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TNO report

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Contents

1 Introduction

This report summarizes the discussions and conclusions that emerged from a one-day seminar, held on 17th April 2014, on the theme of Building Information Modelling (BIM) for the healthcare sector. The seminar was organized jointly by TNO and the European Health Property Network (EuHPN). Invitations were sent to EuHPN-members and professional healthcare (related) organizations that have an interest in the use of BIM in all phases of the building lifecycle, where BIM is used to improve the planning, construction or running of buildings, and to ensure more efficient and effective collaboration between the all of the agencies involved in creating high quality healthcare buildings.

This report presents the most important issues that were discussed during the seminar. It gives an introduction to the possible uses of BIM in the healthcare sector, as well as some ideas about how BIM could help to develop better buildings. The primary point for discussion during the seminar was to form a better and more coherent idea about the possible (dis)advantages of using (open) BIM models in the health care sector. However, although progress has been made on the use of BIM for project delivery, the use of data throughout the facility life cycle is still evolving, and the seminar focused in part in this area. The event was also designed to critically influence the current BIM-projects such as STREAMER. Finally, the seminar also helped to create better links between developments from the BIM/ICT-world and end-users in the healthcare sector.

The seminar program and associated presentations can be found in Appendix A. A total of 17 participants attended from the UK, the Republic of Ireland, Sweden, Norway and the Netherlands. They represented public administrators (national/regional), architects, hospital designers, planners, construction companies and representatives of hospital or healthcare organisations (see Appendix A.1).

2 Overview of BIM

2.1 The Definition of BIM

The seminar made use of the following definition of BIM:

<u>A Building Information Model is:</u>

“A digital description, relevant for a certain scope, in a certain context, of a specific physical structure that exists now or may exist in the future”.

So, it is not a process (which is ‘Building Information Modelling’), nor an R&D area nor even a data structure.

Furthermore, we attach certain characteristics to BIM:
- It uses n-Dimensional Smart objects/properties/relationships (beyond documents & drawings).
- It is structured (i.e. machine-processable).
- It is correct, up-to-date, complete.
- It covers multiple views/aspects/disciplines.

Typically a distinction is made between ‘Little BIM’ and ‘Big BIM’, where the first refers to using BIMs in one organisation, and the latter refers to using BIMs in the communication between organizations. Clearly, the second variant has more stringent requirements with respect to uniformity/openness. To be able to communicate between companies, the BIM should be according to agreed open standards for format and structure.

2.2 Vision of BIM

The general view is that BIM enables optimization and innovation, during the life-cycle and in the supply-chain, by improving information management and communication, and thereby enabling better decision making and collaboration among all relevant stakeholders.

Optimization means integrating existing functionalities:
- Forward integration: reuse information from previous phases as much as possible (no reinvention) and constantly add/enrich the data that is there already.
- Backward integration: reuse information from later phases as much as possible (no reinvention). Select instead of create as much as possible (like reusing existing “object libraries”).

Innovation means: introducing new functionalities. Because BIM brings data sets consistently together new functionalities become possible that better support or even enable new business processes, such as:
- Multi-scale Energy Simulation/Analysis.
- Multi-stakeholder/Multi-criteria Evidence-based design.
- Parametric Hospital (requirements & design) Configuration.

The integration scenario is depicted in Figure 1 where life-cycle/supply-chain processes are supported by different software applications which need to exchange and/or share information despite their native structures and formats.

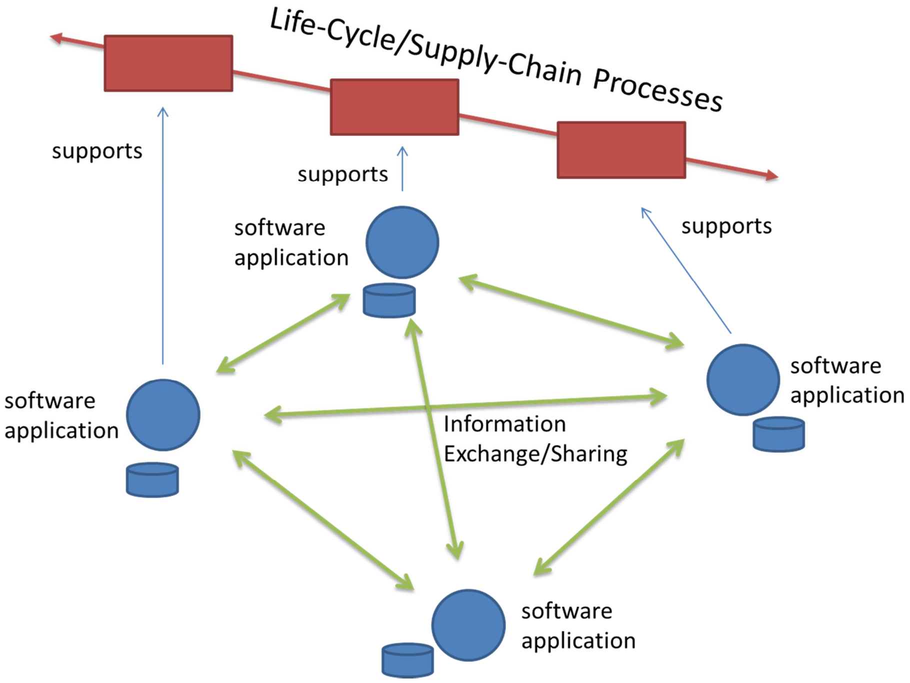

Figure 1 Typical Integration Scenario.

2.3 The Context of BIM

From the start, BIM has been associated with modelling buildings (residential, utility, technical etc.). More and more we see a tendency to also apply the BIM concept to civil infrastructures like roads, bridges and tunnels. Another trend is the incorporation of other (especially lower) levels of details such as areas as in Geospatial Information Systems (GIS) (including urban areas like hospital districts).

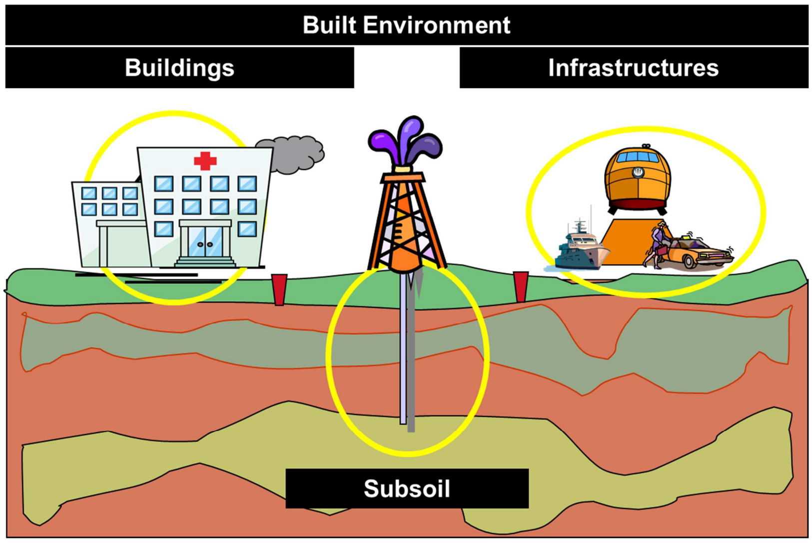

Figure 2 Three main areas in the built environment.

For healthcare the context is 'Health Care Districts', covering all healthcare assets in a particular area – treating them as specialized buildings involving conditioned spaces and installations (see Figure 3).

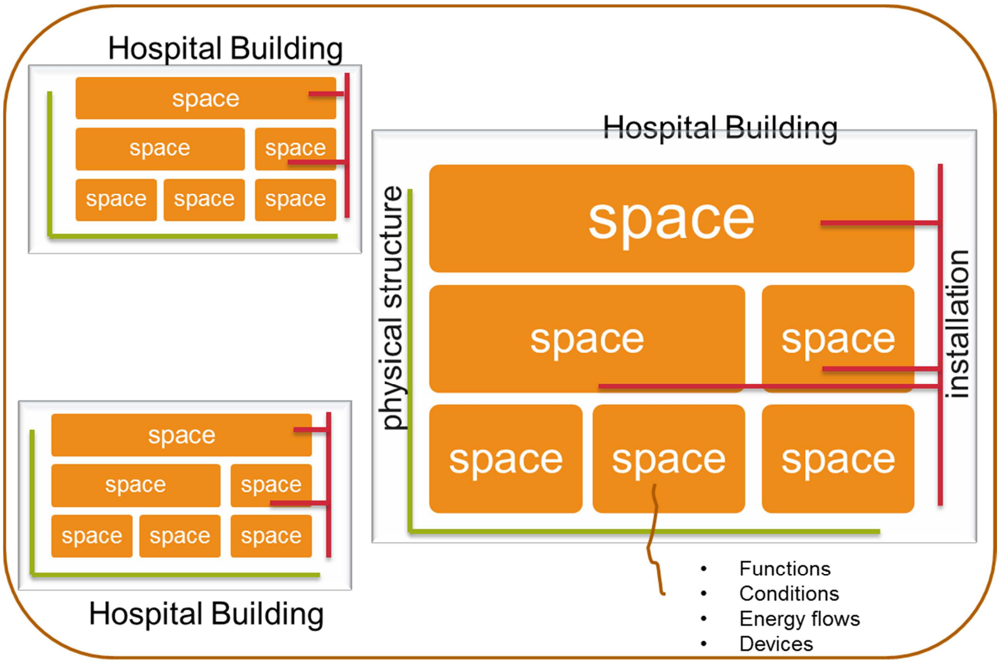

Figure 3 Healthcare district – typical overall structure.

2.4 Scope of BIM: Life-cycle and Supply-chain

We like to view the (potential) scope of BIM as a matrix with two dimensions: the life-cycle phase and the supply-chain level (related to the product structure at hand). In principle, all cells of the matrix denote sub-areas for BIM depending on the information needs of the stakeholders involved (figure 4).

For example, the life-cycle gives rise to different aspect-BIMs:
- BIM as Required (result from the programming phase).
- BIM as Proposed (result from the design phase).
- BIM as Built (result from the building phase).
- BIM as Operated (result from the operational phase).

These aspect-BIM are all linked and are synchronized; transferring and reusing information from previous lifecycles. 'These aspects of life-cycle BIM flow from one to the other, with synchronized links between each phase'.

Life-cycle Phase / Supply-chain Level	Program * ('specification')	Design	Build ('materialization')	Operate *
Areas				
Structures				
Systems				
Parts ("equipment")				
Components				
Materials				

Figure 4 Life-cycle versus Supply-chain.

* Covering both Asset Management, Asset Usage Management & Maintenance.

2.5 Goals (why BIM?)

BIM can involve various goals, such as improvements for patients and staff, the environment, productivity and value-for-money (see Figure 5). It is best to address these goals holistically – taking all of them into account – even if the immediate aim is something simple, such as 'maintaining the same level of environmental comfort'.

People (patients, visitors & medical staff)
More Functionality, better Conditions
Comfort, Safety … in/over LC/SC

Prosperity
Less Cost / Time … in/over LC/SC

Planet
Less Energy/CO_2 … in/over LC/SC

Figure 5 Goals for BIM.

For example, if the project requires a focus on energy use and costs, we should also keep in mind the investments (financial costs) required, but also the eventual benefits to all stakeholders – patients, staff and the public at large.

2.6 Beyond BIM

BIM is typically just one piece of the puzzle. The information produced by BIM processes needs to be managed, shared, monitored and made suitable for

analysis. And just as there is a life-cycle approach for building design and management, so there is a life-cycle model for information and data.
This information needs to be acquired through data gathering and measurement, stored, and eventually manipulated to be useful in decision-making processes that may affect the operational, tactical or even strategic levels.

Information Life-cycle

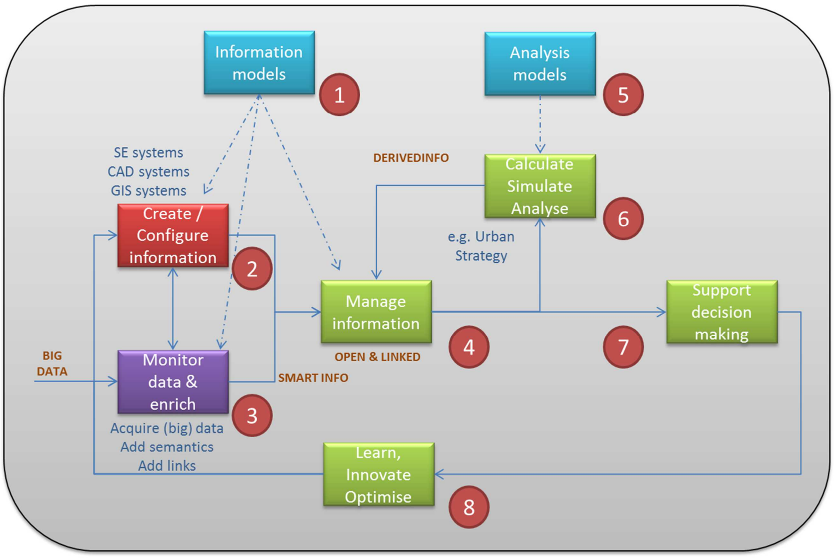

Figure 6 Life-cycle for information acquisition, storage and use.

Another extended view on BIM involves the notion that there is more than BIM, such as Linked Data (LD), Geo-spatial Information Systems (GIS) and Systems Engineering (SE). In black the key organizations are indicated (See Figure 7).

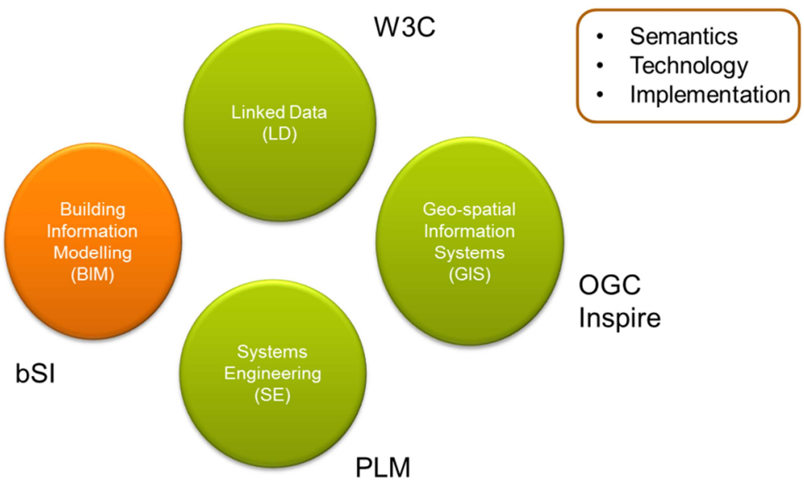

Figure 7 Multiple worlds beyond BIM.

All worlds provide alternative data structures (‘semantics’), underlying technologies like languages and open and/or closed source implementations in application software.

In the end, a smart combination of the most relevant parts of all these worlds is seen as an integral solution to both integration and innovation questions.

2.7 Trends for BIM in Health Care

2.7.1 Demand-side

Some trends emanate from changes in the nature of healthcare service provision:

- Where, by whom & how is care delivered?
- Split between Simple and Complex care.
- Split between Common and Specialized care.
- Split between Preventive, Curative, Palliative care.
- Split between Acute and Chronic care.
- Patient Age differentiation.

It is clear that future changes with respect to these factors will change how hospitals and other healthcare buildings will look like and how they are designed and built. This in turn means changes for the models that representing them.

2.7.2 Supply-side

In the hospital construction sector we currently see a trend away from the traditional, client-specific solution, and towards greater standardisation of equipment and prefabricated elements – even if this is not yet true at the scale of the whole building. Schematically, this industrial approach is depicted in Figure 8, where client-specific programming and design is replaced by industry solutions to be selected and configured.

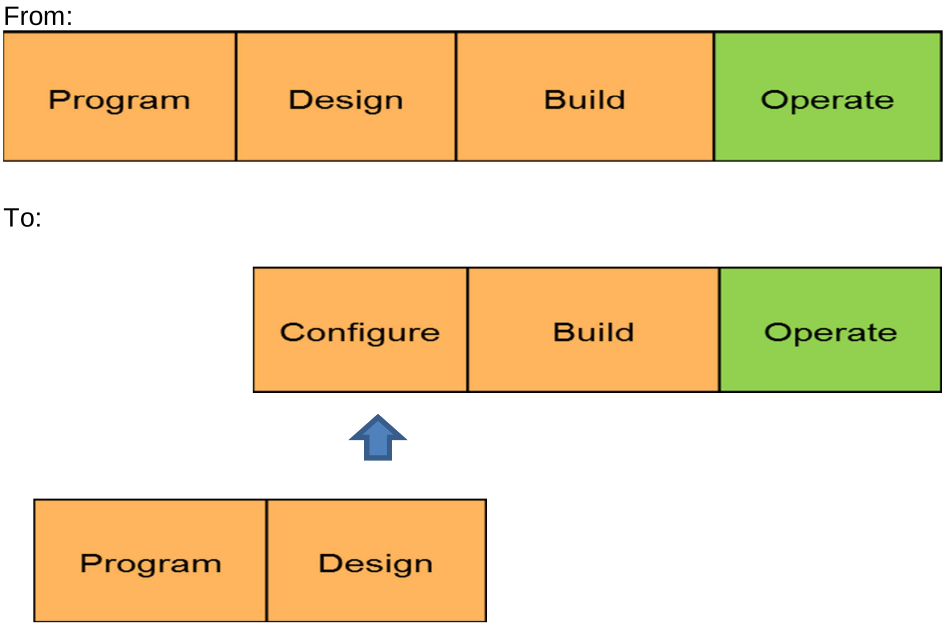

Figure 8 From traditional construction to product/service development.

The effect is that producers or suppliers in the construction supply chain will deliver (already designed) parts of the solution that can be configured by the designer to fit the building. This enables the industry to design modules of high quality for a potential larger customer basis, instead of specifically engineered one off- speciality products

2.7.3 *ICT-side*

On the BIM side we see more and more capabilities for parametric product modelling or in our case parametric BIM. Parametric modelling makes it possible to define families of products (define for a market sector and not for one specific client) in such a way that they can be configured for a specific client situation.

The BIM side itself shows a trend towards smarter models with materials, components, and elements or even whole artefacts to be parametrically designed for a sufficiently large application area stimulating mass-customization and supporting/enabling thereby the trend from the end-users and the industry (figure 9).

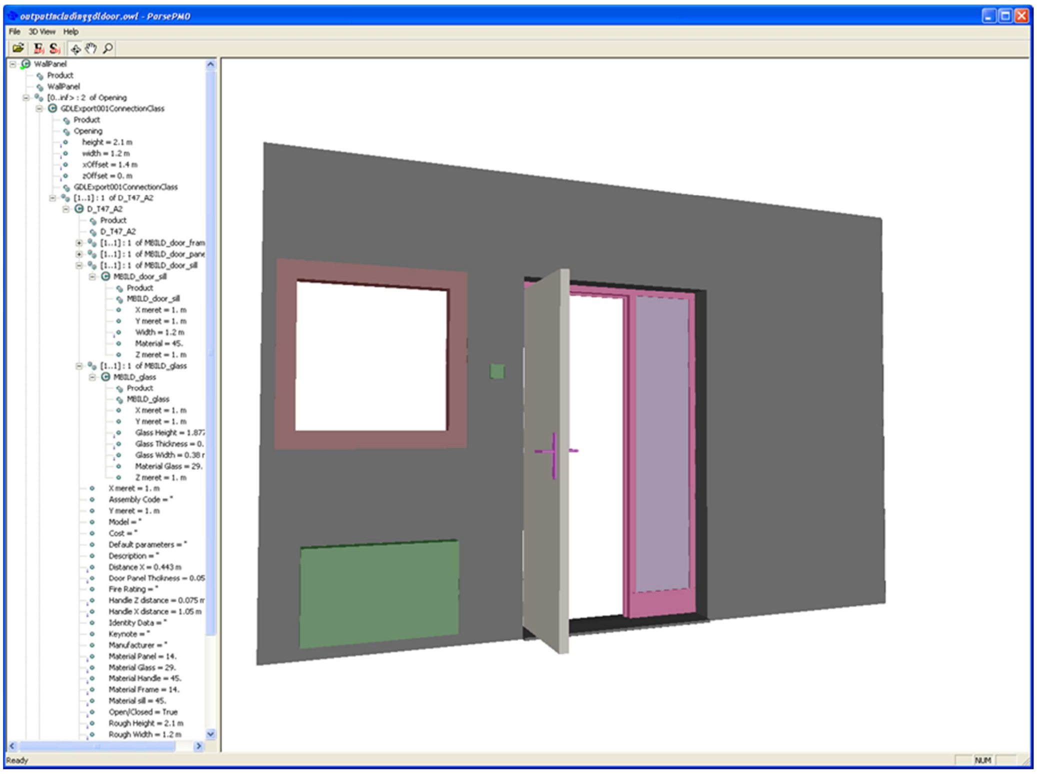

Figure 9 Selecting/configuring instead of recreating.

The effect of the increasing use of ICT is that potential learning effects can occur; by using forward & backward integration, creating better solutions for clients and contractors. Also the full potential of information that is generated during the design and construction can now be re-used in the operational phase.

3 Five surprising things about BIM

Although BIM stands for ‘Building Information Modelling’ (or, on occasions, ‘Building Information Management’), which seems a simple description,- in fact there are many differing understandings of what that phrase refers to. Some people BIM experts claim it is a process, while others some see it as being about collaboration, culture change or a means of gathering and manipulating data. But whatever people think BIM is, most of them agree that it is not about software. Just buying software is not BIM and BIM is not just buying a BIM software tool.

During BIM presentations there is one conceptual picture that keeps returning – a picture of a ‘black box’ in the center with lots of other ‘bubbles’ floating around and connected to it (see Figure 10).

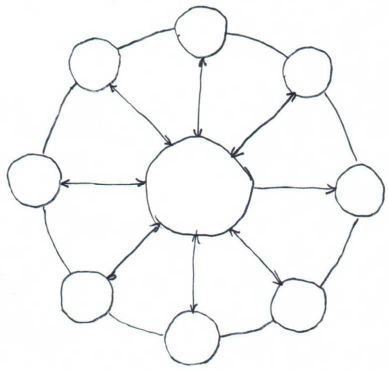

Figure 10 BIM concept.

This diagram was introduced in the early 1990s and was intended to explain that people had to agree on standards to exchange data. The middle circle was originally not a data store, but a data model (model as in ‘simplified version of the world’). The purpose of the diagram was to attempt to explain that the sector needed to agree on the names for the physical components of buildings, their nature (use and function) and their properties. That central ‘model’ of reality was intended to be a mutual agreement between all the parties in a building project, such that the parties didn’t have to interpret several different kinds of agreements, as shown like in the diagram in Figure 11.

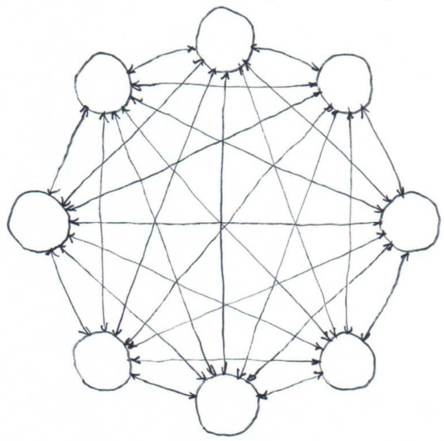

Figure 11 BIM workflow.

The actual dataflow between parties could still be on a one-to-one basis. Recent studies have shown that this proves to be more effective than working on/in a central data storage like figure 10 (where people only communicate with a central server). So in reality the dataflow between parties is still decentralized, but the 'agreements' (the 'model of the reality', the data-standard) is still a central axis or spindle. All data is mapped to that central model (agreement) before it is shared with others. In reality this data flow looks a lot more like this:

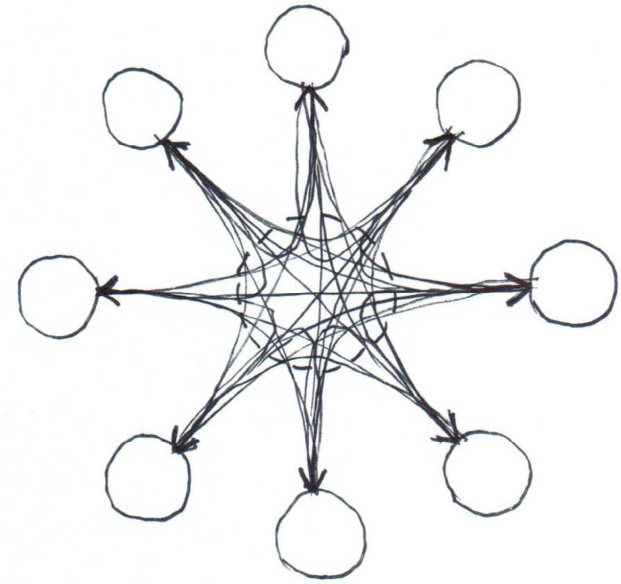

Figure 12 BIM workflow with shared data model (IFC).

This situation reduces the number of interfaces between the collaborating parties, but still keeps the flexibility to communicate in a one-to-one (or on-to-many) setting. There are many examples of this principle. There are well known examples from Denmark, Tekla, Salford and from TNO research in the Netherlands. There is also a reference to the paper "Collaborative engineering with IFC: new insights and technology" from ECPPM2012 (Figures 12, 13, 14 and 15).

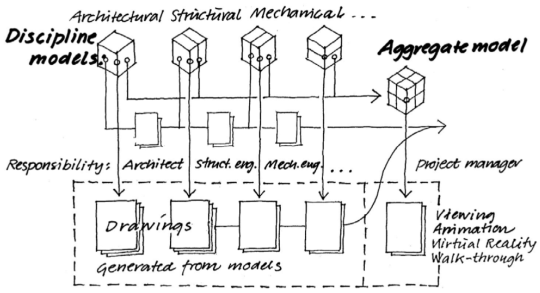

Figure 13 Denmark concept of BIM collaboration from 2006.

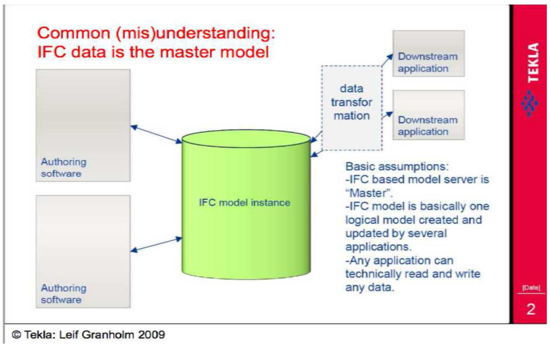

Figure 14 Tekla picture about 'common misunderstanding' of a central IFC model instance.

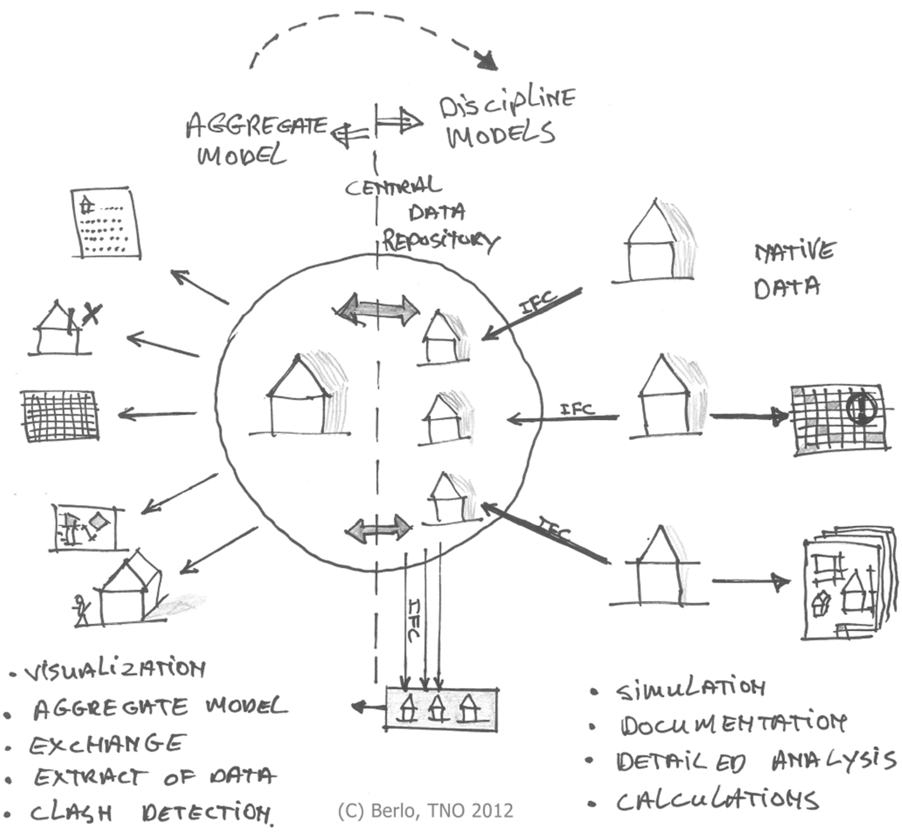

Figure 15 Collaboration concept of working with BIM in a reference model workflow.

<u>BIM as a means to improve collaboration</u>

Many people think working with BIM (and a central storage) improves collaboration, thanks to instant availability of all information.

However, in practice the availability of information doesn't necessarily seem to improve actual collaboration. This is because the more information available, the higher the chance people focus only on their own sub-set.

Whether you work with or without a central model of BIM, it is still possible to fall into the mentality of ‘this is everything I have’ and ‘throwing it over the wall’.

Within a collaborative framework, the big questions are in fact around the roles of individual parties. What information and data do they need to work at their tasks? And what do others need from them? In a good BIM collaboration everybody brings their own part to the team and it is sensitive to the needs of others (Figure 16).

Figure 16 everyone adds their own expertise to the project.

That is also the reason why the existence of the concept of a ‘BIM manager’ is questionable. A BIM manager is often the gatekeeper of the BIM black box:

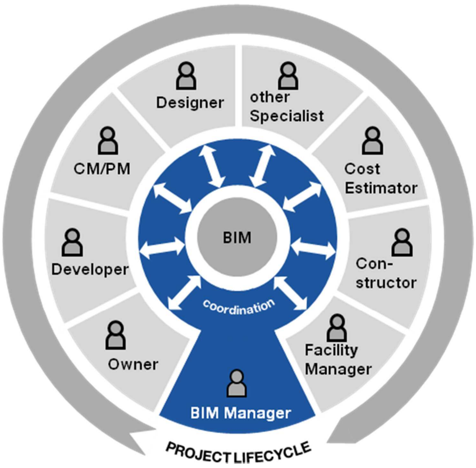

Figure 17 The concept of the "BIM Manager".

In the diagram shown in Figure 17, individual parties have to deal with a BIM manager to collaborate and share information. When the individual parties are all competent in using BIM, one may question whether there is much added value in having a BIM manager. While it is clear that a project manager also needs to have BIM competences, that doesn't make him a BIM manager.

A selection of other (possible) BIM myths

A number of common statements about BIM still come up again and again:
- "You need an object library to really work with BIM".
- "BIM doesn't work in an early design stage".
- "Too many details in a BIM give false accuracy".
- "BIM is expensive and the client won't pay for it".
- "Modelling a BIM can be outsourced to India".
- "You cannot do proper BIM without a BIM protocol".
- "We are ready, but the technology is lacking behind".
- "BIM is new and a hype but is will slow down soon".

In fact, we may have to wait for further practical use of BIM before we can know if any of the above is true, false, or partially correct.

4 Discussing BIM for healthcare; opportunities & challenges

After the seminar presentations a discussion was held that dealt with the opportunities and challenges for using BIM in the health care sector.

The discussions were centered around three themes:
1. How can BIM transform your way of working (now and in future)?
2. How to use BIM in the operational phase of your building.
3. How to integrate knowledge about design outcomes (evidence based designs) into BIM.

4.1 How can BIM transform your way of working (now and in future)

First, a remark: BIM is mechanism that can help to design better buildings in which more efficient processes can take place. In the end it is about users profiting from these better designed buildings to achieve lower operational costs or better outcomes. Seen in this way, BIM is a secondary mechanism that helps to achieve the primary mechanism (the built environment) to help achieve better use for the primary processes that take place in the built environment.

On this basis, BIM could help to achieve:
- Better efficiency in (the development) process of creating a new healthcare environment (or extension) with GIS integration.
- Better efficiency in healthcare process, because the healthcare facility is better designed and understood.

BIM would achieve this not by ‘automation’, but by improved coordination and support, and also by making more iterations possible or addressing more of the life-cycle aspects of healthcare facility design. For example:
- By supporting a better ‘client brief’.
- By calculation/simulation of energy use during the design phase.
- By optimization.
- Some automation/standards: grids used.

To achieve better efficiency you have to better utilize spaces/devices:
- This requires ‘multiple use’ of spaces/devices; different professionals having access to information from the system or working simultaneously in a system:
    - Flexibility is the key concept here.
- BIM should support/enable flexibility especially in the operational phase; making links and sharing information from other systems.
- To be ready for future trends (incl. demographic) and develop plans or scenarios for future alterations.

In the discussion, there seemed to be two relevant schools of thought: the engineer’s way of thinking about the almost deterministic use of BIM and the cultural school of thought in which the to-be-designed object is appraised as a one-off special product in a special context in a specific place.

A 'Hospital has many cultural/emotional issues: it is not a standard building' (a hospital is not a car - architect view).

From the engineer's point of view, actually they like to consider a future hospital (or extension) as a car. This could potentially bring:

- Introduction of 'product/service development' for a market sector, not for a specific client. This enables in turn:
  - Supply side activation (not just client driven); activation could lead to innovation; as proactive suppliers develop new products and services.
  - Enormous potential for reuse and configurator tool support with associated analytics (incl. energy/cost calculations).

The potential lies in scaling up from the individual to the general application of modules and solutions. The validation of design solutions would create possibilities for shared learnings and avoid reinventing the wheel in every new project.
Using BIM not for single projects, but for a series of projects, during all life cycle stages would support the creation of validated design concepts for healthcare.

4.2 How to use BIM in the operational phase of your building

The core issue of BIM in the operational phase is the challenge to capture the knowledge of people 'on the floor'. Most operational managers know which types of door hanger will break early; or which type of carpet takes a lot longer to clean. Getting this knowledge into a BIM model is the main challenge. There is no common knowledge about this, only a few best practices.

Having this kind of information available creates a valuable source for designing new buildings. Knowledge from the operational phase is used to steer or fine tune the design (backward integration). In this setup the use of BIM in the operational phase has a direct link with the workshop about knowledge driven design (see Section 4.3).

Many examples were giving during the workshop from the participants.
In the examples two main thresholds were identified:

- Making sure the data and information is available (in BIM or even outside of BIM).
- Making sure revisions are processed and evaluated to maintain a valuable database with up-to-date information.

Both issues are crucial to use BIM in the operational phase of a building.
The conclusion of this workshop was that there are a lot of practical and organizational issues to overcome before BIM can be of value in the operational phase. BIM had to be presented in a way that operational managers are attracted to it.

A suggestion was made to look at the COBie initiative. COBie is an open data standard for operation and maintenance information about buildings. COBie is presented in a table structure and therefore complies with the needs of operational managers of buildings.

They often work with excel spreadsheets and the way COBie is presented fits in their daily work more fluently than complex 3D BIM models. COBie is mandated for government projects in the US and will be in the UK as well.

It is often seen as the first ‘simple’ step towards complex BIM management, but is much more valuable because of its focus on the whole operational phase of buildings.

4.3 How to integrate knowledge about design outcomes (Evidence based designs) into BIM

In essence BIM represents information that is shareable and deals with real world objects. In terms of planning it represents the information that is shared about the design of the real world object.

Designs, however, are the ideas that emerge from a process to fulfil the needs of clients (design brief). Designs are used to solve needs of clients and users. Designs are made with the best intentions. The problem with design is often that they are unique and one-off. The design process tends to rely on, past experiences, ideas and creative processes. Facts, opinions or culture determine in a way why a design is best suitable to meet the needs. However the determining factors, which influence design decisions, are hardly ever evaluated.

The realm of Evidence Based Design helps to shed light on best available knowledge to help create better designs and buildings. The question for discussion was whether this knowledge on design outcomes (as effects of design decisions) could be applied in BIM (and whether this would be useful). And could BIM support learning from earlier design?

The paramount question here is that we want to link the performance of a design and/or of a building with knowledge about the design process to identify what design decision helped to influence the specific outcome. In itself this forms the start of a learning cycle, when the information of performance is kept for future referencing and re-use (which BIM could support). This learning could help to “predict outcomes in the design process” and link back assessments of performance in the operational phase on key performance indicators.

For organizations that have multiple BIM-projects or support multiple clients the buildup of a library with successful designs could be very useful. Key here is that these successful designs must be properly validated to establish a clear link or association with the design intervention and the specific outcome the intervention has unambiguously helped to change.

Nowadays, this knowledge is often seen as tacitly based on experience and very hard to elucidate. It could be that using BIM and systematically evaluating actual performance against predicted performance on certain key performance indicators would help to make more explicit why design decision works (or don’t work).

In this way BIM could be used as a design decision support tool or to help assess design alternatives for certain events (energy, flexibility, emergency responses). The collection of information both on the level of design and actual performance in a lifecycle approach, would give great insight and possibly generate evidence for validated design concepts in complex interventions that refurbishment projects or new hospitals in essence are.

A Programme of seminar

- Words of Welcome (Joram Nauta/ Jonathan Erskine).
- Overview of BIM possibilities for the healthcare sector (Michel Bohms, TNO).
- Five surprising things you did not know about BIM (Leon van Berlo).
- Case study: Why and how did we start with BIM? Rijnstate Hospital (Willem Jan Hanegraaf), partner in STREAMER-project.
- Case study: Operational management by BIM, case " the new Karolinska University Hospital in Stockholm & Case study "Energy audit by Negawatt-BIM" Mikael Nutsos Locum AB (Sweden).
- Case study: A strategy for use of BIM during the assets life cycle & Case study from New Østfold Hospital - Birger StamsØ, South Eastern Norway Regional Health Authority, Norway.
- Interactive discussion in small groups regarding specific BIM-themes.
- Summing up & Closing.

A.1 List of Attendees

Organisation	Name
Health Service Executive (Estate Office) Ireland	Bernard Pierce
Health Service Executive (Estate Office) Ireland	Michael Gallagher
nCZB	Theo Staats
TNO	FW Bomhof
Erasmus MC	Jan Jaap Zijl
Loughborough University School of Civil and Building Engineering	Eftimia Pantazartzis
VINCI CONSTRUCTION UK LIMITED	Egils Bernovskis
EGM Architecten bv	Nils van Merrienboer
European Health Property Network	Jonathan Erskine
South Eastern Norway Regional Health Authority	Birger Stamsø
Locum AB	Mikael Nutsos
Rijnstate	Willem Jan Hanegraaf
TNO	Joram Nauta
TNO	Michel Bohms
TNO	Léon van Berlo