European Commission

European Construction Sector Observatory

Policy fact sheet

Sweden

Build 4.0 (Bygg 4.0)

Thematic objectives 2, 3, 4 & 5

January 2021

In a nutshell

Implementing body	Sveriges Allmännytta (Public Housing Sweden) – formerly SABO (Swedish Association of Public Housing Companies) – Veidekke, Cementa, Örebro Bostäder, TechniaTranscat & Maestro Design & Management
Key features & objectives	Build 4.0 aimed to design a completely digital construction process for residential buildings. The focus was on the reducing costs and environmental impact, and increasing building quality.
Implementation date	2017 – 2020 (funding ran out in 2020)
Targeted beneficiaries	Home buyers, tenants, municipalities, housing authorities, developers.
Targeted sub-sectors	Residential
Budget (EUR)	Approx. 120,000[1]
Good practice	★★★☆☆
Transferability	★★★☆☆

More than 80% of Swedish municipalities are facing a housing shortage[2]. The construction of new public housing has not kept pace with the housing needs of a growing population. Lack of capacity is leading to long waiting times. High construction costs[3] (land, workers and materials) and inefficiencies in the sector are major contributory factors.

The use of advanced digital construction systems, tools and factory production technologies in the construction sector is on the rise[4]. Their use opens up new horizons, enabling the sector to achieve important efficiencies and quality improvements. However, knowledge about these systems and technologies and their potential benefits is not evenly distributed throughout the sector[5].

Inefficiencies in building design and planning are a particular challenge for Swedish construction projects. Buildings are often far from being fully formed at the start of construction. The process is therefore only schematically planned. Beginning construction based on an incomplete design means that many decisions have to be made during the construction phase[6]. This can lead to changes late in the process causing significant time delay and with potentially huge cost implications[7].

The Build 4.0 (Bygg 4.0) initiative was launched in 2017 to develop a fully digital construction process to help resolve the inefficiency challenge. Its purpose was to transform how buildings are designed and planned. The end goals were to reduce costs and environmental impact, and increase the quality of buildings[8].

Build 4.0 identified four high-impact areas for digital transformation[9]:

- **Collaborative design and construction** in a 3D environment to improve construction process efficiency;
- **Digital prototyping and simulation** to speed up the construction lifecycle and reduce waste;
- **Digital tools and automation** in manufacturing and on construction sites to improve productivity;
- **Internet of Things**: connecting systems and sharing data to provide smarter and cheaper buildings[10].

Build 4.0 researched tools and working methods used other industries. Those used in the shipbuilding industry were identified as the most suitable for construction. They formed the basis for the Build 4.0 digital process and platform[11].

Build 4.0 has only achieved moderate success, to date, largely because of limited funding and industry involvement to ensure validation and market acceptance.

1.

General description

Build 4.0[12] (Bygg 4.0) was launched in 2017. It aimed to digitally transform the planning and design phases of the construction process and to introduce new and more collaborative ways of working.

Build 4.0 was set four principal end-goals[13]:

- **Reduce construction costs by 50%;**
- **Reduce the environmental impact of the construction process[14];**
- **Increase the quality of buildings;**
- **Enable more innovative methods.**

To achieve those goals, Build 4.0 established four main areas of focus[15]:

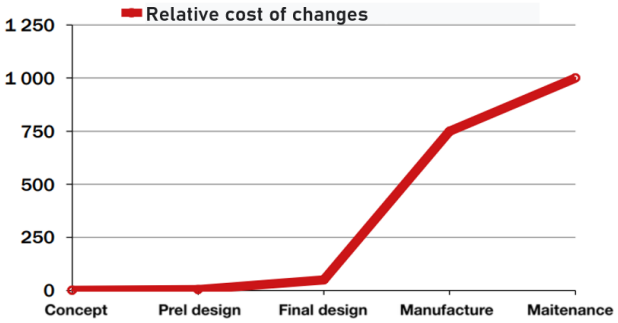
- **A collaborative, integrated design process spanning architecture, estimating, engineering and planning;**
- **Digital prototyping and simulations of the construction process to improve planning, design and process control;**
- **Digital automation of production and installation (materials / parts / equipment);**
- **Use of digital systems (Internet of Things, IoT) to increase flexibility and control.**

Build 4.0 was implemented by a consortium of partners which included Sveriges Allmännytta (Public Housing Sweden) – formerly SABO (Swedish Association of Public Housing Companies) – Veidekke, Cementa, Örebro Bostäder, TechniaTranscat & Maestro Design & Management. Their work was supported by Smart Built Environment, the Swedish Research Council Formas and the Swedish National Board of Housing, Building and Planning.

The measure focused on reducing the amount of waste materials sent to landfill and reducing the construction time cycle. Both challenges are the result of the way the industry is organised. The construction sector is very fragmented and highly manual. That means that costly changes and decisions can occur late in the implementation process.

Figure 1 shows the relative cost of changes when made at different stages of the construction process. In the early concept and preliminary design phases, the cost of changing sketches and drawings is minimal. When the design is finalised, the cost of change increases slightly; however, once production begins, the cost of change rises dramatically[16].

Figure 1: Relative cost of change during the construction process



Source: Build 4.0 / Bygg 4.0[17]

In other manufacturing industries, production planning and design is done in detail before production begins. That means that materials are ordered on time, delays in production are minimised and product quality is increased. In these industries, product design changes are minimised during the manufacturing process[18].

Build 4.0 looked at what the construction industry could learn from other industries. The shipbuilding industry, and the construction of cruise ships in particular, presented clear similarities with the construction of buildings. Both are characterised by single projects to construct complex objects and both produce residential spaces, albeit for holiday purposes in the case of cruise ships. There is also some similarity in the use of piping, HVAC (heating, ventilation and air conditioning) and electrical systems in both industries[19].

Build 4.0 aimed to develop a digital construction process to enable decisions on building design, components, systems and planning to be agreed and completed during the pre-construction phases. The new process was required to adhere to the following principles:

- Completion of all design and calculation before construction begins;
- All involved parties must participate and collaborate in the pre-construction phases to ensure the delivery of a high-quality building;
- An iterative process must be used to incorporate all viewpoints, ideas and solutions in project design and planning.

Today, there are proven systems that effectively support this work in other manufacturing industries.

Traditional project planning in construction is divided into phases. In each phase, the varied roles involved produce a set of documents[20]:

- Programme document;
- Schematic design;
- Detailed design and structural engineering;
- Construction document;
- Production document.

These documents are often incomplete, with information lacking on what to build, how to build and what should be included. In these instances, specific solutions must be devised during the construction process. Delays, low productivity and lower quality buildings are often the result[21].

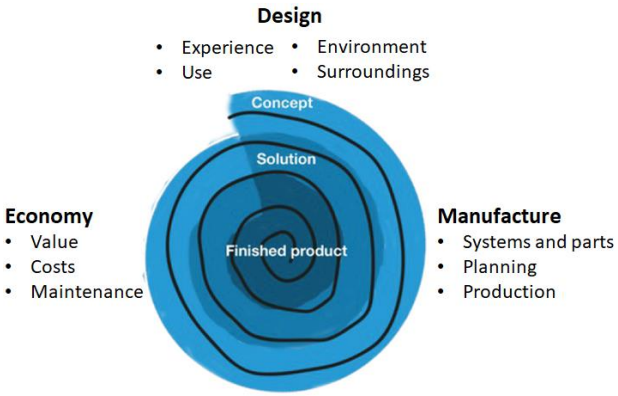
Build 4.0 proposed a building planning process in which planning documents are not independent of each other. On the contrary, with Build 4.0, these documents would be linked to each other and managed in a common database, which would also include cost projections and production planning.

An iterative and digitally supported process would enable decisions to be made at the most suitable time and would allow stakeholders to study, manage and benefit from the results achieved[22].

Build 4.0 stipulated that an iterative process, as shown in Figure 2, would also help to improve stakeholder learning and understanding. In addition, the cost of testing solutions and ideas would be much lower in the pre-construction phases.

Build 4.0 describes an iterative design as *"developing, adjusting and refining a building in order to maximise its value in relation to experience, use, economy, environment and surroundings, in an exploratory learning process, until a satisfactory design and production process has been achieved — before the start of production"*[23].

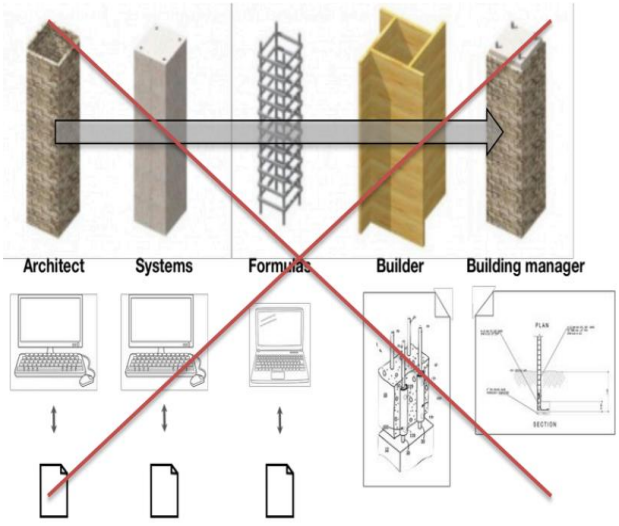
Figure 2: Iterative design process



Source: Build 4.0 / Bygg 4.0[24]

Figure 3 provides an illustration of a typical IT platform used in construction. It features different software programmes, multiple file formats, a low level of integration and the need to export and import files from one tool to another. This type of platform supports a sequential and unidirectional workflow, making collaboration and iteration difficult.

Figure 3: Typical IT platform in construction

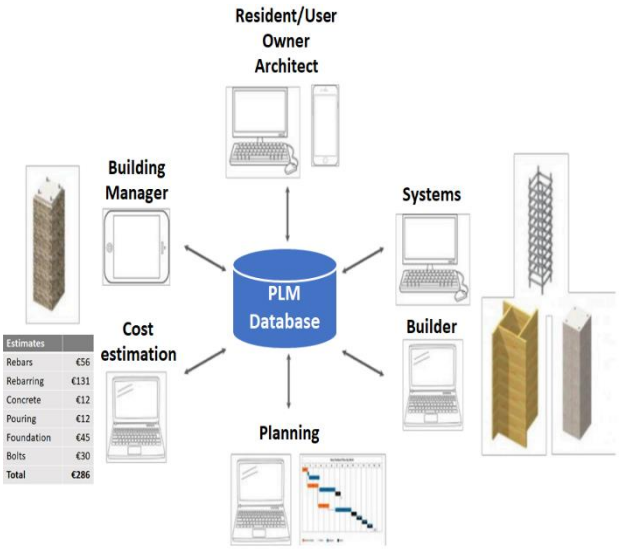


Source: Build 4.0 / Bygg 4.0[25]

The Build 4.0 digital platform proposal is illustrated in Figure 4.

Build 4.0 aimed to support iteration and empower collaboration by implementing a digital platform environment in which a range of tools are able to work in real time, using a common database[26].

Figure 4: Build 4.0 digital platform model



Source: Build 4.0 / Bygg 4.0[27]

The key objectives that the new digital platform was required to deliver include:

- Dramatic reductions in time, work and costs by avoiding the need for late changes;
- Reduced risk of error with improved document version management (common database);
- Common database that can be accessed and updated onsite;
- Management and maintenance of a complete digital twin with all data and information in one place. This should serve as an 'as-built' document for lifecycle management.

The aim was not to develop a new digital platform, but rather to assess platforms used successfully in other industries, such as shipbuilding.

The final aim of the Build 4.0 project was to engage in practical testing and validation of the new digital system and process in real-life project conditions.

2.

Achieved or expected results

The first practical test of the Build 4.0 digital construction process was launched in the autumn of 2018. Testing was conducted as part of a live municipal construction project – the Diamanten project[28].

Diamanten was commissioned by Hyresbostäder i Falköping, a municipal housing company in the town of Falköping (Sweden). The project goal was to construct a parking garage and two eight-storey apartment buildings providing 75 apartments and retail space for commercial premises.

The project owner, Hyresbostäder, was keen to test the ability of Build 4.0 to:

- Reduce costs and improve quality;
- Ensure the design and building would be easy to manage, for example, that inspection and maintenance of heating, ventilation and sanitation facilities could be done quickly[29].

Unfortunately, the testing of Build 4.0 in the Diamanten project did not proceed as planned. The procurement of a turnkey contract that had already been carried out without the necessary requirements, made it impossible to test the application of Build 4.0. Dialogue with the design organisation also made it clear that a trial application would not be possible[30].

In spite of this setback, other activities were undertaken with **alternative partners**[31] to:

- evaluate the appropriateness of digital support platforms for Build 4.0, particularly those being used successfully in the shipbuilding industry;
- test and evaluate Build 4.0 and a preferred digital platform in real-life conditions.

Practical testing was conducted in collaboration with Size Works, a newly formed company that specialises in the manufacture of apartment buildings made of solid wood[32].

The test pilot with Size Works began with a two-day visit to the ship design company Vera Navis[33] in Lisbon (Portugal). Build 4.0 was accompanied on that visit by part of Size Works' project design team.

The purpose of the visit was to assess the feasibility of using SSI ShipConstructor software to draw and plan an eight-storey building as if it were a ship. ShipConstructor[34] is a suite of AutoCAD-based software products designed by SSI (Shipconstructor Software Inc) for engineering and construction in the shipbuilding industry.

Following the evaluation of the ShipConstructor software platform, Size Works took the decision to use the platform for building design and production planning and control. In mid-2019, the company installed the ShipConstructor platform and began trialling it to design an eight-storey apartment building[35].

The contractor experienced a number of issues early in the process which caused some delays. The issues related to the drawing of the frame of the building and the traditional design of the wood panels. Wood panel supply issues were another factor[36].

The practical test phase identified three very positive findings[37]:

- **The design of residential buildings using ShipConstructor works very well. It has demonstrated the potential to achieve significant gains in key areas, such as environmental impact, time and cost savings, and error reduction;**
- **Applying the Build 4.0 digital process, which includes the use of shipbuilding software, the residential building design process can, for example, be reduced from six months to four weeks, purchases from days to minutes, and with fewer errors;**
- **Milling machines can be controlled directly from the production model.**

The test phase also identified some **key challenges**[38]:

- Traditional design and contracting processes are an obstacle;
- The lack of central ownership of the construction process is an issue. Investments tend to be linked to individual projects, and yet a large proportion of decision-making and production takes place onsite. That can lead to unacceptable environmental consequences and costs without corresponding gains in quality;
- The transition from construction documents to a computerised production model is essential.

Following an initial test phase, however, the current status of Build 4.0 is that it remains in the proof-of-concept stage[39].

As a result, Build 4.0 has not yet been able to measure the impact of the new digital process on its intended beneficiaries, such as home-buyers and tenants, municipalities, housing authorities and developers.

On a more positive note, the Lead and Project Manager at Maestro Design & Management[40] says that municipalities, housing authorities and developers have shown interest in the initiative and may adopt Build 4.0 principles and methods in future projects.

Next steps

Moving forward, Build 4.0 intends to continue developing the initiative by[41]:

- **Conducting further testing** in construction and other industry projects to validate Build 4.0 working methods and tools and build a more comprehensive set of validation use cases;
- **Developing new business and procurement models and responsibilities** to create the conditions and incentives for the roll-out of Build 4.0. This will include exploring possible quality certification options and pushing for any legislative changes that may be necessary to remove barriers to uptake;
- **Collaborating** with Svensk Byggtjänst (Swedish Building Centre and construction knowledge hub) and NordBygg – Nordic ConTech (Nordic construction industry event and innovation platform) **to support the growth of start-ups and technology in the construction industry**;
- **Disseminating** the Build 4.0 concept to international audiences to attract investment from software vendors and construction value chain stakeholders.

The key challenges for Build 4.0 in the near-term will be to secure additional funding and greater industry support.

3.

Perspectives and lessons learned

For a digital solution such as Build 4.0 to succeed and achieve impact, it must be developed, trialled and marketed at scale.

A shortage of funding is one of the reasons that Build 4.0 has not yet advanced beyond the proof-of-concept stage, according to the Renovation and Remodelling Project Manager at Sveriges Allmännytt (Public Housing Sweden), an organisation that represents the interests of public housing companies. Another reason is that many construction companies are financially constrained by low productivity, low profits and low profit margins[42].

In contrast, the Property Development Manager at Sveriges Allmännytt argues that the Swedish market is too small for the Build 4.0 initiative to succeed and that it would have a better chance of success at European level[43].

The construction industry business model needs to change.

In most areas of a construction project, especially in the early stages, compensation is based on hours worked. According to the Property Development Manager at Sveriges Allmännytt, this model is unsuitable, as it does not incentivise efficiency improvements and high skills.

A similar view is expressed by the Lead and Project Manager at Maestro Design & Management AB. He argues that the current business model provides companies with little or no economic incentives to introduce changes. This is one of the reasons why measures such as Build 4.0 have had disappointing results[44].

Fragmentation in the construction industry is a big issue.

According to the Lead and Project Manager at Maestro Design & Management, the construction industry is currently very fragmented. 20 to 30 companies are typically involved in the construction of a single building, making it very difficult to introduce new ways to build. This is not just an obstacle for Build 4.0, but for the construction industry as a whole.

Use and build upon existing software solutions.

BIM (Building Information Modelling or Building Information Management) solutions support the digital modelling or management of building data throughout the building lifecycle. However, use of BIM does not guarantee efficiency on its own. According to the Property Development Manager at Sveriges Allmännytt[45], there is a need to develop BIM strategies and methods, and all that that entails, rather than simply using the tool without a strategy.

It would be beneficial to create practical definitions that include roles and processes, to base the software on schemas for interoperable data, instead of file formats (as is common today). To be feasible, this work should be done at a European level to reduce costs and contribute to international BIM developments.

The construction industry could benefit immensely from importing ways of working from other industries.

The initiative was effective at developing a set of principles inspired by the digital tools and working methods used in the shipbuilding industry. According to the Lead and Project Manager at Maestro Design & Management, the goal is to transform working methods and improve productivity in construction with the support of existing digital tools[46].

4.

Conclusion and recommendations

Build 4.0 is an ambitious initiative that aimed to transform construction processes and ways of working in Sweden.

In terms of results, the initiative has only achieved moderate success, however, as it has not managed to achieve its end goals in the intended timeframe.

Build 4.0 aimed to develop a digital construction process supported by digital tools and capable of halving construction costs, reducing the construction footprint, and increasing building quality.

Build 4.0 has succeeded in designing the new process and has identified a suitable digital support platform. However, it has not yet managed to attract sufficient funding, partnerships or industry support to advance the new solution beyond the proof-of-concept stage.

Although the Build 4.0 test and validation phase was rather limited, it did produce a number of positive findings. Use of the ShipConstructor software platform to design residential buildings worked well. Cost savings and reduced errors and environmental impact are also possible.

Although Build 4.0 remains at the proof-of-concept stage, some stakeholders (e.g. municipalities and public housing authorities and developers) have shown an interest in applying Build 4.0 principles and methods[47].

Looking forward, two recommendations are suggested to help improve the reach and impact of future measures similar to Build 4.0:

- More test pilots should be implemented to assess and validate the Build 4.0 process in live construction projects. For the new process to be successful and gain traction in the industry, construction companies need to be convinced that it can deliver tangible results. This is an important pre-condition for the investments they will need to make to effect the necessary changes in their working practices;
- Economic incentives are necessary to encourage and help construction sector companies to introduce new work practices. Measures such as Build 4.0 have failed in the past because of insufficient economic incentives for change.

Overall, Build 4.0 is rated a '3-star good practice measure' on a scale of 1 (low) to 5 (high).

This score is based on the initiative's moderate performance when compared to its intended end goals. The Build 4.0 concept and principles are innovative. However, the initiative has faced a number of significant obstacles that have limited its ability to be fully piloted and tested in live construction projects. As a result, it remains in the proof-of-concept stage. Greater industry support and funding is needed to validate Build 4.0 as a viable construction solution.

The Build 4.0 is rated a '3-star transferable measure' on a scale of 1 (low) to 5 (high).

This score is based on a similar rationale to the score given for good practice. Build 4.0 as a whole is not readily transferable as it has not yet been fully validated by industry. However, the fact that some stakeholders have expressed interest in applying some of the principles and methods developed suggests that the new process or elements of it are potentially transferable.

Endnotes

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42 Information sourced from an interview with Jonas Högset, Property Development Manager, Sveriges Allmännytt, and Karl Törnmark, Renovation and Remodelling Project Manager, Sveriges Allmännytt on 13 January 2021.
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