

An International Environmental Scan

INNOVATIONS AND
NEW APPLICATIONS



An International Environmental Scan

Innovations and New Applications

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Med stöd från

VINNOVA
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 **Energi**myndigheten

FORMAS 

Strategiska
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program

Foreword

Smart Built Environment is a strategic innovation programme that addresses the ways that the built environment sector can contribute to Sweden's journey to becoming a global pioneer in the application of the new opportunities that digitalisation offers. Smart Built Environment is one of 17 strategic innovation programmes that have received support within the framework of Strategic Innovation Areas, a joint investment by Vinnova, the Swedish Energy Agency and Formas. The purpose of the investment is to create conditions for Sweden's international competitiveness and to contribute to sustainable solutions to global societal challenges.

The built environment sector is Sweden's single largest sector and affects our entire human-made environment, but it is fragmented and comprises a huge number of stakeholders and processes. Hence transforming built environment using the power of digitalisation requires collaboration between multiple stakeholders. Smart Built Environment takes a collective approach to the opportunities that digitalisation offers and acts as a catalyst for the dissemination of new opportunities and business models.

The programme's goal is to achieve the following by 2030:

- a 40% reduction in environmental impact from a life cycle perspective for new build and renovation
- a 33% reduction in total lead times from planning to completion for new build and renovation
- a 33% reduction in total construction costs
- several new value chains and business models based on life cycle perspectives, platforms and new stakeholder constellations

The programme involves collaboration between programme parties from the business community, municipalities, authorities, trade associations and interest groups, institutes and academia, which jointly exploit the knowledge generated by the programme.

An International Environmental Scan Innovations and New Applications is one of the projects that have been implemented during the programme. It was conducted by Ann-Kristin Belkert of Actinate AB and implemented in collaboration with researchers, government organisations, municipalities, construction companies, property companies, consultants, architects, and other enterprises that contributed advice and information concerning innovations from countries other than Sweden.

The project included general environmental scanning as well as further analysis and a description of five initiatives based on interviews with organisations, companies and government ministries in Denmark, Estonia, Singapore, South Korea and the USA. This report describes selected results of the environmental scanning as well as analysis and recommendations for a continued commitment to industry-wide environmental scanning. It also includes recommendations regarding potential partnerships in Smart Built Environment's future international work.

Stockholm, 19 October 2020

Summary

The purpose of the project was to conduct an environmental scan that describes innovation initiatives in built environment digitalisation from other countries. Ann-Kristin Belkert of Actinate AB conducted the project with the help of her network of contacts. The project included general environmental scanning (see Appendix 1), interviews with five initiatives (see Appendix 2), a compilation and recommendations. Appendix 1 and 2 are currently only available in Swedish.

Below are a number of conclusions:

- The world is buzzing with talk about building digital twins, but there is considerable variation in exactly what this entails, how to update them, etc.
- AI is a buzzword that both private and public sector stakeholders claim they are working on, but the technology is still in its infancy.
- The level of digital maturity in the built environment sector is not only low in Sweden but in other countries as well. However, several countries are far more advanced than Sweden, both in terms of work processes and technical solutions.
- There are a large number of forums and projects where cities with partners in the private sector and academia share knowledge. Results could be disseminated to other stakeholders more extensively.
- There is a great deal of inspiration to be drawn from other parts of the world, but also a huge amount of knowledge and lessons to learn from our Nordic and Baltic neighbours as well as the rest of Europe.
- It is an inspiration to observe the agile and innovative approach that the Ministry of Economic Affairs and Communications in Estonia has adopted to drive the work of built environment digitalisation forward, with one hand outstretched to the private sector.
- An increasing number of services are open source and free of charge. Platforms are being created that connect public and private clouds and services.

Actinate recommends that the commitment to digital, open and industry-wide environmental scanning of sustainable built environment be continued. Development, management and maintenance should take place in collaboration between private and public stakeholders, civil society and citizens. Smart Built Environment should initiate this development.

Furthermore, it is recommended that Smart Built Environment should act as national co-ordinator and disseminator of knowledge in regard to the development of digital twinning, which could begin with a strategic project.

Parts of this report should be translated and supplemented with Swedish examples. Collaboration with a number of key organisations is recommended as part of the internationalisation strategy. In an international collaboration, the possibility of creating some kind of “arena for arenas”, i.e. a hub for arenas located in different parts of the world, could also be discussed.

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Project

Project description

The project involves international environmental scanning that describes innovation initiatives in built environment digitalisation in countries other than Sweden. The results encompass initiatives, investments, approaches, forms, systems and tools in other countries that have contributed to and enabled innovative solutions for more efficient and sustainable built environment process with digitalisation or industrialisation as a driver. They include examples from the early stages of planning to operation, management and maintenance.

Background

Innovations and new applications is one of four thematic areas within Smart Built Environment. It focuses on promoting good ideas that have a clear application and that can be implemented in the foreseeable future in order to generate value in an organisation or process. This project is the first of several strategic investments in this thematic area during programme period two.

Smart Built Environment aims to promote and advance innovation by creating environments and conditions that enable different stakeholders to meet and challenge each other through new ideas. For example, during the first programme period, an ideation workshop was conducted to promote an innovative climate, and test beds were used to bridge the gap between project results and operational applications.

The background of the project is that the built environment sector from an international perspective has the potential to become significantly better at innovation and digitalisation. Digitalisation is an engine of change in many industries and sectors, but this has not yet taken place to the same extent in built environment.

Purpose

The purpose of the project is to conduct international environmental scanning that describes innovation initiatives in built environment digitalisation from other countries in order to support Smart Built Environment's continued national and international strategy. The project also aims to provide guidance and inspiration to the sector's stakeholders, both public stakeholders such as municipalities and authorities, and stakeholders in the business community and academia.

The project aims to draw inspiration and ideas from how others have worked to increase the degree of innovation, but also to identify potential synergies and future collaborations. As Smart Built Environment employs a strategy of internationalisation, this project can contribute valuable insights into possible future partnerships. The results will be useful in terms of determining the programme's future focus and for the industry as a whole. Smart Built Environment intends to use the scan to learn from what others have done and draw inspiration from their strategic efforts to promote innovation in the sector.

Goals

The ultimate goals are to reduce the environmental impact of new build and renovation, to reduce lead times and costs from the planning stage to the finished project, to reduce construction costs, and to create new business logic.

The project goal was to conduct and document an environmental scan of initiatives, investments, approaches, forms, systems and tools in other countries that have contributed to and enabled innovative solutions for a more efficient and sustainable built environment process with digitalisation or industrialisation as a driver.

Boundaries

The general environmental scan is certainly not a comprehensive inventory and description of every project, model, etc. around the world. Nor does it include descriptions of how every scanned country works with digitalisation in the human-made environment from a general level down to project level. It highlights a selection of different initiatives, both large and small, from different parts of the world. Many more results from the scanned cities and countries, as well as from other countries, have not been included in the report. The project boundaries prevented the inclusion of scan results for every aspect of AI, VR, AR, IoT and BIM, etc. However, it encompasses examples from different built environment stages, i.e. from initial planning to implementation, management and maintenance, and there are of course other examples from different stages.

Project organisation

Ann-Kristin Belkert of Actinate AB conducted the project, with the help of her network of national and international contacts, which comprise universities, colleges, research institutes, organisations, consultants, architects, construction stakeholders, property companies, municipalities, government agencies and ministries. A total of 550 individuals were contacted, including:

- All project managers who have conducted or are conducting projects at Smart Built Environment
- Swedish embassies with innovation and research councils
- The World Green Building Council and Green Building Councils in other countries
- Universities, colleges, institutes and innovation offices in Umeå, Karlstad, Örebro, Gävle, Uppsala, Stockholm, Linköping, Gothenburg, Lund and Malmö
- National and international organisations
- Property companies and construction companies
- Consultants and architects
- Municipalities
- Government organisations

Implementation

The project was implemented in three steps:

- Step 1 General environmental scanning
- Step 2 Further analysis and description
- Step 3 Compilation

Step 1 General environmental scanning

The project began with a general environmental scan and a description of various initiatives and approaches. Scanning was carried out by means of online research and via contacts with national and international channels of information.

The environmental scan sought to identify examples of:

- Projects in which digital innovation has streamlined processes and/or resulted in more sustainability during development
- How information is created and stored to ensure usability as well as flow through all process phases and the end product
- How gaps between stakeholders and processes can be plugged to ensure that all stakeholders have access to relevant information, duplication of work is avoided, and processing times are minimised
- Forms, work methods, business models and models for collaboration and/or new partnerships that have created more efficient and/or more sustainable processes
- New organisational forms for construction projects and built environment in which digitalisation is used as an aid
- How to focus on behavioural and cultural changes to achieve a better understanding of the opportunities and benefits of digitalisation in the construction industry
- Innovative start-ups with a description of the service/product that the companies deliver

Examples have been sought for different stages in the built environment process – but not limited to the traditional process;

- Ideation and planning
- Project planning
- Production
- Operation, management and maintenance

Step 2 Further analysis and description

A selection of initiatives (5) was chosen as particularly worthy of further understanding. The selection was approved by the process manager for Innovations and New Applications and the programme management group, after which the work of further analysing and describing these initiatives began.

Stakeholders who had been involved in the initiatives were interviewed to learn how they proceeded, what work and collaboration methods they had employed, how innovation had occurred and what role digitalisation or industrialisation had played.

Suggestions for interview questions were drawn up and approved by the process manager and the programme management group, after which interviews were booked and held with representatives from the selected initiatives. The interviews were held on Zoom, which provided good prerequisites for dialogue and is an efficient way of documenting interviews compared to holding them on the phone.

Step 3 Compilation

Finally, the general environmental scan and further analysis was compiled in this report. Recommendations were made regarding how the results of the environmental scanning could be used in Smart Built Environment and how it could provide a basis for the internationalisation strategy.

The structure of the report is an initial description of the project and its implementation, followed by a presentation of the results of the environmental scanning and further analysis. Finally, discussion points are raised and conclusions are drawn, after which recommendations are made.

The report includes a summary with a presentation of the primary results, discussion, conclusions and recommendations. Additional, more detailed information with results from the general environmental scan and interviews can be found in two appendices (only available in Swedish).

The report and its appendices have been designed in a way that enables companies, public stakeholders, civil society, organisations and academia to obtain an overall picture relatively quickly and skim through to the information that is most relevant to them. Appendix 1 and the results of the general environmental scan include short descriptions of a large number of different initiatives, projects, processes, etc. with links to more information. These references have been intentionally added in the text as links to websites, reports, etc. (not as footnotes).

This is not a scientific report, but the results of a general environmental scan whose scope, boundaries and methods have been developed in dialogue with the programme management group of Smart Built Environment.

Results

General environmental scanning

The results of the general environmental scanning can be found in Appendix 1. Results of global initiatives and projects are presented first, then results from individual countries, starting with the Nordic and Baltic countries then countries in Europe, Asia, Oceania, and North and South America. Appendix 1 also contains links to additional information. Below is a general description of results with selected examples.

Global initiatives and projects

There are a large number of different conferences and initiatives that focus on knowledge sharing and collaboration between different countries and stakeholders; Futurebuilt, Carbon Smart Building, SynchroniCity, the Climate Positive Design Challenge, the Smart Cities Hub, Securing Smart Cities, JPI Urban Europe, URBACT, the 100 Intelligent Cities Challenge, the EU BIM Task Group and the EU Smart Cities Information System, to name but a few.



A great deal of inspiration and concrete results can be drawn from the Smart Cities and Communities lighthouse projects, which are funded by the EU via the Horizon 2020 research and innovation programme. The purpose is to bring cities, the business community and citizens together in order to demonstrate solutions and business models that can be scaled up and replicated, and which lead to quantifiable benefits in terms of energy efficiency and resource efficiency, new markets and new jobs. A total of 17 lighthouse projects have been funded, including 46 lighthouse cities and 70 fellow cities. Appendix 1 contains links to all the projects and a number of results are presented from different countries. The City of Stockholm participated in GrowSmarter, Umeå Municipality in RUGGEDISED and the City of Gothenburg in IRIS.

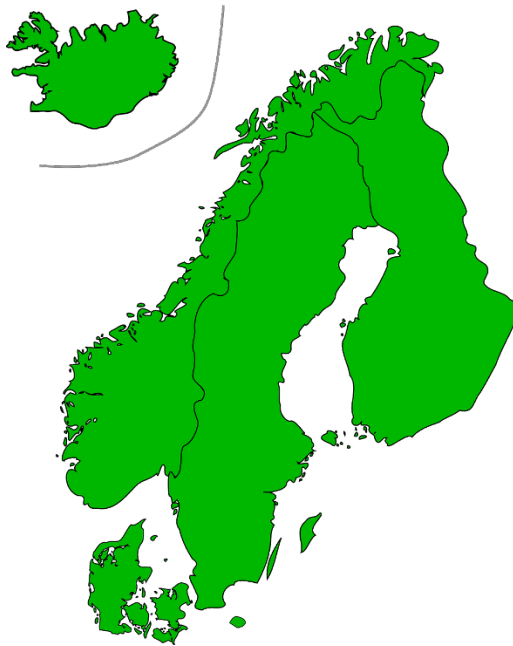
The World Summit on Digital Built Environment, WDBE 2020, was held on 29-30 September, 2020. The organisers were KIRAHub (Finland), ril (Finland), the Estonian

Ministry of Economic Affairs and Communications and the Estonian Digital Construction Cluster.

The summit was planned to take place as a physical summit, in Helsinki one day and Tallinn the next, with a boat trip between the cities and social activities. However, due to the pandemic, the organisers opted for an online format and a new approach, and it was held in collaboration with game developers and experts in virtual events, with Tallinn and Helsinki as virtual host cities.

The Nordic countries

There are numerous initiatives and concrete results from our Nordic neighbours that we can draw inspiration from.



In **Norway**, municipal, regional and national organisations are collaborating to manage a national, geographical infrastructure that ensures that the whole of society has easy access to geodata via the Norway Digital initiative. All municipalities and regions as well as many government agencies are currently involved. Geonorge is the national website for cartographic data and other location information in Norway.

KIRA-digi is a **Finnish** project that was implemented to create a good seedbed for a digital ecosystem for business operations in the Finnish property and construction industries. The project involves harmonising information management, drafting legislation and reforming public administration, as well as trials and pilot projects. Appendix 1 briefly describes 98 of these projects with links to further information.

In **Denmark**, a strategy for digital construction was launched in January 2019. For example, digital best practice will be mediated and better guidance will be given to construction stakeholders concerning the use of digital tools. The strategy will also

clarify the legal framework for digital construction, develop and test new collaboration models, and clarify challenges when using quantity-based tenders. ConTech is another Danish initiative, whose aim is to increase the construction industry's productivity and sustainability through the use of technology in all areas of construction.

BLOXHUB is a **Nordic** hub for sustainable urban development that helps its members find partners, share knowledge and create business opportunities. BLOXHUB is headquartered in Copenhagen and collaborates both nationally and internationally. See the interview with Torben Klitgard, the CEO of BLOXHUB, in Appendix 2.

The Baltic nations

Estonia lies at the leading edge of digitalisation due to its unique public-private partnerships. The Ministry of Economic Affairs and Communications maintains a close dialogue and close collaboration with private stakeholders via the Estonian Digital Construction Cluster (EDCC). The cluster was established to enable the joint development of future digital solutions that make the construction process more efficient, more transparent, faster, more manageable and ultimately cheaper.



The Estonian e-construction platform will be launched this year. The platform will bring public services together, but it is also an open platform that enables private services and databases to connect. Estonia is also building a digital twin of all domestic built environment in the system. In Appendix 2, you can read more about the initiatives in Estonia in the interview with Jaan Saar, Head of Digital Construction at the Estonian Ministry of Economic Affairs and Communications, and Indrek Vimberg, Cluster Manager at EDCC.

The Association for Construction Industry Digitalisation in **Latvia** is an organisation that introduces new digital processes and technologies to the construction sector and trains it to use them, thereby streamlining the work. It also develops and implements

tools such as BIM, improves KPIs, influences legislation, and promotes sustainability, etc.

In **Lithuania**, The Ministry of Environment and partners are conducting the “Creation of measures to increase the efficiency of the life cycle processes of public sector construction works using Building Information Modeling (BIM)” project. The Ministry is also developing a strategy for implementing BIM at state level and has launched a website for all the initiatives related to construction sector digitalisation in Lithuania. This year, the government passed a law that requires applications to design and construct public buildings with special requirements to include BIM methods from 1 January 2021. Addenda to laws have been approved that enable customers to set requirements or criteria when procuring.

Other European countries

There are numerous interesting ventures in **the UK** such as the Construction Innovation Hub, the Industrial Strategy Challenge Fund, the UK BIM Framework and the UK BIM Alliance. The British government has also developed Digital Built Britain, which is a programme for creating a digital, integrated approach to built environment. The programme has been designed to transform how professionals in the British construction and facility management industries view social and economic infrastructure through digital technology. It includes how they plan, build, maintain and use infrastructure as well as the reconstruction, restoration and new build of built assets.



The Centre for Digital Built Britain (CDBB) is the home of the UK BIM and Digital Built Britain Programmes. The CDBB organises working groups and arranges the National Digital Twin programme (NDTp), whose goal is to enable a national digital twin and bring the business community, academia and government on board. DTHub has been

created by CDBB, which is a forum for owners and suppliers of digital twins as well as for experts in information management.

Bristol, which operates a team dedicated to developing its “smart city strategy”, is frequently cited as one of the UK’s smartest cities. They also believe that smart city initiatives that include or are led by the citizens themselves attract more support, and are more successful and sustainable as a result. The team, known as the City Innovation Team, is part of the City Council and consists of internal innovation advisors with expertise in, for example, smart technologies, data, social factors and user-friendly design, design thinking, future thinking, social innovation and civic engagement. The team collaborates within the City Council as well as externally across the city to support innovation, meet challenges and implement smart city solutions.

Smart Dublin, founded by the City of Dublin in **Ireland**, brings technology providers, academia and citizens together to transform public services and enhance the quality of life.

The Morgenstadt: City Insights innovation network in **Germany** comprises 13 cities, 20 companies, 11 Fraunhofer institutes and 6 strategic partners. The aim of the network is to integrate cities of different sizes. Appendix 1 describes a few digitalisation projects implemented by Cologne in Germany as part the GrowSmarter project.

Amsterdam in the **Netherlands** aims to become circular by 2050, i.e. a city in which valuable materials are recycled and no waste is produced. The city engaged Kate Raworth to produce the Amsterdam City Doughnut, a model that describes how society and companies can contribute to economic development while respecting the boundaries of our planet and our society. The Amsterdam Circular 2020-2025 strategy is based on a circular processing ladder and includes the food and organic waste, consumer goods and built environment value chains. Amsterdam has also developed an implementation programme to achieve the strategy’s goals. The city is also home to Smart City, an innovation platform that brings proactive citizens, innovative companies, knowledge institutes and public authorities together to design the Amsterdam of the future.

Barcelona in **Spain** is involved in over 100 smart city projects, which, inter alia, concern smart lighting, recharging infrastructure for electric vehicles, as well as Wi-Fi provision in transport systems and public environments.

Switzerland operates a national competence centre, the National Centre of Competence in Research (NCCR) Digital Fabrication. The aim of the NCCR is to revolutionise architecture by means of a seamless combination of digital technologies and physical construction processes. More than 60 researchers from six different academic disciplines are collaborating to develop cutting-edge technologies for the construction of tomorrow.

NEST in Switzerland is a building for research and innovation. It is a physical platform where companies can test-build and try out ideas for several years.

Asia

NEOM is a 25,000 km² site in Saudi Arabia that has been planned for development as a smart city. The project will reduce Saudi Arabia’s dependence on oil and will be

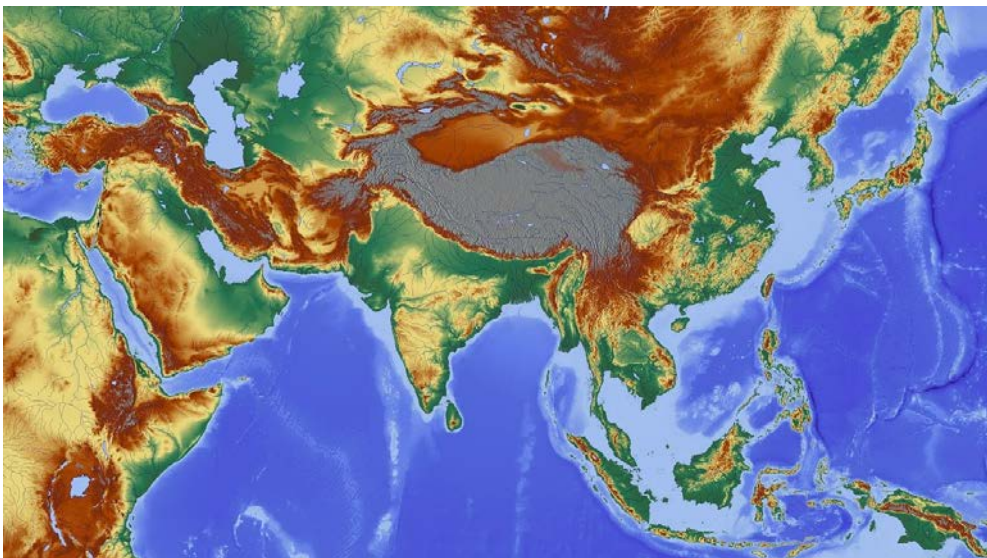
equipped with advanced renewable energy technologies. Core industries in the city will include biotechnology, food technology, advanced manufacturing, etc. Universities will focus on AI as well as VR and AR technologies. The city will be required to be carbon neutral, and passenger transportation will consist of autonomous vehicles.

Smart Cities Mission in **India** includes the development of 100 new smart cities.

A new smart city called Xiongan has been planned for construction outside Beijing in **China**. All businesses not linked to Beijing's role as a capital city will be relocated to Xiongan, which will ease Beijing's population, air pollution and congestion issues.

Hong Kong has conducted a strategic planning and technical study in regard to the use of underground spaces (similar studies have also been conducted in Singapore and Helsinki).

Singapore, where nearly all public services are available online, has ambitions of becoming the world's first "smart nation". The city-state's "Smart Nation Platform" is currently ramping up testing in a range of sectors such as health, housing and transportation. Smart Nation collects data from sensors across Singapore and a 3-D model of the city enables city planners to analyse traffic flows and test concepts, etc. Singapore lies at the forefront of autonomous vehicle testing. The town of Punggol in Singapore has been designated as a sustainable city with technology as an enabler, which is evidence of the republic's ambitions of becoming a smart nation. Singapore employs a national strategy for AI and conducts many different initiatives related to AI. In Appendix 2, you can read more about the strategy and how it is applied in interviews with Sim Kai and Lim Bryan from the National AI Office.



Woven City, situated at the base of Mount Fuji in **Japan**, is a “living laboratory” that houses residents and researchers who will test and develop technologies such as autonomy, robotics, mobility, smart homes and AI in a real-world environment. Woven City is powered with solar energy and hydrogen fuel cells.

Kashiwa-no-ha Smart City outside Tokyo in Japan has a strong focus on sustainable development and digitalisation.

Songdo in Seoul, **South Korea**, was developed as a showcase for South Korea’s commitment to sustainable growth and technological innovation.

Oceania

Smart Cities Council Australia New Zealand provides support to suppliers, cities, researchers, research institutes and start-ups. The organisation holds the secretariat of the Local Government Smart Cities Network, which is aimed at local councils in **Australia** and **New Zealand**. They also organise a think tank known as Bounce Lab that focuses on the recovery of cities from COVID-19 using digitalisation. In addition, Smart Cities Council facilitates the Digital Twin Hub, the Centre for Data Leadership and various task forces.



Building 4.0 CRC was established in 2020 as part of the Australian Government’s Cooperative Research Centre (CRC) Programme. It is intended as a catapult for the business community that will enable an efficient, connected and customer-oriented future. CRC aims to take up new opportunities across the value chain in collaboration with government, research and business organisations.

North and South America

Montreal in **Canada** was named “Intelligent Community of the Year” in 2016.

Lakeview Village in Mississauga, Canada, is a planned mixed-used development, with housing, services and an Innovation District, which will include a “Learning Centre” (a sustainability centre). One of the desired results of the project is digital innovation, for example the aim is to develop a digital twin. In Appendix 2, you can read more about this in the interview with Chungha Cha from the Re-imagining Cities Foundation in South Korea.

Quayside is an urban development project on the waterfront in Toronto, Canada, that was planned by Sidewalk Labs, a Google subsidiary. There were numerous plans to develop the area as a “smart city development” but also harsh criticism about how data would be used. The project will not be implemented due to the pandemic.

In the city of Peachtree Corners, a suburb of Atlanta, **USA**, an environment has been built for real-world testing of smart cities known as Curiosity Lab. It consists of a 25,000 m² innovation centre and a test track for autonomous vehicles in a 500-hectare technology park, where 7,500 people work and 1,000 people live.



INDUS.AI in the USA has developed construction site services that use camera surveillance and AI to reduce risk, optimise processes and improve safety. Appendix 2 includes an interview with Walter Terry at Skanska USA Building, who has used INDUS.AI services.

Mighty Buildings is a construction and technology company in Oakland, California, that builds affordable, sustainable homes using 3D printing, robotics and automation.

Terridata is a statistical database in **Colombia** which presents indicators that provide knowledge about different parts of the country. SKL International participated in the development of Terridata, using the Swedish tool Kolada for inspiration. The knowledge is used as a basis for goals and actions at local and regional level, in research and in communications with citizens.

Further analysis and description

Appendix 2 (only available in Swedish) presents documentation from five interviews that were conducted in order to provide further analysis and a description of a selection of the initiatives. Results from the interviews are described in brief below.

The following individuals were interviewed:

- Torben Klitgard, CEO, BLOXHUB, Denmark.
- Jaan Saar, Head of Digital Construction, Estonian Ministry of Economic Affairs and Communications, Estonia
- Indrek Vimberg, Cluster Manager, Estonian Digital Construction Cluster, Estonia
- Sim Kai och Lim Bryan, National AI Office, Singapore
- Walter Terry, Vice President, Project Planning, Skanska USA Building, San Francisco, USA
- Chungcha Cha, Co-Founder & Chair, Re-imagining Cities Foundation, South Korea

Selection took place in consultation with the programme management group for Smart Built Environment and the process manager for the Innovations and New Applications thematic area. The five interviews were selected with the aim of:

- Addressing a wide range of issues from the entire built environment process
- Interviewing stakeholders involved in initiatives with a connection to Smart Built Environment's goals
- Ensuring a mixture of private and public initiatives
- Creating a geographical spread of examples

Torben Klitgard

The interview with Torben Klitgard provided more insight into how BLOXHUB was founded and funded, how the hub operates and what impacts it has.

BLOXHUB is a non-profit organisation founded in 2016 by:

- The philanthropic organisation Realdania
- The Danish Ministry of Industry, Business and Financial Affairs
- Copenhagen Municipality

The purpose of the organisation is to contribute to creating new solutions that will ensure sustainable urban development. The founders were looking to create a physical place – a building – in the centre of Copenhagen that could function as a meeting place for private and public stakeholders, large and small enterprises, research, etc., preferably in transversal combinations. BLOXHUB is founded on the belief that success in solving large, complex problems requires the support of a large group of people from different professions. BLOXHUB is committed to enabling sustainable urban development. Its focus is on urban development, construction, design and architecture – the entire field related to urban built environment.

BLOXHUB is housed in a building called [BLOX](#), which also houses the Danish Design Center and the Danish Architecture Center. This creates a concentration of enterprises engaged in architecture, design and urban development that can grow stronger together, for example activities can be matched, similar products exhibited, etc.

BLOXHUB has three pillars:

- **SPACE:** A co-working office environment, which currently comprises 9,000 m², housing 120 enterprises and about 700 employees.
- **COMMUNITY:** A community of enterprises (currently about 350). What unites these enterprises is their interest in sustainable urban development.
- **PARTNERSHIP:** Matchmaking at different levels – from short collaborations to more far-reaching innovation programmes in which different enterprises are connected together.

Realdania pays BLOXHUB an annual operating grant that corresponds to about 50 percent of BLOXHUB's turnover, which also has both a project funding and a commercial revenue source. It employs 25 employees, 15 of whom work with matchmaking. Letting out work spaces in the co-working part of BLOXHUB is the commercial element.

The community is essentially an ecosystem with a large number of stakeholders that possess different areas of expertise and that operate in the field of urbanisation; technology, human science, analysis, construction, architecture, engineering, etc. Urban development is an interdisciplinary field, which BLOXHUB needs to reflect.

Torben usually describes BLOXHUB as an airport where businesses looking to fly out into the world or land in Denmark and the Nordics can receive help. The impacts of BLOXHUB's programmes include increased business potential, a better capacity for innovation, and a network effect for the members. Likewise, collaboration between researchers is enabled, and research results are disseminated to the members.

Jaan Saar and Indrek Vimberg

The interview with Jaan Saar and Indrek Vimberg provided an understanding of how public-private partnerships take place, how progressive, agile and innovative government organisations in Estonia are, and what an important role the EDCC cluster has played in encouraging involvement and developing expertise in the private sector.

The Estonian Ministry of Economic Affairs and Communications is responsible for building regulations and laws related to built environment. It also manages a centralised information system known as the Building Registry, where all planning permits are managed and which provides a unique opportunity. The system is currently being redesigned to improve user-friendliness and several new services will be added (including a digital planning process). The system, which will be known as the E-construction Platform, will be an open platform that allows users to connect to private services. The Ministry is also constructing a dynamic digital twin of all built environment in Estonia in the system.

E-residency enables users to manage their companies or property remotely with identification (including people from other countries), which is legally binding.

Every year, a hackathon is held that acts as a seedbed for start-ups and enables them to grow. The EDCC has seen an increasing number of startups joining its clusters, where Jaan and Indrek have experienced a start-up boom in the past 2-3 years. Due to Estonia's size, many start-ups already have the global market in mind from conception, and Estonia is developing into a test bed and a springboard for testing ideas and concepts. The start-ups are bringing about a positive cultural change, and the government is committed to encouraging and enabling them.

Public-private partnerships are certainly the key to the successful results. Jaan and several other civil servants at the Ministry have previously worked in the private sector. Indrek says that they are very enthusiastic and pragmatic, and that they have brought that approach with them to the Ministry. At the same time, they still have an extensive network in the private sector, which makes it easier to communicate and collaborate on the same wavelength. Members of the EDCC and the Ministry meet every month.

The Estonian Digital Construction Cluster ([EDCC](#)), which was formed four years ago, is a non-profit with a membership grounded in the triple helix of private, public and academia. An increasing number of start-ups are joining. The cluster has a number of working groups that hold approximately 15-20 meetings every month. The EDCC is a platform for sharing knowledge, ideas and solutions that enable members co-create innovation. It also acts as a channel to the government. In addition, the cluster creates partnership opportunities for internationalisation and exports. One goal of the EDCC is to contribute to the flow of information between different stakeholders (architects, urban planners, construction stakeholders, property owners, etc.) across the life cycle. Indrek believes that the greatest value that the cluster offers is in potential to streamline the construction sector, reduce the effect on the climate, and transform the culture of the industry.

Sim Kai och Lim Bryan

The interview with Sim Kai and Lim Bryan at the National AI Office provided insight into how important it is to design a concrete strategy. Singapore is at the forefront of built environment digitalisation, which is an inspiration.

Smart Nation is Singapore's "next-gen nation-building effort". The aim is to transform Singapore into a unique city-state that exploits all the benefits of technology to solve problems. AI is the next step in adopting intelligence in systems. The National Artificial Intelligence Strategy was developed and launched in 2019. The Singapore vision is: "By 2030, Singapore will be a leader in developing and deploying scalable impactful AI solutions in key sectors of high value and relevance to our citizens and businesses". The National AI Office is responsible for implementing the strategy.

The purpose of the National AI Strategy is to:

1. Focus attention and resources at national level on key areas
2. Describe how the government, companies and researchers can collaborate to develop the ecosystem that enables the strategy (the enabling ecosystem)
3. Address issues and risks proactively as AI implementation is ramped up

Singapore is not advancing technology for technology's sake. The strategic emphasis is on deployment and development, and research must be related to deployment. Singapore is targeting efforts at key sectors where AI can generate benefits and major impacts in order to improve people's lives or create economic value.

Singapore examined strategies from other countries and discovered that the focus was very much on ecosystem enablers, as was Singapore's strategy initially. However, the realisation came relatively quickly that it is not easy to create enablers in a vacuum. A strategy needs to be established and grounded in specific projects. Learning while doing is essential, and consequently projects were necessary to test the enablers.

The strategy is divided into two parts: National AI Projects and Ecosystem Enablers.

The five national projects are:

- Intelligent Freight Planning
- Seamless and Efficient Municipal Services
- Chronic Disease Prediction & Management
- Personalised Education through Adaptive Learning & Assessment
- Border Clearance Operation

Singapore employs five ecosystem enablers:

1. Triple helix partnership
2. AI talent and education
3. Data architecture
4. Progressive and trusted environments
5. International collaboration

Walter Terry

The interview with Walter Terry at Skanska USA Building in San Francisco provided an understanding of how digitalisation services can contribute to better safety, reduced risk, more efficient work methods, reduced costs, better resource efficiency and a smaller carbon footprint.

Walter described various services that INDUS.AI provides, many of which focus on health and safety. One service concerns ensuring compliance with social distancing rules on construction sites. There are also modules that focus on ensuring that personal protective equipment is used correctly and that alert anyone entering an unsafe “exclusion zone” on the site. Other modules concern monitoring production and operations, and predicting how long various steps will take. There is also a module that captures, records and classifies trucks entering and exiting the site and that provides a basis for optimising delivery scheduling, which can impact emissions, time and costs.

It was a challenge for the staff to understand how to use the information they received. Processes to manage this issue will be developed in future projects.

One question that was raised was about how common it is to use cameras on construction sites, regardless of whether Indus services are employed or not. In Sweden, camera surveillance is uncommon due to privacy concerns. Walter said that it was important to ensure anonymity. He was not interested in facial recognition or in knowing who the individuals are. On the other hand, he needs the information that the cameras provide. When used correctly, camera technology is essential in order to resolve aspects of productivity, scheduling, workplace procedure, and safety. In addition, using cameras enables the construction process itself to be documented.

Walter described his views on workflow optimisation. There is frequently a great deal of information in different “downpipes”. How can a continuous flow of information be achieved in work processes? How can a digital workflow be automated? Where are the bottlenecks? How can work processes be improved? How can algorithms and machine learning help?

Walter’s description of a digital workflow:

- A sequential, predictable combination of data, guidelines and tasks that make up the everyday processes of an operation
- Defining workflows digitally enables users to:
 - Look up crucial data immediately
 - Keep track of processes and tasks
 - Streamline productivity
 - Automate tasks

Chungha Cha

The interview with Chungha Cha at the Re-imagining Cities Foundation in South Korea provided inspiration about the importance of linking sustainable urban and property development with business development and the financial sector – even in concrete urban development projects.

Chungha Cha has extensive experience of working in the financial and property sectors, smart buildings and cities. He believes that public stakeholders do not have enough money to address the challenges; hence private capital is also needed. Without private funds, changes will not take place quickly enough.

Chungha Cha is the Smart City Advisor to the Lakeview Village urban development project in Mississauga, Canada, which is a planned mixed-used development, with 8,000 apartments, services and an Innovation District. The Innovation District will include a “Learning Centre” (a sustainability centre). Most of the land has been purchased by private developers.

The Re-imagining Cities Foundation has reviewed how goals for the town, residents and construction stakeholders can converge. Desired results have been established as regards employment, digital innovation, climate-positive zones and smart mobility, as well as health and well-being. A Japanese quadruple helix model will be applied for governance. When discussing smart cities, people frequently bring up technology, but Chungha Cha believes that it is important to focus on the desired results first. Only then should the structure and technology that will facilitate these desired results be discussed. After that, the exact approach to establishing the ecosystem of stakeholders in the quadruple helix model, which focus areas are necessary in specific sectors and possible partners can be determined.

The Innovation District will drive economic growth, but merely managing and maintaining an office district where anyone can establish is not part of the plan. The aim is to attract companies that are linked to the goals for the mixed-use development and that possess the technologies that will allow these goals to be achieved. In other words, they also want the companies to establish their operations locally.

One of the desired results is digital innovation, for example the development of a digital twin. Many of the potential partners with which the project has had discussions are interested in digital twinning. They are looking for offices in the area and can also participate in and finance the development of the digital twin. They hope to have a first trial version ready by early next year.

Chungha Cha says that everyone talks about open data, but the reality is that not everyone wants to share all their data. In a hybrid cloud, some public and private data can be shared openly.

There are over 100 buildings in the development. The Re-imagining Cities Foundation is developing a model with energy simulation at area level. They are also developing an area dashboard that will be used for measured results regarding energy consumption, energy supply, and health and well-being (levels of air pollution, noise, etc.). The energy optimisation dashboard also includes calculations of savings in the form of money. Energy optimisation helps property owners increase their profits and it also reduces the effect on the climate.

Discussion points and conclusions

Below is a summary of conclusions based on the general environmental scan and the interviews. Discussion points and conclusions focus on the benefits that Smart Built Environment and participating stakeholders can derive from the completed environmental scan and a continued commitment.

Sweden's position in comparison to other countries

The discussion points and conclusions section primarily describes overall conclusions about insights, lessons learned and reflections about future needs. A direct comparison between Sweden and other countries was not included in the framework of this project.

Nevertheless, the following is evident:

- The world is buzzing with talk of building digital twins of buildings, city districts and cities, but there is considerable variation in exactly what this entails, how to update them, etc.
- AI is a buzzword that both private and public sector stakeholders claim they are working on, but the technology is still in its infancy. Singapore, which lies at the forefront of AI development, launched its strategy last year and has only recently begun implementation.
- The level of digital maturity in the built environment sector is not only low in Sweden but in other countries as well. However, a number of countries are far more advanced than Sweden, both in terms of work processes and technical solutions.

Collaboration (multiple helix) between and within cities

There are a large number of forums and projects in which cities with partners in the private sector and academia exchange knowledge. Some are at a general level while others are more concrete, using cities and buildings as test beds.

An abundance of results from these initiatives could be disseminated to other municipalities, private stakeholders and academia. For example, contact could be made with Horizon 2020 initiatives to enquire whether analysis and synthesis is planned and whether it can be disseminated from the Smart Cities and Communities lighthouse projects, where a total of 17 lighthouse projects have been funded, including 46 lighthouse cities and 70 fellow cities. An early step could be to invite the City of Stockholm, Umeå Municipality and the City of Gothenburg to seminars to share knowledge from the projects in which they participated.

Many clusters, projects and initiatives are conducted using multiple helix models, i.e. in collaborations between the public and private sectors, academia, civil society and citizens.

Platforms for public and private services

An increasing number of services are open source and free of charge. The general environmental scan revealed both private and public initiatives. There is also a trend of creating platforms that connect public and private clouds and services such as the ones in Estonia and Lakeview Village in Canada.

The importance of linking to the financial aspect

The interview with Chunga Cha provided insights into the importance of linking sustainable development goals with future operations when developing an area. This can also be a way of generating funds for initiatives in planning, implementation and deployment related to digitalisation and sustainability. Both public and private funds are needed in order to achieve sustainable built environment and for investments in digitalisation. Using concrete dashboards that show the potential in reducing energy consumption and the subsequent cost reductions provides private stakeholders with financial incentives that can drive sustainable development forward.

This is also a point that Jaan Saar at The Ministry of Economic Affairs and Communications in Estonia raised. The government invests in an open platform for services in built environment digitalisation, which private stakeholders can then develop further and which they can also charge for.

The interview with Walter Terry increased understanding of the potential that exists for streamlining resource usage, transport deliveries and work methods on construction sites as well as the role that digitalisation in general and AI in particular can play. It can provide major gains in terms of finance, resources and climate protection. It can also increase safety, improve health and well-being, minimise risks and improve insurance terms and conditions.

Ambitious goals and actions needed from cities

The City of Amsterdam is an inspiration in terms of the need for a high level of ambition regarding sustainable development, digitalisation, new approaches, and strategies and resources for goal implementation that maximise the chances of success. One of their three value chains is built environment, which might be worth monitoring closely going forward in addition to results from Amsterdam Smart City. Singapore, Bristol and Barcelona are other examples of leading-edge cities.

Concretising strategies and approaches

Singapore analysed the strategies of other countries and learned its own lessons from its initial sole focus on ecosystem enablers. It soon became evident that it is not easy to create enablers in a vacuum. A strategy needs to be established and grounded in specific projects. Learning while doing is essential, in other words projects were necessary to test the enablers.

The same thought occurred after the interview with Torben Klitgard at BLOXHUB, which has a very concrete approach. In the Urban Partnership Programme, members can identify challenges for which solutions must then be created in an innovative and iterative process in collaboration with other stakeholders. Their other programmes are also concrete, for example they frequently involve matching construction companies in

Denmark with tech companies in Europe. One should not network merely for the sake of networking. There needs to be a purpose.

At the ECDD in Estonia, there are several working groups that work in a concrete way with standards, BIM, new approaches, cultural transformation and communications. Working groups at the CDBB in the UK and Smart Cities Council in Australia and New Zealand have a similar approach.

Recommendations

Below are a number of recommendations regarding a continued commitment to industry-wide environmental scanning and international collaboration for Smart Built Environment.

Digital, open and industry-wide environmental scanning

During this environmental scan, approximately 550 individuals were contacted, many of whom contributed time, advice, knowledge and lessons learned. Many others replied that, unfortunately, they did not have any examples to offer or the resources to devote to environmental scanning within their organisations. However, they were very interested in learning the results, which they were also keen to disseminate.

A continued commitment is recommended in order to develop digital, open and industry-wide environmental scanning of sustainable societal development. This could be a powerful driver for sustainable built environment, with digitalisation as the crucial engine. Nor is this something that the government would need to fund itself. There would be considerable interest in participating from private stakeholders, and much could be gained from establishing a common platform for private and public stakeholders, civil society and citizens. However, this type of collaboration does not take place on its own and should be initiated by the government (one suggestion might be for Smart Built Environment to collaborate with other SIPs). This environmental scan should be viewed as a small shoot that could grow into something completely different than just another report on a website.

“Don’t cross the stream to find water”

When conducting an environmental scan like this one, it is easy to imagine that the freshest, most innovative examples can be found a long way from Sweden, and indeed much inspiration can be drawn from countries in other parts of the world. However, an enormous amount of knowledge and lessons can be learned from our neighbouring countries in the Nordic-Baltic region and from the rest of Europe.

Much of the advice that was gathered during this general environmental scan indicates that initiatives in the Nordic countries, Estonia, Europe and Singapore are the ones leading the pack. Whether this is true or due to the fact that many of our contacts were just more aware of initiatives from these areas remains to be seen. However, contacts were also made with embassies, organisations, companies and cities internationally outside Europe.

The interviewees from Estonia and Denmark provided enormous inspiration in terms of concrete approaches and collaboration models. Public and private stakeholders in Sweden have much to gain from the initiatives in these countries, above all from the progressive, agile collaborative approach that government organisations in Estonia have adopted. The same can be said about the drive and the bridge created between the public and private sectors and academia via initiatives such as BLOXHUB in Denmark and the ECDD in Estonia.

Long-term, innovative approach from the government

The innovative way in which the Ministry of Economic Affairs and Communications and other government departments and organisations in Estonia are powering the work of digitalisation with an outstretched hand to the private sector provides insight into how important it is that governments adopt a proactive approach. It is a hard task for other construction stakeholders to succeed in a concrete way without innovative thinking and long-term processes from the authorities. If, on the other hand, the government takes the lead, private stakeholders and municipalities will ramp up their levels of ambition and resources.

In all likelihood, an even more long-term solution than Smart Built Environment and other SIPs will be necessary to ensure management and maintenance, in other words a solution that is even more concrete and deep-rooted for municipalities, construction stakeholders and property companies, etc. This could consist of a platform that benefits them in their daily operations and which facilitates collaboration between the above stakeholders and consultants, architects, start-ups and academia. Alternatively, a platform like the one suggested above could also be agile and adapt to trends and developments in the rest of the world. This would enable a strategic innovation programme (Smart Built Environment) to start up the platform. Subsequent evaluation and development could take place on a regular basis and other initiatives could be connected to the platform.

Manage results and drive development forward

It is important at this stage to consider how all the results from Smart Built Environment should be managed and maintained, and to consider a continued commitment from the government, which has already invested in Smart Built Environment in the long term for up to 12 years. Many initiatives concern creating new arenas, new contacts and collaborations, and implementing projects that will generate results and impacts. A long-term platform for management, maintenance and further development that will advance sustainable societal development should be created, which could also be a base for continuous national and international scanning.

If stakeholders that are considering becoming involved know that there is a long-term platform available where their results and the results of other stakeholders could be managed, maintained and disseminated and where new knowledge and innovation could be created after government initiatives have concluded and new elections have taken place, their commitment would be reinforced. However, this is an issue that also concerns other SIPs and other built environment ventures in Sweden.

Maximise existing results

A huge number of results and lessons learned about processes and impacts are available to exploit if we are to avoid reinventing the wheel and reduce the take-off distance for the Swedish construction industry. This environmental scan only touches on a few of all the results that exist. One only has to look at all the concrete results from the Finnish KIRA-digi initiative, not to mention their understanding of the need for management, maintenance and further commitment to collaboration and knowledge sharing, which will take place via KIRIHub.

Keep a track of future results

The environmental scan identified interesting results that will shortly emerge, for example the feasibility study and continued work conducted in Denmark's ConTech initiative. Likewise, the results of the implementation of the Danish strategy for digital construction, for example to convey "digital best practice", will offer better guidance to construction stakeholders as regards digital tools and developing collaboration models. If a commitment were to be made to continuous environmental scanning, these and similar future results could be mapped and the information obtained.

Funding of hubs, clusters and other NGOs

One insight gained from the interviews is that it is important for hubs, clusters, etc. to receive financial support from the government or other external funders, which is the case with Realdania and BLOXHUB in Denmark (50% of its annual turnover). It is a hard task for non-profit organisations to run a business while simultaneously developing products and services due to the fact that they need to raise funds for both development and operations. We can also learn the same lesson from Swedish non-profits.

Digitalisation should not be its own "downpipe"

The "Future Cities in the Making: overcoming barriers to information modelling in socially responsible cities" project at the CDBB in the UK has identified and described barriers to information modelling (BIM and CIM) and how these can be overcome. The study supports the researchers in their conclusion that dialogue about planning, smart cities and construction often takes place in "downpipes", i.e. separate from each other. These fields have potential overlaps. Bringing them together could help improve efficiency and decision-making processes. This would be an interesting issue for further exploration.

Bristol in the UK appears to be attempting to overcome these and other barriers using a team of internal innovation advisors with expertise in a range of fields such as smart technology, data, social factors and user-friendly design, design thinking, future thinking, social innovation and civic engagement. The team collaborates both internally within the municipality and externally in the city to support innovation, overcome challenges and implement solutions for smart cities. Teams like this would be beneficial to Swedish municipalities and would result in digitalisation being implemented in collaboration with the people who actually need the digital products and services and not by the IT experts alone.

National co-ordination for digital twinning

Smart Built Environment could act as national co-ordinator and disseminator of knowledge for the development of digital twinning, which would be similar to the situation in the UK. The co-ordination could start with a strategic project and discussions about which open data should be provided and which visualisations should be made, which is why it is recommended that Statistics Sweden be invited to join any potential collaboration.

Collaboration with international organisations

Many organisations that act as prime movers and collaboration platforms for sustainable built environment and increased digitalisation collaborate internationally, some on a regional level and others globally. This is a golden opportunity for Smart Built Environment to identify key organisations with which it can collaborate as part of its internationalisation strategy and implementation going forward. Initiating an exchange like this would enable the identification of many more organisations of interest and possible collaborations.

For example, collaboration and knowledge sharing could take place with the following:

- Projects funded by the EU (e.g., Horizon 2020.)
- Parties at Norway Digital
- KIRAHub and the Finnish Artificial Intelligence Accelerator in Finland
- BLOXHUB, government ministries and agencies responsible for digital construction strategy and the stakeholders responsible for ConTech in Denmark
- The Ministry of Economic Affairs and Communications och Estonian digital construction cluster (EDCC) i Estland
- The Association for Construction Industry Digitalisation in Latvia
- The Ministry of Environment in Lithuania
- The Centre for Digital Built Britain (CDBB) and the Construction Innovation Hub in the UK
- BIM organisations in other countries
- The Morgenstadt: City Insights innovation network in Germany
- The Metabolic Cities Program in the Netherlands
- Leading-edge European cities such as Amsterdam, Bristol and Barcelona
- The Smart Nation Digital Office including the National AI Office in Singapore
- Smart Cities Councils from different parts of the world

The above is only an initial list of possible partners. Identification of potential national and international partners can be carried out during further continuous and joint environmental scanning. An initial suggestion is that international collaborations could be initiated by contacting the Nordic and Baltic countries stakeholders. In the event of this contact, more stakeholders from the above countries and from Iceland could also be added. In order to draw inspiration from how public and private stakeholders in Estonia collaborate and the progressive and innovative approach of the Estonian government, a meeting with Jaan Saar and Indrek Vimberg in Estonia is recommended. The Centre for Digital Built Britain (CDBB), Smart Cities Council Australia New Zealand and Smart Nation in Singapore are also high on the list of partners.

In the event of an international collaboration, the possibility of establishing some type of “arena for arenas”, in other words a hub for arenas located in different parts of the world, could also be discussed.

Furthermore, it is recommended that parts of this survey be translated and supplemented with Swedish examples. It can then be distributed to organisations that Smart Built Environment is interested in collaborating with, to provide examples of the benefits that international collaboration in environmental scanning can provide.

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