BIM for Sustainability in the Built Environment

– a Strategic Research Agenda for enhanced competitiveness
Contents

Sustainability in the built environment ................................................................. 2
Why is an SRA needed? .......................................................................................... 3
What is BIM? ........................................................................................................... 4
What is the current situation? .................................................................................. 6
Future vision ............................................................................................................ 7
What needs to be done? .......................................................................................... 8
Area 1. Standards and regulations for BIM .............................................................. 9
Area 2. BIM implementation and use .................................................................... 10
Area 3. Skills provision ......................................................................................... 12
What happens now? .............................................................................................. 13
About work with the SRA..................................................................................... 13
**Sustainability in the built environment**

Our physical and social environments shape our society. Success in addressing the social challenges of an ageing population, energy efficiency, a robust infrastructure and urban sustainability depends largely on the ability of the built-environment sector to manage and develop the built environment. The future will place heavy demands on how our society is planned and designed, how construction is performed and how our built environment is managed, renewed, maintained and renovated.

In **planning**, long-term prerequisites for sustainability in the built environment are established through the provision of resources, transportation systems and supply systems that factor in population growth, services and job opportunities. Planning and co-ordination require access to accurate geographical data to ensure that the vulnerability of essential social functions is minimized. Laws and regulations define and govern requirements for the built environment and overall environmental objectives.

During **design and construction**, prerequisites are determined for the realization of long-term objectives and the optimization of life cycle-based resource consumption and operations. Users must be involved in these processes to facilitate greater public benefits. Visualizations and modern technology are a solid foundation on which to highlight shared visions. Risk analysis by means of simulations and though the optimization of diverse scenarios is a valuable aid in achieving long-term sustainability. An industrial strategy can enhance resource efficiency while maintaining and increasing solution diversity.

In the **facilities management phase**, resource minimization, sustainability and robustness are the guidelines. Processes are characterized by industrial lean thinking as well as risk and life cycle analysis carried out using simulations and the optimization of future scenarios. This applies to trends such as increasing urbanization, rising climate threats and an ageing population. Settlements are designed to cope with the impact of these trends. Suitable products ensure that user benefits are created in parallel with the fulfillment of social requirements, whether these regard established environmental objectives, emissions targets, energy and resource-saving targets, or standard requirements for the built environment.

A prerequisite for establishing and maintaining sustainability in the built environment is that information is of the right quality and accessible over time. This concerns information regarding current conditions in the existing built environment and its adjacent surroundings, the plans and planning processes of society, laws, norms and regulations, and the demands otherwise imposed on the physical environment. It also regards information about future facilities. All this information must be available over time and organized in such a way that it can be traced, refined and re-used.

To summarize, one could say that a prerequisite for sustainability in the built environment is effective information management that underpins construction and facility-management-friendly industrial processes with a focus on ultimate customer benefits. In other words, it is the standards, processes and tools in these areas that must be advanced to ensure wider general application. This requires joint initiatives from industry, facility-managing companies and organizations, academia and government. It is this aspect of sustainability in the built environment that this Strategic Research Agenda (SRA) concerns.

**Håkan Blom**

Member of the project group, IQ Samhällsbyggnad
Why is an SRA needed?

Sweden has the potential to become a world leader in BIM. IQ Samhällsbyggnad (the Swedish Centre for Innovation and Quality in the Built Environment) has defined IT in the construction and real estate sector, and specifically Building Information Modelling (BIM), as an area of Swedish strength that VINNOVA (the Swedish Governmental Agency for Innovation Systems) is keen to identify through its focus on strategic areas of innovation (SIO). In July 2012, VINNOVA awarded a planning grant to the IQ Samhällsbyggnad project to develop an SRA concerning BIM and sustainability in the built environment. The SRA was submitted to VINNOVA on 30 April 2013. The “ICT BIM for Sustainability in the Built Environment Agenda – an SRA for enhanced Swedish competitiveness” document is available for download at www.iqs.se.

Swedish governmental initiatives in strategic areas of innovation (SIO) are aimed at creating the necessary prerequisites for international competitiveness and sustainable solutions to global social challenges. Energimyndigheten (the Swedish Energy Agency), Formas (the Swedish Research Council), and VINNOVA are to collaborate on selection and monitoring in these areas. As a first step, support was offered to SIO agendas, whose purpose is to stimulate strategic dialogue between stakeholders that will clarify areas of collaboration in research and innovation strategies as well as the needs and opportunities that exist. The second step will allow support to be solicited for SIO programmes by which the suggested projects and activities in the aforementioned agendas can be implemented.
What is BIM?

The built-environment sector is characterized by a large number of stakeholders whose work is primarily conducted on a project basis. Both the operational and facility management stages are information intensive, which requires a well-organized flow of information that allows stakeholders to access the right information at the right time. Furthermore, there is a considerable need for digital information to be refined and re-used rather than recreated. This is what is driving the trend for structured information management in digital form, generically known as BIM.

How is it used?

BIM involves the utilization of information in a systematic manner, with consistent three-dimensional designs and explicit classification of information concerning the facilities, thereby facilitating all the possibilities that technology provides, such as simulations, optimizations, cost estimates, and time and resource planning.

What are the benefits of BIM?

Coherent digital information management using BIM is a strategically significant area for the built-environment sector. Traditional processes evolve and become more efficient, and access to accurate information in digital model-based form enables quality enhancements, cost and time savings, as well as contributing to better designs for users and end-users.

- Enhanced quality
- Greater user benefits through modern IT solutions
- Lower costs
- Time savings
- Better designs

As early as the design and operation phases, structures must be created that enable long-term information gathering for the management, operation, maintenance and development of real estate and infrastructure. ICT also provides opportunities for the existing stock by means of sensors, actuators and methods of measurement that assess the condition and prolong the service life of buildings and infrastructure.

Coherent, efficient information management, ICT BIM, is beneficial in enabling the provision of appropriate products – buildings, facilities and infrastructure – that fulfil the needs and requirements of users and end customers, while providing a foundation for sustainability in the built environment.

More than just technology

ICT BIM provides substantial opportunities for facility managers and users to create value effectively in their business transactions and usage. Current information related to operational status, maintenance requirements and customer satisfaction is always available. The way that facilities are used can be measured and analyzed automatically to enable regular streamlining and optimization of operational functions, in addition to highlighting potential improvements and the reuse of experiences. Skills in ICT BIM applications provide unprecedented opportunities for new innovations and business concepts, growth and job opportunities. Only the imagination sets the limits.
Strong international player

On a national level, growth in the built-environment sector provides better conditions for all other activities in the national market. This specifically applies to ICT BIM, where case studies, for example in Australia, show that the transition to BIM has resulted in a significant increase in GDP. Even more growth can be achieved if a country can increase its exports through access to and utilization of BIM.
What is the current situation?

The Swedish construction sector is robust by international comparisons, both in terms of building construction and with respect to infrastructure. A high standard of quality in built environments, classification systems and regulatory requirements has allowed Sweden to become an international benchmark. Designers, contractors and material manufacturers in an expansive domestic market, despite moderate competition, have succeeded in achieving this high quality level partly due to strong property developers. Nevertheless, the existing construction and management of buildings, facilities and infrastructure is still characterized by relatively static traditional processes, heavy fragmentation, resource wastage and inadequate experience feedback.

Traditional processes are established in project-based activities and methodological issues are resolved locally in individual projects with a sub-optimized project economy as the only control mechanism. Knowledge and skills have increased but these are mainly tied to individuals rather than to organizations and companies. Intersectoral co-ordination and sharing of knowledge, skills and experiences has been rare.

The potential for streamlining in the sector is huge and one of its facilitators is BIM. BIM is currently applied at an early stage to visualize and communicate intended outcomes to users and decision-makers; during design for intersectoral examination, to minimize errors, and to perform analysis and simulations of structural strength, energy, fire safety, acoustics, etc; during construction to integrate scheduling and costing, logistics and machine guidance; during facilities management partly to co-ordinate the processing of information relating to surfaces, operating and maintenance instructions, energy consumption and energy flows, equipment documentation, etc. Stakeholders continuously develop BIM applications to suit their own roles and needs in the process.

As often occurs when new innovations emerge, they are initially applied to existing processes, with a degree of streamlining in existing operations as a result, in other words people do the same things as before, only faster. The value chains that form the basis of traditional processes are then put under significant pressure to change. The construction sector is currently at the end of such a stage and opportunities to rationalize existing processes have reached the end of the line – it is now likely that the shorter timelines will impact negatively on quality due to an increase in errors, a decline in self-monitoring and inadequate acceptance inspections.

In the next stage, processes, procedures and business models are modified and entirely new ways of refining products and services will result, with appreciable improvements in efficiency and productivity. The construction sector is at the beginning of such a stage, and this places great demands on innovation, adaptability, leadership and development initiatives. Existing roles, processes and approaches will start to be questioned, and BIM will pave the way to new value chains, and enhanced processes and products.
Future vision

The overall vision of this agenda is sustainability in the built environment and the maximization of user benefits through effective information management.

Maximized benefits for users and facility managers. Digital models of our physical environment, both facilities and their adjacent surroundings, are employed in a consistent manner to meet the demands of society and maximize benefits for users and facility managers.

Accurate, accessible and traceable digital information. Information related to our physical environment is accurately presented in digital form, traceable and widely accessible over time.

Collaboration with users and stakeholders. Planning, design, construction and management of facilities is conducted virtually in collaboration with users and other stakeholders before real-time resources are deployed.

New value chains, roles and business models. BIM has generated new, more iterative processes with revised role divisions, new services, business models and value chains as a result. Sensors are embedded in materials and products to capture, analyze, and disseminate data for a wide range of purposes.

Continuous monitoring using digital models. Throughout a facility’s life cycle, operation, management and maintenance as well as refurbishment and renovation is performed with the aid of digital models that provide continuously updated information about its condition, status and function as well as user experiences.

Den övergripande visionen för agenda är ett hållbart samhällsbyggnad och maximal brukarnytta genom effektiv informationshantering.
What needs to be done?

Needs can be divided into three distinct priority areas

Area 1. Standards and regulations for BIM
Area 2. BIM implementation and use
Area 3. Skills provision

Facts about:

Building Information Modelling (BIM)

BIM (Building Information Modelling) can be defined as a technology that is used to create, communicate and analyse building information models. These are composed of parametric objects that represent facilities and infrastructure units as well as related adjacent spaces, structural elements and components. Digital objects incorporate data that details all the relevant characteristics necessary to perform extensive monitoring, analysis and simulation of the functions and processes of the represented building during its life cycle.

Information and communications technology (ICT)

The BIM concept is also associated with information and communications technology (ICT), with which one can create, communicate and manage information. This takes place using interoperable and intuitive interfaces with views that are tailored to specific applications and users. The information is consistent, coherent and non-redundant to ensure that changes in a specific view are represented in all its associated views.

GIS

Geographical information means information related to a specific geographical location. Systems that manage geographical information are known as geographic information systems (GIS).

A GIS is a computerized information system that supports the capture, storage, manipulation, analysis and presentation of geographical data.

OpenBIM

OpenBIM is a cross-sectoral development programme initiated in 2009. It is conducted on an association basis and funded by stakeholders who are actively involved in projects, stakeholder groups, workshops and seminars.

IQ Samhällsbyggnad

IQ Samhällsbyggnad (the Swedish Centre for Innovation and Quality in the Built Environment) is a membership organisation whose mission is to support the built-environment sector through research, innovation (R&I) and quality enhancement. The association pursues issues of value to the entire sector from a social and user perspective; consequently it operates at the intersection of business, politics and academia.
Area 1. Standards and regulations for BIM

A prerequisite for the widespread adoption of BIM is joint national and international standards and policies regarding data storage formats, terminology, requirements and characteristics, information delivery and contract types.

Problem description

Current standards for data storage formats, terminology, information delivery, regulations and contract types are insufficient or overlap, and they are completely lacking for certain stages of information delivery.

Actions

The sector needs to apply common information structures and methods to facilitate collaboration, for example when making demands or verifying during information exchange between the various stakeholders during the planning phase and in dialogues with the authorities. A development project initiated by OpenBIM and financed by Svenska Byggbranschens Utvecklingsfond (Development Fund of the Swedish Construction Industry) was conducted in parallel with this agenda with the aim of identifying standardization requirements for BIM, during which actions were proposed in the form of concrete projects.

Action requirements in brief, standards and regulations for BIM

Develop requirements definitions and verification of information delivery, as well as contract types for digital deliveries

The basis for an information exchange is that agreement has been reached both as regards the information that is to be supplied in each situation and the legal status of the information itself.

Comprehensive concept terminology for information

To enable deliveries to be filled with unequivocal data, a common concept terminology and common definitions of object classes are required. This applies at all levels of complexity, for example for concepts such as railway, building, door and fan.

Uniform definitions of object characteristics

Uniform definitions are needed to aid in defining requirements and verifying objects and characteristics. These make the models more versatile and sure that they underpin the life cycle perspective, e.g. safety, environmental, aesthetic and energy requirements etc.

Practical data management

To define and clarify the application interface and ensure the same common format for managing input and output in the systems.

Find ways of connecting BIM and GIS

GIS is primarily applied during the concept phase, research stage and during facility management, whereas BIM is mostly applied during the design and operational phases. The development of standards for formats and encoding must be co-ordinated between the systems.
Area 2. BIM implementation and use

BIM has the potential to regenerate the operation and management of facilities in respect of information concerning condition, status, and function for the benefit of life cycle-based and optimized resource management. This also provides enhanced opportunities to fulfill tenant and user needs and requirements.

Problem description

Information management in facilities management processes involves entirely different prerequisites to information management in project processes due to the time perspective. A project process can last several years, whereas the time perspective of long-term facilities management can span 100 years or more, during which time numerous changes in platform, format, standard and method will have been implemented. In other words, a balance must be achieved for facilities management information between technological level, flexibility, sustainability, requirements during the project process as well as costs in comparison to benefits. An adjustment will also require significant changes in procurement methods, methods of organization and contract types, which will impact on every stakeholder in the value chain. The changes also mean that some roles will be strengthened and new roles added, while others will be undermined or even disappear, threats and opportunities from which new business models will emerge.

Actions

The potential of BIM lies in the process adjustments and can be found in all stages: the early stages (planning and approval), in design and construction as well as in the operational and facilities management phases. The focus of this agenda is on applications in the early stages, the facilities management phase and on change management and implementation.

Action requirements in brief, BIM implementation and use processer

Process renewal

Digital planning and approval processes. A prerequisite for establishing and maintaining sustainability in the built environment is that information is of the right quality and accessible over time. This concerns information regarding current conditions in the existing built environment and its adjacent surroundings, the plans and planning processes of society, laws, norms and regulations, and the demands otherwise imposed on the physical environment. It also regards information about future facilities.

When information is organized into object-oriented and three-dimensional models with associated characteristics, existing plans and prerequisites can easily be carried forward to the next stage, which ensures lower costs for construction and real estate development. This can take place using development projects that harmonize digital planning and approval processes tailored to BIM, digitize laws, norms and regulations that can be applied in a BIM environment, and develop demo platforms for planning which the public can view.

Simulation and optimization of industrial concepts.

Project concerning how configured facilities and installations can be simulated, optimized and certified from an ecological, economic and social perspective.

BIM in project-based processes. BIM also enables the storage, co-ordination and refinement of information from a life cycle perspective, which requires stakeholders to deliver with a focus on the entire process and life cycle perspective, but also that the processes, roles and value chains are revised and renewed.
BIM for facilities management processes

Information management in facilities management processes involves entirely different prerequisites to information management in project processes due to the time perspective. For this reason, models of existing facilities and structures based on scanned data are also required. Using intelligent facilities in BIM, ongoing information relating to the condition of facilities can support facilities management activities and optimize operations, e.g. energy consumption, air quality and lighting. It is also possible to embed sensors in facilities to enable the continuous monitoring of functional conditions for control, management and analysis of operational situations.

Implementation, interaction and leadership

The unique aspect of BIM and GIS is that benefits can be created using the same system both for the small details and for the big picture in a way that was previously impossible. The ability to support and benefit individual users directly can be combined with support and benefits for complex entities in the same system, which is more or less revolutionary. This constitutes an area for new concepts and innovation, one which facilitates new value chains, roles, business transactions and business models. It also allows a wide scope for innovation once the change process has been initiated.

BIM innovation and implementation processes. There is a need for behavioral research and the compilation of research and implementation project results, as well as support for implementation. New collaborative models, incentives and contracts are also required. Furthermore, it is important to measure the impact of new BIM processes continuously in order to guide development.
Area 3. Skills provision

Skills provision is essential if the appropriate knowledge and skills are to be supplied to the market to enable the potential of BIM, and consequently underpin conditions for sustainable growth and enhanced competitiveness in Swedish industry. There is an ongoing shortage of skills in many professional fields as a result of age structures, among other factors, and this is especially true in operations and facilities management. Hence ICT BIM represents an opportunity to facilitate the recruitment of young people to these professions.

Problem description

Traditional processes currently dominate in the early stages, in the design, construction and facilities management phases. New tools and methods are experiencing setbacks during implementation, partly because activities are project-oriented and often separated business-wise into a design phase and a construction phase. Operations and facilities management are performed with insufficient incentives to achieve sustainable goals from a life cycle perspective. This is preserving traditional forms of procurement and contracting.

ICT BIM represents substantial opportunities for a shift towards greater sustainability, maximum customer benefits, and resource and cost savings. This will require significant changes in procurement methods, methods of organization and contract types, which will impact on every stakeholder in the value chain. Adjustments also mean that some roles will be strengthened and new roles added, while others will be undermined or even disappear, threats and opportunities from which new business models will emerge. Opportunities to manage this development are linked to change willingness, attractive incentives, stated objectives and decisive leadership. Increased knowledge in change and implementation processes in addition to new forms of collaboration is another critical factor in achieving successful BIM deployment.

Actions

A prerequisite for developing new approaches and processes using BIM, both in design and construction and in facilities management, is the presence of extensive individual knowledge and skills in all parts of the sector. Shared knowledge is required concerning the nature of BIM, how BIM is currently applied and how BIM can be developed and utilized going forward. Furthermore, different types of detailed knowledge are required for different stakeholder roles in the sector.

This will require actions such as:

- **Basic training**, for example an introductory course in BIM that can be included in related training courses in every university college and university in the country.
- **Further training courses** at university colleges/universities.
- **BIM in research and innovation**, for example the establishment of a shared center of excellence divided between several educational institutions.
- **Targeted actions** towards facility-managing organizations.
What happens now?

On 30 April 2013, the ICT BIM for Sustainability in the Built Environment Agenda was submitted to VINNOVA. The SRA will form the basis of an application to VINNOVA to conduct a strategic innovation programme in which proposed actions can be implemented. IQ Samhällsbyggnad intends to apply to participate in a joint programme scheduled to start in autumn 2013 in collaboration with the agendas for Industriella processer (Luleå University of Technology) and Position Sverige (National Land Survey of Sweden). Work on the application began in spring 2013.

About work with the SRA

This SRA was developed on the initiative of IQ Samhällsbyggnad, OpenBIM and Bygginnovationen. The work involved interaction with a large number of IQ Samhällsbyggnad and OpenBIM member organizations via a project group supported by a reference group and a steering committee. During the work, collaboration was solicited with a large number of stakeholders from within and outside the built-environment sector to enable a broad perspective on innovation opportunities and to identify mutual areas of interest. It was also carried out in close collaboration with other agendas, for example the agenda for Industriella processer (Industrial Processes) and the agenda for Renovering av flerbostadshus (Renovation of Apartment Buildings).

The first step was the preparation of a current status report on this issue. In order to identify and define deficiencies in standards for concept terminology, processes and formats, both on a national and international scale, a special development project was conducted, funded by sector organizations and the SBUF (Development Fund of the Swedish Construction Industry). The final conclusions drawn from this project form the basis of the agenda’s proposed actions in the area of standardization. A workshop attended by forty selected experts was also conducted as well as a broad establishment seminar involving approximately 80 participants. During the final phase of the work, the agenda was submitted for referral to IQ Samhällsbyggnad’s committee and has been available at IQ Samhällsbyggnad’s website with a commenting facility. Finally, the SRA was presented at OpenBIM’s conference in April 2013. It can be downloaded in its entirety at www.iqs.se.