM or 3D models, but are flat 2D drawings without information in general. They have a heavy job to do internally.” [#2]*

In use of the building information, there is a tension between 3D modelling tools used in the design phase and a tendency to rely on 2D drawings in later phases. In the detailed design phase the detailing of the structural designs is done primarily in 2D drawings, primarily intended for paper based use by the building contractor.

> *”Next step is detailing for us, the connections between beams, between everything, how it should be done. That is what we do, everything that is 2D. […] It is going to be coded in a 2D way, in a line way, this line belongs to this kind of layer, but it is nothing we export to other people, because no-one wants to know*

about that kind of stuff. The architect does not really want to know what is inside a concrete wall, they do not really care, it does not really matter for them. […] we make the drawing for them [the builder / contractor], but they do not interact with out models, they just want the drawings, the physical paper […] [with] a lot of connection points, if you miss something, then the builder does not know how to do it." [#6]

It is considered wasteful when design is 3D modelled in Revit, and coordinated using Solibri, but that future users may very well rely on 2D drawings, for example in DVG format, later on in the project [#2].

8.2.6 Classification practices

In the first sub-section on classification in use we will share some fragments of interviews about the classification practices in structural engineering:

"…we export all the models into IFC models, and uhm from that we can put them in the Revit program. So, it is a different type of file. […] It is working, it is not the best but it works. […] There are plenty of different files you can use, but some of them does not work, through all the different software's, and some of them is just too much information […] that is why everyone is using the IFC, it is the more common one. If you want loads of information in the elements, I don't think IFC is the way to go. But that kind of detail we do not do in the model in Revit, because you need to put much more time in it. Let's say the exact length of the column, or the exact length of the beam, all that information we do not do in 3D […] that is still 2D yeah." [#6]

Later in the same interview, an example was given where extensive detail in classification practices may be too much work.

"It takes too much time, that is why, you usually have the column, that is between two floors right, and what happens is just right in between the column and the concrete you maybe want some kind of plate, and that is 10 millimetres, and then you have to lower all the columns, because all the columns need this 10 millimetre plate, and some of them may be a 20 millimetre plate, and the same with the bottom ones, and sometimes you need columns that are a little bit shorter, so that for the builders to build it, it is easier to move. All this kind of stuff, all the columns get more or less different heights, and this we do not put in the model, this is just text form – we say plus minus ten mm for all the columns." [#6]

In another interview, a practical solution to a potential conflict between architect and structural engineers in designing and classifying walls were discussed.

"If you consider the outer wall like I do, then we have a support structure in concrete [...] bricks, insulation, and then the question, do we classify the [outer] bit or does the architect do that? Now it is said in any case that we draw [our] bit, and the architect draws their bit in our 3D model [...] so the contractor gets the models and will be able to measure, how many cubic [meter] concrete, how many square [meter] floor, and then it is important that it does not become double so

much concrete. So now it is that we draw the inside and the architect draws the outside." [#5]

8.3 Innovations

In this section, the innovative aspects of the hospital building project are described and discussed. This section is organised initially according to the innovation benefits identified in the literature study of the BISI project (Beemsterboer & Koch, 2016). In with the literature review, innovation is seen as a process of implementing something new or significantly improved. This section is firstly organised in line with the seven innovation benefits of standards as described in Table 3. Afterwards other innovations is discussed that was found in the case study.

Table 2: Possible innovation benefits due to standardisation

Standards may benefit innovations due to:
1. Improved coordination enables higher complexity 2. Quicker diffusion of innovations 3. Direct efficiency gains enable exploitation of new ideas 4. Indirect efficiency gains open up resources to do something new 5. Standard adoption requires organisations to innovate 6. Standard development increases capacity and network of participants 7. Standards might enable business model innovation 8. Standards can lead to systems innovation

Source: (Beemsterboer & Koch, 2016)

The innovative aspects described below are first and foremost related to the hospital project and the participation of the organisations in the hospital project, and not only to the effects of the CCS standard. The interviewees are not being assumed to have necessarily a reflexive understanding of the links between standards, information, and building innovation.

8.3.1 Improved coordination enabling higher complexity

In general, the standardisation of information should allow more information to be captured. In the building process, the scale of information that is include is larger than the ÅF partner is experienced with. The extent to which this is caused by the adoption of the CCS standard cannot be determined.

The CCS standard is intended to improve the coordination between users of different drawing software packages. The idea to improve coordination between the different software packages is welcomed and consider necessary. This being said, the interviewees express doubt as to the extent the Spine software actually improves coordination compared to the normal ways of working.

The use of the Spine software is not directly attributed to a higher complexity in the design phase of the hospital. However, it is anticipated that the building operations phase may benefit from the detailed information that will be included in the models using spine. In the building operation phase, the improved information from the design phase could be re-used and further extended to include aspects such as costs of the materials and a time of maintenance [#1, #5]. To enable this the files should be both forward and backward compatible [#1]

8.3.2 Quicker diffusion of innovations

The PTS standard shapes hospital design in a way that those hospitals that are built in line with the standard should be relatively similar. PTS can be interpreted to enable interaction between hospital organisations and employees in Sweden. In Karlskrona the experiences with using PTS are positive, from a clients perspective [#1] and more mixed from a architect perspective [# 8,9],

Furthermore, the PTS standard allow for learning process to take place in hospital design. Intended as a guideline, the PTS communicates demands and expectations from the building client to the designers. It is possible to make diversions from PTS and register them (avsteg), even if this option was not used in Karlskrona. Inversely, the PTS absorbs experiences from the current hospital projects and translates it into changes in the standards guidelines. In this way, the PTS not only increases learning at the designers, but also between building clients of different hospital projects.

It should be added that PTS is occasionally viewed (in other projects) as a barrier for innovation [#8]. When some hospital clients interpret PTS as a norm to be followed, PTS can come to prevent innovations.

The PTS standard enables the diffusion of innovations from one building hospital project to the next. An example of such an innovation could be the installation of a new dialyse alarm which is coupled to a smartphone to enable a silent alarm to be sent and directed to the right people [#1]. When such a technology is deemed desirable, the necessary infrastructural attributes can be taken up in the PTS. The standard can thus act as a mechanism of diffusion for such an innovation.

Furthermore, the RFP gives prescriptive guidelines for which components should be in each room. It is reasonable that compared to the previous hospital buildings in Karlskrona, there will be new solutions and functions implemented in the new building. It is difficult to judge to what extend the RFP led to more innovative solutions, or not.

8.3.3 Direct efficiency gains enable exploitation of new ideas

Practically, having improved building information in the form of LCC data can show that more expensive building components are cheaper in the long run, possibly guiding decisions towards the use of higher quality building components.

8.3.4 Indirect efficiency gains open up resources to do something new

A clear benefit of BIM and 3D modelling in particular is that it able to do a more thorough collision control during the design phase, reducing the amount of collisions that emerge during the build phase, when solving the problems is more expensive. Better interoperability between different modelling software's would lead to indirect efficiency gains. Interviewees did not observe that CCS and Spine software made a positive contribution to efficiency due to improved interoperability between software packages. If something, efficiency is negatively affected during the design phase as using Spine requires extra effort and capacity.

One of the risks identified with the introduction of Spine and the CCS is that it could actually take more time and become more expensive. This clearly needs to be avoided.

8.3.5 Standard adoption require organisations to innovate

The adoption of the CCS standard and the Spine software means for many participants in the project a first encounter with this kind of translation software.

8.3.6 Standard development increases capacity and network of participants

The building clients together developed the PTS standard, and meet every month to exchange experiences and update the standard. This can be considered to deepen the network between the participating county council building clients.

The consultants, architects and engineers are part of several other hospital projects and the community distinguish between which are more or less innovative also with respect to standard use and digitalisation. The present project has in this context acted more as a receiver of standards and innovation than acting as diffusor of innovation.

Personal growth may also be accomplished through the building project. Even when a building project is nothing new for the organisations involved, it may be new to the people within some of the organisation enabling them to work on new things and increase their personal capacity and network.

8.3.7 Standards might enable business model innovation

The case findings does not show any innovations of this type.

8.3.8 Standards can lead to systems innovation

Blekinge Landsting adopted fi2 and PTS. Fi2 was used for room classification and Blekinge Landsting shared their developed room classification. PTS was followed during the design, which was a smooth process. Both examples have the potential of contributing to the further development of the the health innovation system in Sweden and the community innovation around fi2/BIM alliance.

8.3.9 Other Innovations

In the following we consider innovations (and non innovations) found during the case study

8.3.10 Product innovation possibly without connection to standards

When Tengbom did their conceptual design in the autumn of 2015 *daylight access* to the internal of the building was lifted up as an important issue. Tengbom suggested several new solutions for providing daylight to the workplaces in the building with reference to the Swedish work environment law (which demands daylight access for workplaces in the same manner that other EU countries does). To provide sufficient daylight to the core of the building proved difficult. Tengbom suggested the use of light shafts (Ljusgårde / ljusschakt). However, this solution collided with installation going horizontal in the buildings. Alternatively, Tengbom suggested the use of solar tubes, a type of roof mounted prism that can spread light inside the building via mirrors and that should be placed in the core of the building. This solution was found the risk delaying the project. Finally, Tengbom did conceptual changes of the façade and twisted the staircase house providing daylight in patient waiting rooms (#10).

In family with this innovation Tengbom also changed the shape and the size of the building and enlarged it with a small wing. These *conceptual changes* are connected with an intention of creating a hospital building with a holistic approach creating clear hierarchy, transperancy (genomsikt) and enabling the patient finding their way (orienterbarhet). The hierarchy is creating priority to rooms and places in the building where patient is over rooms and places for other uses. Transparency and enabling patients to find their way is about enabling patients traffic through the building (# 10, there is actually very few beds in this new hospital building and most patient will be outpatients)

When creating these innovation employees at Tengbom where enabled by the used of BIM tools also including standardized building information. However, the creation of these innovation are not understood by the actors as directly created by these IT tools. It can be maintained that such innovations are side effects of the flexibility of design that BIM provide. Room programming was useful when the building underwent changes to create light and to follow the overall holistic design principles.

8.3.11 No innovation

For symmetrical purposes, it should be noted that many of the interviewees do not consider the hospital building itself to be especially innovative, even if the adoption of Spine is something new for most. Some actors even points at absent elements in the solutions chosen, such as sustainability and a fully fleshed BIM use in the process

9 Conclusion

The constellation of IT systems and way of working in the Karlskrona project is characterised by the use of three different CAD system; MagiCad, Revit, and Autocad. A document system, byggnett were also central. The way of working is a mixed IT-paper method where also several less interoperable IT systems have been involved. To transform 3D BIM models to 2D pdfs has involved considerable extra work in the process.

Standards such as the Fi2, BSAB or PTS standards can be interpreted as organisational 'tools'. They give guidance, sometimes prescribe, but also act as an object around which different actors can organise their interaction in a project. In this project the CCS building component standard differs from the RFP and PTS standard in that it is less visible. It supports a BSAB coding that can be entered in Revit models. The more visible expression of the CCS standard is the Spine software package. In six out of eight design areas, the use of Magicad made the Spine/CCS function suboptimal and in these areas it did not appear to be very effective in allowing actors to organise their interaction. Clearly, this limits the extent to which the classification BSAB/CCS can drive innovation. To some degree this is due to the inexperience of actors with the software, as many have not really used it yet.

The classification of building components was thus done predominantly in a reactive manner, in due time before it was to be used by the clients and less in a proactive manner in the internal process. However other more hidden classification of building componets were done in a proactive manner, such as the use of MagiCAD and Revit internal ordering functions.

The limited use of BIM and limited attempts to integrate the IT architecture have multiple explanations. However, a central is the clients lacking demands of integrated BIM in the design. This has been exhibited through a low priority of IT demands in contracting and low priority of strategic management as well as project management of BIM. No IT agreement has been accorded upon. Adding to this large parts of the consultancy team in the design operated under a low level of BIM integration. These characteristics in turn created barriers for classifications and standardisations beyond Bleking Landstings own room classification, Fi2, and AMA (AMA stands for "Allmän Material- och Arbetsbeskrivning" General material and workmanship specifications).

IFC *was* used to assure occasional coordination of models, roughly once a month. But in this context the Spine/CCS implementation support could not overcome these barriers.

The analysis of innovations in the project showed that there is few examples of actual innovation and they are not related to the use of classification standards. However benefits such as improved coordination, increased knowledge capacity and indirect efficiency gain may contribute to more innovation in the hospital project. However, it is important to emphasize that no causal relation between these concepts and innovation has been established in this case study. Using an imaginary example, increased efficiency may very well lead to an increase in profit for the private companies instead of more innovative solutions. It is important to emphasize this as the case study only to a limited extent lead to straightforward identification of innovation in the hospital project. On the other hand it can also not be denied that innovation will take place due to standardisation. The concept of ”new” in innovation is a relative concept, for the actors involved in a context. This makes it difficult to judge, as clearly the new hospital building is different from the old one, but whether it is innovative in a broader context i.e.compared to other hospitals is beyond our methodological reach here, let alone the impact of the standard in this respect.

10 Annex – methodology

This report presents a Swedish case study of a hospital building project where CCS is intended to be implemented. The case study is limited to the design phases of the building project that were ongoing in the time during which the project was studied – i.e. from January 2015 until October 2016. This means that the programming phase, and the construction and operations phase fall outside the scope of this report.

Empirically, the case study is based upon a combination of document analysis, informal dialogues, interviews, and observations as to the activities ongoing on the project platform.

The document analysis covers material uploaded on the common project web (byggnet), publically accessible material from the web and document given to the researchers by actors in the project. In January and august 2015 participation in two kick off meetings was done.

Informal dialogues have been carried out with actors in the project throughout the study phase. Especially Per Erlandsson has kept an ongoing contact with Landstinget Blekinges representative Anders Johansson, acting as the project’s IT coordinator.

In November 2015 four interviews with the architects and the structural engineering company was done. In November 2016 two telephone interviews were done with the client and the structural engineer. In May 2016, 6 semi-structured interviews were conducted with Engineering consultants. The involved actors is entered in Table 3. Nine of these interviews were conducted face-2-face on location in Karlskrona, Kristianstad, Malmö and Linköping. Three was carried out as a telephone interview. The interviews lasted between 40 and 90 minutes each and were taped with permission of the interviewees, with exception of two telephone interviews, where notes were used. Consequently, the tapes were transcribed into text and organised according to suitability for one or more of the sections in the report.

Some actors of the project was deselected for interviewing for resource reasons. This include the electricity engineering company Amhold, the room planners of Blekinge Landsting, and Fire engineering. The possibility of following the project through byggnett largely compensated for these deselectings.

Analytically, a selection of sub-sections was done by the researchers after transcribing the interviews. In doing so, it was attempted to account for the diversity in perspectives and contributions made by the interviewees while also maintaining a degree of coherence intended to help the reader.

Table 3: Actors interviewed in the hospital building project under study

#	Org.	Actors identified	Position	Interview code
B	Landstinget Blekinge	Lennarth Ohlsson	project director, Construction project manager El	#1, #12
A	Tengbomgruppen AB	Helena Beckman	Leading architect	#10
A	Tengbom	Christel Dell'Aquilla	BIM coordinator	#9
A	Tengbom	Jenny Palm	Architect	#8
K	Gudmund Israelsson Ingenjörsbyrå AB	Gudmund Israelsson	Managing Director	#7, #11
K	Gudmund Israelsson Ingenjörsbyrå AB	Kent Phung	Structural engineer	#6
K	Gudmund Israelsson Ingenjörsbyrå AB	Johan Hammarbäck	Structural engineer	#5
VVS	ÅF-Infrastructure AB	Robin Cederqvist	Assignment manager HVAC and sprinklers	#2
VVS	ÅF-Infrastructure AB	Krister Hansson	Administrator piping	#3
VVS	ÅF-Infrastructure AB	Anders Nilsson	Administrator air	#4

Source: own compilation based on interview list of Landstinget Blekinge

In section 8.3 on innovation, the sub-sections of interviews were selected based on a literature review conducted for the BISI study (Beemsterboer & Koch, 2016).

11 Annex – translated terms

Allmän Material- och Arbetsbeskrivning (AMA) - general material and workmanship specifications.

byggprojektledare – construction project manager

byggskedet – building phase

detaljprojekteringsskedet – detailed design phase

dragbänk – air bench

dragskåp – fume cabinet

förvaltningsskedet – operation management phase

handläggare - administrator

huvudprojektledare – project director

informationssamordnare – information coordinator

interessent analys – stakeholder analysis

landsting – county council

projekteringsskedet – design phase

projektledare – project leader

rumsfunktionsprogram – room function program

rör – piping

samordnad general entreprenad - coordinated general built contract

systemhandlingsskedet – system documentation phase

tilluftsdon – air supply valve

uppdragsansvarig – Assignment manager

VVS (värme, ventilation och sanitet) – HVAC (Heating, ventilation and Air conditioning)

12 References

Amhold. (2016). About us. Retrieved from http://www.amhold.eu/?id=98

Beemsterboer, S., & Koch, C. (2016). *Literature review BISI project*. Chalmers University of Technology, division of construction management. Unpublished manuscript.

BIM alliancen (2016) Fi2 standarden . Accessed on http://www.bimalliance.se/produkter_och_tjanster/verktyg/fi2xml_relaterade_verktyg

Blekinge, L. (2016). Årsredovisning 2015. In http://ltblekinge.se/globalassets/om-landstinget/sa-styrs-landstinget/landstingsplan-och-arsredovisning/arsredovisning_landstinget_blekinge_2015.pdf (Ed.).

Bosch-Sijtsema, P., & Gluch, P. (2016). *Modellsamordnarens roll och funktion som kunskapsledare*. Retrieved from: http://www.cmb-chalmers.se/wp-content/uploads/2016/10/Presentation-CMB-frukostmote-161007.pdf

Byggepedia (2016): Byggipedias hemsida http://byggipedia.se/ritningslasning/om-bygghandlingar/ritningar-i-olika-skeden/

Israelsson, G. (2015). Om oss. Retrieved from http://www.gi-ing.com/omoss

PTSforum. (2016). Program for Technical Standard. Retrieved from https://www.ptsforum.se/in-english/

Tengbom. (2016). Om oss. Retrieved from https://tengbom.se/om-oss/

UULAS. (2015). *Programhandling och Gestaltningskoncept Byggnad 46. Blekingesjukhuset i Karlskrona*. Retrieved from

ÅF. (2015). Om ÅF. Retrieved from http://www.afconsult.com/sv/om-af/