The design of Phase 3 of New Hospital West Gødstrup

Investigating the use of standards and their impact on innovation

Case report in the BISI project

Building Information Standards and Innovation

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01 Executive summary

This case report covers the design of one phase of the new greenfield hospital currently being built in Gødstrup, Denmark. The phase three project is here labelled TR3. The case report is part of the BISI project. The aim is to map and analyze changes in innovative direction in public procurement of buildings enabled by building information classification.

The design of TR3 has been a long process. It commenced in spring 2014 and by late autumn 2016, at the end of the BISI case study, the design was almost finished. The BISI project supported implementation of Cuneco Classification System, CCS through providing the Spine software and training. BISI has been limited in resources following the prolonged process of the TR3 project, the method being predominantly interviews.

The main result of this report, is that it has not been possible to show positive effect of classification on innovation in the period of study. A number of initial barriers for working with classification has been salient. In later phases an explicit use of Cuneco Classification System CCS was commenced supported by the software Spine, and the final design is classified with CCS.

The most remarkable innovation, was the reverse innovations, meaning the substantial redesign and reduction of the initial design to better fit the budget. A process that took more than a year to realise. The innovations occurred in all aspect of the design from overall size to choices of minor installations. The reverse innovations occurred using Revit –classification (naming and numbering) without classification support from CCS.

The realized innovations in TR3 are remarkably different from the expected. First a central innovation was the reverse: realizing a substantial reduction in functions of the envisioned hospital product. Second many other expected innovation, such as in the process of design, was not prevalent. This includes process innovation, process stability, efficiency gain that open for innovation. On the other hand the CCS standard did require innovation when implemented “backwards” driven by the concern for common classification across the hospital project and future use of a Facility management system. Also business model innovation was enabled through the establishment of the company Projectspine.

The classification with CCS was done in a reactive manner, immediately before it was to be used by the clients and less in a proactive manner in the internal process. However other more hidden classifications were done in a proactive manner, such as the use of Revit ordering functions.

The study have identified a number of occasions and passages where proactive CCS classification could have made a positive difference. One example is the bill of quantities and materials for the tendering the process. The design project organization made the CCS classification immediately before the tender and the contractors chose to use other component information as the bill of materials and quantities include redundant information. This implied that the contractors safely could carry out their requests to further sub suppliers, do their calculation etc., but it meant the automated transfer of component information did not came in play.

The project has been and is an extensive learning process for the involved parties. When the client commenced the project neither CCS nor BIM7AA were present, i.e. they were not even developed. During the project the participants had to learn and adapt to these classifications.

02 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 classifications ans standards active in the Nordic building sectors. The BISI goals are therefore:

- 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 and use of Spine - software, (Spine is Standard Project Information Network Exchange, Projectspine 2017)

Answering to these aim is done through BISI methods. These are described in appendix 1 in section 11.

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, Molio 2017). 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. 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:

Danish concept	English translation	Actual project
Dispositionsforslag	Outline proposal	TR3 Nov 2014-
Projektforslag	Project proposal	TR3 Several jan 2015-maj 2016
Forprojekt (myndighedsprojekt)	Preliminary project (regulatory project)	TR3 Spring 2016
Hovedprojekt	Main project	TR3 Somatics aug 2016-okt 2016
Udbud	Tender	TR3 service center feb-july 2016
Udførelse	Construction	TR3 Service center August 2016-

Building process norm terms translations in column 1 and 2 are taken from FRI, Danske Ark (2012). An outline proposal can be understood as a brief. 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
- Central Region Denmark (Region Midtjylland) DNV-Gødstrup
- Helse Nord Øst, Universitetssykehuset i Tromsø
- Landstinget Blekinge, Sjukhuset I Karlskrona
- Astacus, Motala, Sweden

Enjoy!

03 Presentation of the project

This section makes a short presentation of the building project before the following sector will present the participants, the organization, the IT organisation, the IT architecture and the timeline of the project.

The Phase 3 of the hospital contains two main parts, roughly two buildings:

- The Somatics department including Cancer, Neurology, Day surgery. This is a multi story rectangular building with two wings.
- The Service Center containing service functions for the hospital such as kitchen and laundry. This is mainly a two story building.

The overall timeline for phase 3 commenced with a design brief in January 2014, and building was planned to commence 2016 and did so for the service center in autumn 2016. The Service center is planned to be ready for operation in 2017 and Somatics in 2019/2020.

Phase 3 should according to the 2014 plan be ready for operation by end of 2018, beginning 2019. The project is delayed until 2020 at present (June 2017). The service center is delayed until February 2018 at present (June 2017).

Phase 3 is part of a larger greenfield project, see below.

Somatics

The somatics unit is a multistory rectangular building. The total number for square meters is at the commencement of construction at 22.000 m2. In 2014 it was planned to be at 33.000 m2 and seven floors. It by summer 2017 contains six floors and the following functions;

- Ortopedic surgery
- Day surgery (dagkirurgi)
- Hematology
- Neurorehabilitation
- Oncology

Two further functions was removed from the project and transferred to the phase 2 project ; the department of Ear, Nose, and Throat and Administration and hospital management.

Service center

The Service center contains a number of technical support functions for the future hospital. In 2014 it was planned to be at about 5.000 m2, raising to 7244 m2 when it was tendered for building in May 2016 (Tender material 2016). 836m^2 is separate socalled ”technical houses”, 521m^2 are technical facilities placed on the roof of the service center and 46m^2 the cellar of the service center.

The technical support function encompasses:

- Goods receival
- Waste handling
- Linen and Sheet washing
- Workshops

- Central kitchen,
- Sterilisation Unit,
- Cytostatic Unit
- Pharmacy
- Mail functions
- Archives
- Offices
- Personnel facilities
- Technical facilities building

Interface to other parts of the Hospital project

The phase 3 project is carried out under the auspices of the previous phase 1 project who did the overall design, including winning an architectural competition, but also detailed design of 98.000 m2 of the hospital.

The Hospital as a whole is by summer 2016 planned to be at 125.000 m^2 (reduced from 135.000 m^2). A somatic hospital, financed by the Danish Government Quality fond funding. The overall budget is at 3,15 billion DKR (2009 prices).

Also further units are part of the project, including a psychiatric hospital of 12.800 m^2 (reduced from 15.000) financed by the region itself, budgeted to 380 m. DKR (2012 prices).

The building process began in September 2012 and is expected ready for use by 2019-2020. Last element to go into operation is the psychiatric unit.

By summer 2016 phase 1 was under construction, reaching beyond the building core in up to six stories and finalizing the façade before outfitting will continue towards finalization in 2019/2020.

04 Actors in the project

The client

In Denmark hospitals are managed by regions. There are five regions, each encompassing a number of municipalities and each referring to several state ministries.

The Central Denmark Region (Region Midtjylland) is responsible for several new hospitals and the case here is part of the greenfield western unit.

The client has an organization dedicated to this particular hospital. Overall this organization refers to the region council. It is the hospital unit west management, which also manage the project. A 20 person strong project secretariat is responsible for doing the operational client task. A project manager is leading the secretariat. An external client's counselor is hired to assist the secretariat. The client's counselor also assisted in IT-issues.

The companies: Full service (Totalrådgivning)

The case here is the third phase of the hospital. The companies involved is, first the full service consortium of architects and engineering consultants (totalrådgivere). Second the contractors subsequently winning the tenders of the service center and somatics.

The organization of the project is described in the next section, below is just given a rough delimitation of each companies responsibilities. Moreover some of these have changed over time.

The TR3 consortia consists of

Architect 1: Mangor & Nagel

Architectural design, overall management of the full service consortia and landscape design.

Tasks in the project: Building envelope, Top and cellar floors of the Somatics building, landscape design service center and somatics.

Architect 2: CREO

Architectural design, overall design management (projekteringsledelse), overall IT coordination

Task in the project: midlevel floors in Somatics

Engineering Consultant: Oluf Jørgensen

Engineering design, participation in design management, IT coordination selected professional areas.

Tasks in the project: Water and heating, Ventilation, EL (somatics)

Engineering Consultant: Brix og Kamp

Engineering design, participation in design management, IT coordination in selected professional areas

Task in the project: Structural Engineering Service center and Somatics, Electricity, Water and heating and Ventilation (Service center)

The companies: Contractors

By February 2016 six contracts was tendered in a prequalification round for the service center**.** 26 contractors were prequalified. The six winning contractors was announced by 1 of July 2016:

1. Building Structure (råhus) Jørgen Friis Poulsen (JFP)

2. HVAC (heating and ventilation): Caverion A/S - Hovedfirma

3. Carpentry: Bjarne Thomsen Tømrer og Snedkerfirma

4. Floors: LH - gulve a/s

5. Painting: Malerfirmaet Carsten Sørensen

6. Electricity: Bravida Danmark A/S - Tilst

Tendering for the Somatics building was expected to be carried out in late 2016, yet was done in the spring of 2017. By june 2017 earthworks is ongoing.

05 Organisation

This section describe and characterize, first the overall project organization of TR3, and second the used IT-organisation.

Overall project organization

The overall project connects to the clients representatives as well as the clustered organization of the client related to the hospital and the region (cluster refer to "klyngegruppe"). The four companies that jointly do the full service consultancy is represented on all levels. The four companies were presented in the previous chapter.

The overall representative for the full service consultancy comes from Mangor & Nagel, the design manager (projekteringsleder) comes from CREO (substituted in summer 2014, November 2015 and in summer 2016). The project management group have four further members, one from each company, organized to cover the service center (one member) and the somatic unit (two members).

The seven project work groups encompasses five with focus on various clusters and elements of the somatics unit, one with focus on the service center and one with focus on landscape. Each work group have two or three members depending also on the contemporary task. These seven groups engaged with user groups with hospital representatives with similar focus, especially over the autumn of 2014 (room design) and 2015 (project contraction).

Attached to this structure is an IT-organisation (see below), and the main project management group also have direct reference to project management risk, hospital expertise, building economics, project economics, and progress control. All support functions manned by company representatives

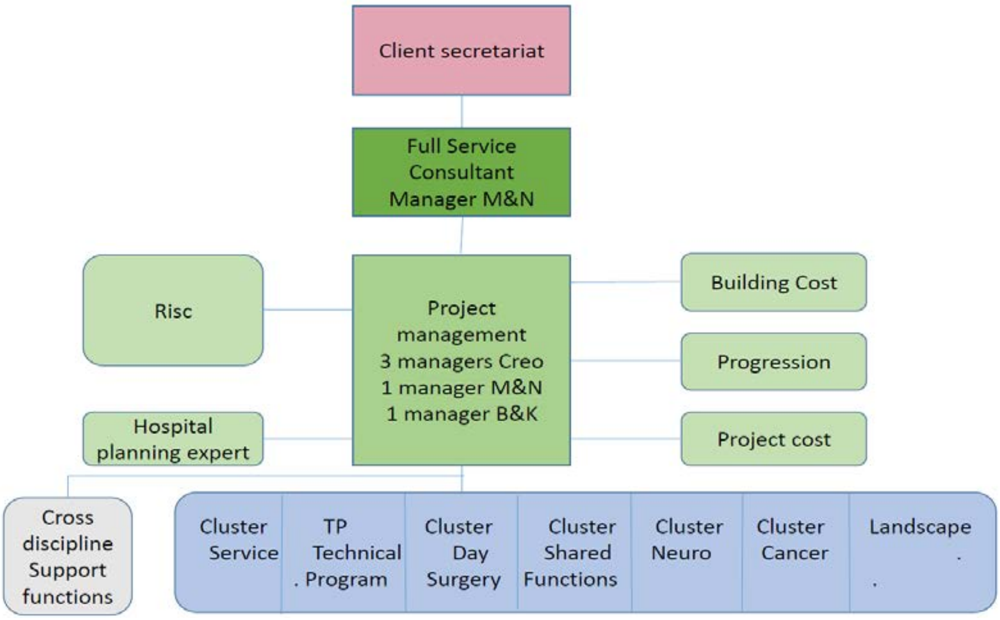

Table The initial project organization. (Source: TR3 consortium 2014).

It should be noted that the organization in the table above is the initial organization. Several persons were substituted and different part of this organization was dormant in periods.

The IT-organisation

The IT organization is attached to the project organization in a crosscutting manner. A joint IT/BIM management group consists of the overall BIM coordinator and three other, together covering the seven project work groups. Across the groups is appointed a number of special responsible:

- Model coordination architecture
- Building components, CCS, and material take off
- dRofus room programming
- Byggeweb (project web)
- Structural BIM model
- Electrical BIM model
- Heating BIM model
- Ventilation BIM model
- Landscape BIM model
- Spine classification

Cross discipline Support functions	Cluster Service	TP Technical Program	Cluster Day Surgery	Cluster Shared Functions	Cluster Neuro	Cluster Cancer	Landscape
IKT / BIM Management 4 persons: Creo BIM 1, M&N1, OJ 1, B&K 1							
Model coordinator Arc	Creo 1		Creo 2	M&N 1	Creo 2	M&N 1	
Building components CCS and quantity take off	Creo manager 1						
dRofus Database structure	M&N 1						
Project Web	Creo BIM project coordinator						
Model responsible Struct	Brix & Kamp (B&K) 2						
Model responsible El	B&K 1		OJ 2				
Model responsible Heat	B&K 1		OJ 1				
Model responsible Vent	B&K 1		OJ 1				
Model responsible Lands	M&N 2						
SPINE responsible one p. company	Creo, M&N, OJ, B&K						

Table: The initial BIM organization (Source: TR3 consortium 2014)

The IT organisation link to the clients organisation, where two persons directly are responsible for IT-issues.

The BIM organization had a frequent set of meetings in the fall of 2015 and were less active in 2015. Also this organization had persons substituted. For example two out of four in the BIM coordination group (upper left hand in the table) left the project. Also further people from the architects company left the project.

06 The IT architecture

A host of IT systems in use in the companies, more or less integrated. Some of the main systems were:

- CREO dRofus, Revit, Sketchup, Sigma/Estimate ;
- Mangor &Nagel dRofus, Revit, Sigma/Estimate, (Autocad)
- Oluf Jørgensen: dRofus, Revit, Sigma/Estimate (AutoCad),
- Brix & Kamp: dRofus, Revit, Sigma/Estimate.

The project experienced spatio technical issues as it was place on five different addresses if one count the client address as well. It was early decided to use a videoconferencing system for coordination. It was also investigated whether a cloudbased solution could strengthen the integration in a purposeful way. This solution was judget too expensive and the project group invested in a Virtual Private Network (VPN) connection instead. This proved problematic in the early architectural design phase where model coordination between the two architect company had to be supported by manual coordination on a weekly basis.

On the engineering areas the coordination between models were carried out firstly inhouse and secondly across the project organisations, BIM coordinator who did regular collision control sessions. A series of BIM models were in use. See the table

Table: BIM models in use

Actor	Focus of model	Software
Architect	Façade Outfitting (Aptering) Landscape	Revit Revit Autocad
Engineers	Structural Electricity Heating Ventilation	Revit Revit Revit Revit

07 Timeline TR3

Below some main events in the project is pinpointed. Many of them are further explained and discussed later in the report.

2010

The hospital project in Gødstrup commence. Phase 1 design begins.

2014

TR3 wins the tender for full service consulting (totalrådgivning) in early 2014.

The TR3 consortium formally objects to the budgetary frame of the project.

In Maj 2014 the first outline proposal 1 (dispositionsforslag) for somatics is handed in to the client by the consultants.

Similarly in September 2014 the first outline proposal 1 (dispositionsforslag) for the service center is handed in to the client by the consultants.

November kick off meetings of CCS and Spine use and the BISI project.

2015

January training session of architects in CCS and Spine

In February outline proposal 2 (Dispositionsforslag 2) is handed in. it represents a massive budget overrun (57-65%) in the project proposal (forprojekt) calculated in the end of January including Somatics and the Service center. The client initiates a cost cutting and functionality reduction process.

The following year, until around December 2015, the TR3 project group had to reduce and redesign the design brief. This include in depth reduction of all aspect of the design:

- Overall building body
- Facades
- Balconies
- Roofs
- Floors
- Electricity
- Ventilation
- Heating

The changes in the overall building body include, one story less, and fewer square meters per floor. The initial 33.000 square meter design was reduced to 22.000 square meter.

During this process most companies used the structure and classification provided by their Revit software. CCS did not come into use as it was asserted to be too early to do the classification

The client has previously invested in a facilities management system and in the process of preparing for future operation a "cleaning" and restructuring of a Spine database of CCS classified components from phase 1 was carried out . This Spine database was provided to the TR3 project as a basis for their classification in the design of the service town and somatics buildings. Thereby the clients also assure that classification is harmonized across phases of the overall hospital project.

The main project design of the service center commenced in late 2015. Here CCS was used to classify the designed objects. Information levels are not in use. They were not actively demanded by the clients beyond the early contract agreement, and not brought in use by the companies.

2016

From February to July 2016 the tendering and contracting process of the service center is carried out. The TR3 companies are using a mixture of CCS, their Revit and proprietarian classification and partially translate this into CCS coding in the tendering material.

22 contractors was prequalified for 6 contracts for the service center. Contractor did use the CCS classification offered in the tendering documents. Contracts were signed in july. However the CCS offer digital tender list (digitale tilbudslister) was not used.

In May the main project design of Somatics begins. The engineers initially commenced doing detailed design of rooms. They started by identifying standard rooms and arrived by june 2016 at 10 different types [interview engineer VTM june 2016]. Examples is office, patient bed room (senge stue) and surgery theatre (operationsstue). In this process they drew on the dRofus content of description of each room of the future buildings. This content was grossly ordered according to a CCS room classification.

Overview timeline Service Center

Time	Danish concept	English translation
May –September 2014	Dispositionsforslag 1	Outline proposal
September 2014 -February 2015	Projektforslag/ Forprojekt (myndighedsprojekt)	Project proposal/ Preliminary project (regulatory project)
December 2015	Hovedprojekt	Main project
February 2016	Prækvalifikation	Prequalifiqation for Tender
Maj 2016	Udbud	Tender
July 2016	Kontrakt med 6 entreprenører	Contract with 6 contractors
Autumn 2016	Byggeri	Construction

Note that project proposal and preliminary project was merged for the Service Center project

Overview timeline Somatics

Time	Danish concept	English translation
Maj 2014	Dispositionsforslag 1	Outline proposal 1
September 2014	Dispositionsforslag 2	Outline proposal 2
Februar 2015	Projektforslag 1	Project proposal 1
April 2015	Dispositionsforslag 3	Outline proposal 3
Februar 2016	Projektforslag 2	Project proposal 2
April 2016	Forprojekt (myndighedsprojekt)	Preliminary project (regulatory project)
May 2016	Hovedprojekt	Main project
November 2016 (planned)	Prækvalifikation	Prequalifiqation for Tender (planned)
December 2016 (planned)	Udbud	Tender (planned)
Spring 2017	Udbud	Tender (de facto)
Summer 2017	Byggeri	Construction

08 BISI support to implementation of CCS

The BISI project supported the implementation and use of CCS in the TR3 project through providing the Spine software, training and telephone support.

The Spine software was provided free of charge to the participating companies from nov 2014 to june 2016.

Spine is a cloud based collaboration platform. It enables building project members to collaborate and share building codes, project data and object properties instantly between them. In principle independently of design platform, location or time (Projectspine 2017).

BISI project member introduced the BIM organisation of TR3 to CCS and Spine at a kick off meeting in november 2014, followed by training sessions in January and February 2015.

As the project became focused on reducing functionality to meet the budget over 2015, the actual use of Spine came a lot later than planned.

It was initially the client who demanded the use of CCS and later established the collaboration with the TR3 project. Another client decision outside the BISI project that had major impact on the use of Spine and CCS was taken by the client in the fore summer of 2015. Here it was decided to harmonize the CCS code used in phase 1 and bring it up to date. A database was created in Spine that contained these codes. This was in turn used by TR3 at, first, the design of the service center in autumn 2015 and second for the main design of the somatics in 2016

09 Analysis

This section contains the analysis of the Gødstrup TR3 project. The structure of this chapter is the following: a. the project in general, b. the classifications in use, and c. the innovations. Where a. and b. are relatively short, c. contains a number of themes; different innovations, expected and non expected.

09A. Analysis: The project in general

None of the companies had previous to the TR3 project worked with cuneco classification system.

The companies all had substantial experience with various IT systems supporting Building Information Modelling.

Spring 2015 A series of reductions of the functionality of the buildings to obtain cost reduction. Almost any part of the building has been scrutinized several times to reduce 65% in the designed cost. Paradoxically, use of BIM enables also the many iterations like this where the product is reduced. For example one story less, less square meter per story, shift of façade concept and elements. There are however also examples of that the BIM enabled coordination between the many design and data elements fails to perform, for example when iterations of cost cutting and reduction were only partially documented or captured in the models.

In the summer of 2015, The client initiate a cleanup of the building component coding made by a previous phase project group. This results into a Spine database of coded building components shaped to fit the future Facility Management IT system (MainManager).. The clients ask the project group of the phase three to use the Spine database as reference for their coding. This leads to a ease of use, as ambiguities in coding is solved and the data base is easy accessible.

The efforts of the client initiate a shift to proactive coding amongst the designing architects and consulting engineers.

From early 2016 the detailed design of the Service facility is done using CCS. This involves however predominantly two of the companies Brix and Kamp and CREO. The two others wait for the main project (hovedprojekt) of the Somatics part to start in may 2016.

The detailed design of the Somatics has commenced and is underway (july 2016). It is planned to run from May to October 2016.

09b Analysis: The Classifications in use

Below is entered a list over the classifications in use in TR3.

Project	Phase	System in use	Classifications in use
TR1	Design build main body	Revit dRofus Sigma/Estimate	SfB, CCS v.1 rooms, components
TR3	Brief expansion	Revit dRofus	BIM 7AA CCS v 1 rooms CCS information levels Revit
TR3	Brief reduction	Revit dRofus	BIM 7AA CCS v 2 (rooms) CCS v2 (building component) Revit
TR3 Sub Project Service Center	Design Service center	Revit dRofus	CCS v2 (building component) BIM 7AA Revit
TR3 Sub Project Service Center	Tender and bid service center	Revit Estimate	CCS v 2 (building components metrics (måleregler), information levels,)

Figure. The five main phases/episodes and the building information standards used

The CCS package also involve a number of supportive tools such a mapping table to translate from one classification to another, the CCS property database, tender support (tilbudslister). Those did not come into use.

However other Bips tools such as ”B1000 beskrivelsesværktøj” did came into use.

The different classification options that the participants had in TR3 entered their arena in different manners. All companies followed market trends and invested in Revit, which involves certain classification possibilities including shared parameters and frames. Several company representatives were in contact with the development of CCS and BIM7AA as emerged from 2010 and 2013 respectively (BIM 7AAA is a building component type coding, BIM7AA 2016).

When TR3 won the task of designing phase 3 an IT agreement was put in place as part of the contracting. This involved the compulsory use of CCS room programming, building components, metrics and information level (the latter in a less elaborated manner). This was a demand from the client. However the client merely specified the use of this in the deliveries that TR3 was hired to do. This implied that TR3 had the discretion of deciding how to classify with CCS. In principle this can be done in a proactive or reactive manner. The proactive manner implies that the CCS 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 CCS as late as possible.

A proactive set up was originally adopted by TR3. Introduction sessions to CCS was carried out and the Spine software was provided in late 2014 while architectural outline proposal was underway. However as 2015 developed, the focus became redesign and reductions.

Moreover to many actors in the project it is not obvious that building component coding is needed when developing the outline proposal, project proposal or preliminary project (regulatory project). The companies chose to wait with the classification, and it eventually entered the main project of the service center in autumn 2015 and the somatics in early summer 2016.

The classification with CCS was thus done predominantly in a reactive manner, immediately 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 Revit ordering functions.

Another important feature of the use of CCS classification is that it was implemented in the TR3-project because the client demanded it. CCS use was put up as a demand in the IT-agreement made when TR3 started. However all participating companies distinguish between this project and other projects as well as common company support facilities such as object libraries. In these other context the companies follow other strategies.

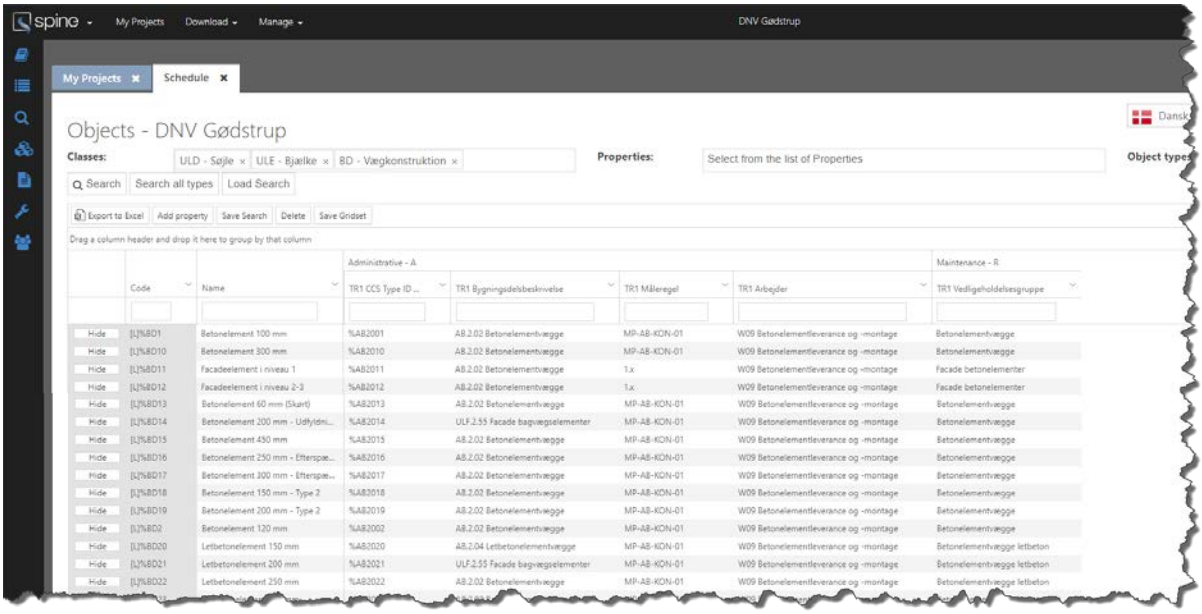

Figure: Screen from the Spine database in the project with entered rows of classified concrete columns. See also appendix 3 for more examples.

09c Analysis Standards impact on innovation

In this section the impact of standards on innovation is analysed. We do this by first outlining what our literature review established would be the expected innovations – and we then turn to what are the realized.

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 1. Afterwards other innovations is discussed that was found in the case study.

Table 1: Possible innovation benefits due to standardisation

Standards may enable innovations through:
1. Improved coordination enables higher complexity 2. Standards enable process stability 3. Quicker diffusion of innovations 4. Direct efficiency gains enables exploitation of new ideas 5. Indirect efficiency gains opens up resources to do something new 6. Standard adoption require organisations to innovate 7. Standard development increases capacity and network of participants 8. Standards enable business model innovation

Source: (Koch &Beemsterboer, 2017)

Improved coordination enables higher complexity

The TR3 project is carried out by four companies operating from different addresses. Video conferences were used extensively to realise sufficient, timely coordination. This coordination was moreover put under pressure when the project underwent a long phase of reduction economically and functionally.

The IT and classification enabled coordination thus have to be understood in this general context of coordination challenges.

Internally in engineering company OJ the use of Revit across ventilation, heating and electrical engineering was coordinated on an online basis and in principle continually during the phases of outline proposal, project proposal, preliminary project (regulatory project) and main project. During this process a shift from Revits internal classification to BIM 7AA building component coding and finally to CCS in summer 2016 was handled.

In the autumn of 2015, during the early outline proposal phase the implemented revit/BIM coordination between the two architects firms enabled them to handle the complexity in joint process, even if they worked at different geographical addresses. The weekly coordination and merge of BIM models assured that their division of labor could handle the complexity. This encompassed two BIM models, one for the façade and one for architectural fixtures and fitting (Aptering). This work was drawing on user demands documented in the room programming software, and transferred manually to the models.

Shift in classifications, like OJ's shifts from Revit to BIM7A to CCS, added to the complexity viewed over the comprehensive design effort, yet reduced the complexity in early phases and in intermediate phases. Moreover interoperability between the classifications enables the companies to make such shifts and even count on them for future projects.

Standards enable process stability

As most of 2015 was spent to reduce the project, there has been some overall unstable features in the project's progress. But there have also been more stable periods like autumn 2014 and spring 2016. In this context a common IT architecture with common use of standards would have possibly led to process stability and the more stable periods of the project did produce important results, like the autumn 2014 process leading to a calculated budget by January 2015 that led to the management understanding of the need to start cost cutting and functional reduction (se below).

One important tool for creating stability is the CCS standard of information levels. This standard is intended to help project participants jointly negotiate the information deliveries during the project. The Client did originally include this standard in the IT-agreement made with the TR3 partners and therefore signalled that it should be used by TR3. However it did not come in active use in the process. It is therefore not possible to evaluate which role it might have played. One company did refer to other projects where CCS information levels had become a central object of negotiation.

Quicker diffusion of innovations

The organisation behind the standard could have become a hub for Danish building information standards. Instead this organisation underwent significant reorganisation and are presently only vaguely promoting a standard development community.

Direct efficiency gains enables exploitation of new ideas

As it will be described below, most of the cost reduction enabled, were used to reduce the functions of the product. Efficiency gains were therefore "swallowed" by these and were not able to provide free space for creativity and innovation.

Indirect efficiency gains opens up resources to do something new

The indirect efficiency gain underwent the same usage as direct ones described just above.

Standard adoption requires organisations to innovate

In the summer 2015 the client initiated an ordering of component codes in a database also with a view to future use in a facility management system.. The data was already organised using CCS building component classification by the previous project (Curavita), but in an earlier version and in an uneven manner. After having prepared the Spine database, the client provided the database with coded building components to the four companies and demanded that they had to follow this version of CCS coding. In October 2015 the architects started using CCS during design of the service center (estimated 75 building component to be used). In November 2015 the consultants engineer commenced using the database (estimated 2000 building components to be used) for the service center design. In the early summer of 2016 the CCS system came in use in the detailed design (hoved projektet) of the Somatics unit.

Standard development increases capacity and network of participants

Apart from CCS also BIM7AA has emerged as a community of hospital builders in Denmark. Experiences using these standards are transferred from one hospital project to another in several ways. First because clients coordinate, second because companies come to participate in more than one hospital project and draw on their experiences and develop new. Third because employee mobility enables transfer of knowledge and experience.

Unfortunately the two standards communities has ended up in somewhat of a competitive situation. It is predictable that they will continue to coexist. Here automatic mapping between the two might overcome inefficiencies generated from that firms will have to operate two or more standards.

Standards enable business model innovation

Several companies linked, related to TR3 have been able to develop businesses based on the use of the information standards. This include Projectspine, dRofus, Sigma and Likan.

Projectspine developed as a company as a result of a spinoff from Betech data. So, while developing the classification support tool, Spine people from Betech became aware of an opportunity to create a new company. The company were able to sell licenses of Spine to the TR3 companies and the client Region Midtjylland.

The other companies dRofus, Sigma and Likan similarly developed software and services that can be used in future building project.

Realized Innovations – other than expected

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

Reverse Innovation

As part of handing in a design brief in February 2015 the client demanded an estimate of the cost of the brief. This estimation was made using the Revit models and objects and also using BIM 7AAA and CCS. The result of this estimation was an overprize of 65%. The client therefore demanded a substantial cost reduction, without harming the functional demands developed during the autumn of 2014.

This triggered a series of reverse innovations. Literature normally define reverse innovation as a process, where an existing highvalue product is reduced into a more affordable offer (Radjou et al 2012, Von Zedtwitz et al 2015). Reverse innovation is often understood as reduction and concentration of functionality of a product, to target a lower market than the initial product envisaged could target. This definition is close to that of “frugal innovation" which is the process of reducing the complexity and cost of a good and its production (Radjou et al 2012)

Reverse innovation is here used in a slight different manner than often seen, since here the product stays with the same client and the innovation is not developed in a developing country context and later introduced to an advanced country (Von Zedtwitz et al 2015).

Reverse innovation in Phase 3 Gødstrup

What we found in this case was that reverse innovation can be carried out at an overall strategic level and then in two different directions. Either one can reduce in depth through removing one or two parts of the intended products entirely or One can reduce (a little) throughout the intended design (grønthøstermetode). Here the last method was used, as every part of the designed models was searched for possible reductions. This effort came to include an in depth reduction of all aspect of the design:

- Ground plan
- Number of stories
- Facades
- Balconies
- Internal Roofs
- Floors
- Panels
- Indoor equipment
- Installations (Ventilation etc)

The initial 33.000 square meter design was reduced to 22.000 square meter. The façade concept was redesigned to one that look like the previous project group have done, but which consisted of other and fewer elements. The changes also include one story less, and fewer square meters per floor. Through dialogue with the health and safety authority it was made possible to reduce the number of bathrooms at the personnel facilities with 50. Also two surgery theatres came to share a ventilation system, in contrast to the first outline proposal, where safety concerns made the user and designers specify one independent ventilation system per surgery studio. At the water and heating supply design a change of radiators and shift of toilet, from a wall mounted to a floor mounted model was done. Adding to these there are also examples of functions that are “parked” in a manner making it possible to take them out at a later stage. This goes for example for a exercise gym, which is placed in a corner making it possible to remove it.

The process was carried out stepwise, producing a number of proposals in intervals of month length. Each outline proposal and project proposal handed over to the clients involves a calculation of the cost as comprehensive as possible at the time. This involved “take off” of material quantities of the architectural BIM models and engineers using experience based square meter prizes. Also figures from the phase 1 tendering was scrutinized. Thus, the relation between functionality and cost were kept in strict synchronization.

These revisions became enabled by the use of building information models. The architects remade their façade model, but were able to maintain the outfitting and fixtures model relatively intact. During this process most companies used the structure and classification provided by their Revit software. CCS did not come into use until October 2015. There were during the process also occasions where coordination between the many design and data elements failed. An example such an occasion happened when iterations of cost cutting and reduction were only partially entered in the company’s system.

One architectural employee observed:

“We cut away balconies, building components ... TR3 is something of the most “scraped” ... not the same functions anymore. There is linoleum floors all over, 60*60 (cm) ceiling panels all over, wooden panels…”

Most participants in the project that contributed to the reverse innovation views it as a commonly occurring exercise in building projects, a situation where one have to improvise in the particular context to find ways where the complex functionality can be reduced without harming the value proposition of the product too much.

In the process of reduction the client tried to maintain (patient oriented) functionality as specified in the room programming and entered in dRofus. As the overall calculated future needs of number of treated patients also fell, there was a possibility to remove three surgery halls and some bed rooms.

The client eventually approved to the realized reduction and also viewed it as the TR3 organisation really had been creative, possibly derived from the cost pressure. At a time it should be noted that the architects and engineer were payed (extra) to do the reduction exercise.

Innovation and better learning across hospital projects through standards development

Although a more formal standards development process of CCS did not occur, the actor did achieve benefits and learning from previous projects they had participated in, both as companies and as persons. The includes the new Ålborg Hospital and the new hospital in Odense. The previous project at Rigshospitalet and the new university hospital in Århus (Skejby).

Product innovation possibly without connection to standards

An important product innovation was triggered by the reverse innovation effort. The face of phase 3 was in the beginning of TR3 specified to match the neighboring phase 1 building. However as cost cutting was necessary the TR3 architect and engineers developed another façade system. This resembles visually the phase 1 building by also having horizontal window band (langsgående vinduesbånd) , but where the phase 1 building uses manually built brick walls (skalmur), TR3 now propose use of standard precast concrete elements with window holes. Pillars has also been removed. In a passage without brick wall TR3 suggest the use of aluminium mounted on a sandwichelement. This solution is also used in the bedroom parts (sengetårnene). The sandwich element is a low cost solution and TR3 calculated that this is a lower cost than the phase 1 solutions.

The hospital project has operated a concept called “The stable of innovation” (Innovations stalden). This premise has provided space for a 1 to 1 size testing. And indeed have tested a large number of possible solutions. When TR3 began their project a praxis was well established were all solutions that could be tested indeed was tested. This goes for around 100 types of room in the hospital, representing around 80% of the rooms in the hospital. But also for example ventilation piping has been tested. This gives a certainty when it comes to dimensions. But has also support that different types of rooms to a higher degree has become substitutable. Subsequently room programming in dRofus has been accommodated.

One can note that Virtual Reality solutions have not been used to test the design of rooms. The hospital client explains that with that VR has developed rapidly the later years, whereas many basic decisions was taken as early as 2010.

No innovation

Several interviewees understood their work as mainstream for design in the Danish building sector and did not find they could point at any new innovations in this particular project. Seen from the client's perspective this can be seen as a less risky approach as solutions from TR3 could be considered well tested and in use.

One central idea of using a common information standard is to make interfacing and transfer of information smoother and more efficient through obtaining consistency. However, when the service center tender commenced, the TR3 partners chose a safe route for generating bill of materials and materials take of their BIM models. Thus each partner carried out the take off and manual coordination was used to assure the quality of the data. Second when this material was handled over to the contractors they did no use the option of automatically generating the bill of material through using the CCS codes. Instead the calculators used more traditional ways of understanding what the project demands, thus using the (usual) redundant information in tendering documents (the descriptive material, beskrivelser).

10 Conclusion

The aim of this case report is in line with the central aim of the BISI project namely to map and analyse changes in innovative direction in public procurement of buildings enabled by building information classification in Denmark, Norway and Sweden.

The case of this report is the Danish project. This greenfield hospital is split in several phases, and the BISI project have followed phase 3, called TR3 by the project consortium.

The design of TR3 has been followed. This has been quite a long process. For the project it commenced in spring 2014 and for BISI it commenced in November. By late autumn 2016 the design was almost finished.

Our main results, answering to our main aim is: It has not been possible to show positive effect of classification on innovation in the period of study. A number of initial barriers for working with classification has been salient. The strongest innovative activity, the reverse innovations, occurred using Revit –classification (naming and numbering) without classification support from CCS.

The realized innovations in TR3 are remarkably different from the expected. A central innovation was the *reverse*: realizing a substantial reduction in functions of the envisioned hospital product. *Process innovation* was expected to relate to improved coordination enabling the handling of higher complexity. However, the TR3 project was carried out by four companies operating from different addresses using video conferences to do sufficient, timely yet complex coordination. On top of this coordination was under pressure when the project underwent a long phase of reduction economically and functionally. The IT and Revit classification enabled coordination in this context did have some occasional strength. For example, in the engineering company OJ the use of Revit across ventilation, heating and electrical engineering was coordinated on an online basis and in principle continually during all phases. During this process a shift from Revits internal classification to BIM 7AA building component coding and finally to CCS in summer 2016 was handled. Another example is that during the early outline proposal phase the implemented revit/BIM coordination between the two architects firms enabled them to handle the complexity in a joint process from different places. The weekly coordination and merge of BIM models assured that their division of labor could handle the complexity. Shift in classifications, like OJ's shifts from Revit to BIM7A to CCS, actually reduced some complexity in early phases and in intermediate phases. Moreover, interoperability between the classifications enables the companies to make such shifts and even count on them for future projects. Another process innovation expected was that standards could enable process stability. As most of 2015 was spent to reduce the project, there has been some instability. But there have also been more stable periods like autumn 2014 and spring 2016, leading to important results. There a common IT architecture with common use of standards would have possibly led to process stability. One important – and absent- tool for creating stability is the CCS standard of information levels. This standard is intended to help project participants jointly negotiate the information deliveries during the project. The Client did originally include this standard in the IT-agreement made with the TR3 partners and therefore signalled that it should be used by TR3. However, it did not come in active use in the process. It is therefore not possible to evaluate which role it might have played. One company did refer to other projects where CCS information levels had become a central object of negotiation. It was expected that standards would enable a *quicker diffusion of innovations*, but due to external conditions this has not been the case on a formal level. The organisation behind the CCS standard (Bips/Molio) could have become a hub for Danish building information standards. Instead this organisation underwent significant reorganisation and are presently only vaguely promoting a standard development community. A more informal manner of diffusion did occur as project organisation members came from, worked in parallel and continued with other Danish Hospital projects. It was expected to find direct and indirect efficiency gains opening for innovation. However most of the cost reduction enabled, were used to reduce the functions of the product. *Standards might also more directly require innovation*. This actually occurred when the client's previous purchase of a facility management system and goal of ordering the classification required a particular version of CCS classification used. The client provided the database with coded building components to the four companies and demanded that they follow it. This did happen during design of the service center and later the main design of the Somatics unit. The CCS Standard did enable a *business model innovation* as it during the project was feasible for a group of Betech data to establish a company, Projectspine, with the Spine software as basis.

The classification with CCS was done in a reactive manner, immediately 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 Revit ordering functions.

The study have identified a number of occasion and passages where proactive CCS classification could have made a positive difference. One example is the bill of quantities and materials for the tendering the process. The design project organization made the CCS classification immediately before the tender and the contractors chose to use other component information as the bill of materials and quantities include redundant information. This implied that the contractors safely could carry out their requests to further subsuppliers, do their calculation etc., but it meant the automated transfer of component information did not came in play.

The uptake and use of CCS and BIM 7AA was an extensive learning process for the involved parties. When the client commenced the project neither CCS nor BIM7A were present, i.e. they were not even developed.

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12 Appendix 1 Glossary

Below the used translations from Danish is listed

The translations is done with general translation tools, National Health Service in UK vocabulary and Danish labour market associations translation of agreements.

Dansk = English

Words/Concepts

Aptering = Fixtures and fittings

Bed rooms= Sengestuer

Beskrivelser = Tendering descriptive material.

Dagkirurgi= Day surgery

Dispositionsforslag =Outline proposal , Brief

Forprojekt= Preliminary project (FRI term)

Hovedprojekt= Main project

Linoneum= Linoneum

Myndighedsprojekt= Regulatory project

Operationsstuer = Surgery room (NHS)

Projektforslag = Project proposal

Servicebyen= Service center

Somatisk afdeling = Somatics

Totalrådgivning = Full service consulting

Udbud=Tender

Udførelse= Construction

12 Appendix 2 Method

The main period of study has been November 2014-July 2016. This implies that the project had been followed from outline proposal to commencement of construction of one of the two buildings involved. In the following period summer 2016-summer 2017 the project has been followed in a more lax manner.

The method builds on interviews, literature studies , document analysis, self reporting and presence at joint meetings.

Interviews

Both direct interviews face to face and telephone interviews has been carried out. In total 42 interviews, whereof 6 has been on telephone. Face to face interviews have taped and transcribed.

The interviews weee carried out with

Project manager of TR3: 1

BIM coordinator project: 2

Architects and constructing architects: 10 (two rounds, first 7, second 3)

Consulting Engineers and Technicians: 18 (two rounds, first 11, second 7)

Clients representatives: 2

Managers from the participating companies: 6 (two rounds first 4, second 2)

Telephone interviews were done with selected contractors during and after the tendering process. Three contractors were interviewed out of the 22 contractors prequalified for 6 contracts for the service center. One won their contract. The interviewed were bidding calculators and tender managers.

Document analysis

Document analysis has been don on materials provided by project participants. It includes project plans, and public information of the project. There have not been access to the joint project web.

Participation in joint meetings

The participation in joint meetings encompassed

- Meeting with client representative spring 2014
- Kick off meeting for TR3 november 2014
- Kick off meeting for BISI at Oluf Jørgensen November 2014
- Training session on CCS and SPINE January 2015.

Self reporting on daily activities

A webbased questionnaire was designed and distributed from January to may 2015.

It was intended as a weekly survey on work activities covering IT use, work activities, use of classification. It sent to a group of nine participants in TR3. BIM coordinators, architects, engineers, constructing architects. 56 week surveys was collected.

The results of this effort was very limited as it was aimed at following the use of CCS and Spine that was not in use in the spring of 2015.

Limitations

The project has benefited from sufficient access throughout, to the TR3 projects.

The resources of the BISI- project have been small compared to the long high resource efforts of the TR3 project located in four companies and a client organisation in total residing at five addresses. It has been neccessary to focus the data collection to a few occasions, working with a lot of “expost” information, information that is built on how actors interpret something that happened in the past.

12 Appendix 3 Screens from the Spine database