CONSTRUCTION INDUSTRY COUNCIL
建造業議會

Construction Digitalisation Roadmap for Hong Kong

A Pathway Towards Smart Construction

Revision History

Version	Date	Revision
1.0	1st November 2021	First Release

Disclaimer

Whilst reasonable efforts have been made to ensure the accuracy of the information contained in this publication, the CIC nevertheless encourages readers to seek appropriate independent advice from their professional advisers where possible. Readers should not treat or rely on this publication as a substitute for such professional advice.

Enquiries

Enquiries may be made to the CIC Secretariat:

CIC Headquarters

38/F, COS Centre, 56 Tsun Yip Street,

Kwun Tong, Kowloon

Tel: (852) 2100 9000

Fax: (852) 2100 9090

Email: enquiry@cic.hk

Website: www.cic.hk

Abbreviation

Abbreviation	Definition
3DiMap	3D Intelligent Map
AECO	Architecture, Engineering, Construction and Operations
AIM	Asset Information Model
AP	Authorized Person
BCA	Building and Construction Authority (Singapore)
BD	Buildings Department
BEAM	Building Environmental Assessment Method
BEPAD	Building Environmental Performance Assessment Dashboard
BIM	Building Information Modelling
BIM-AM/FM	Building Information Modelling - Asset Management/ Facility Management
BMS	Building Management System
CAD	Computer-aided Design
CAFM	Computer-aided Facility Management
CCTV	Closed Circuit Television System
CDBB	Centre for Digital Built Britain (UK)
CDE	Common Data Environment
CEDD	Civil Engineering and Development Department
CIC	Construction Industry Council
CIC-ZCP	CIC Zero Carbon Park
CIM	City Information Model
CIOB	Chartered Institute of Building

CITAC	Construction Innovation and Technology Application Centre
CITF	Construction Innovation and Technology Fund
CITM	Construction Industry Transformation Map (Singapore)
CityGML	City Geography Markup Language
COBie	Construction Operations Building Information Exchange
CSDI	Common Spatial Data Infrastructure
DA	Digital Application Area
DEVB	Development Bureau
DfMA	Design for Manufacture and Assembly
DWSS	Digital Works Supervision System
E&M	Electrical and Mechanical
EIA	Environmental Impact Assessment
EMSD	Electrical and Mechanical Services Department
ESH	Electronic Submission Hub
GBA	Greater Bay Area
GBP	General Building Plan
GEO	Geotechnical Engineering Office
GFA	Gross Floor Area
GI	Ground Investigation
GIS	Geographic Information System
HIM	Heritage Information Modelling
HKSARG	The Government of the Hong Kong Special Administrative Region
HKUST	The Hong Kong University of Science and Technology

HyD	Highways Department
ICT	Information and Communications Technology
iCWP	Integrated Capital Works Platform
IDD	Integrated Digital Delivery (Singapore)
IFC	Industry Foundation Classes
IoT	Internet of Things
ITB	Innovation and Technology Bureau
LandsD	Lands Department
LT	Laboratory Test
MEP	Mechanical Electrical and Plumbing
MiC	Modular Integrated Construction
MiMEP	MultiTrade Integrated MEP
MNC	Multinational corporation
MOHURD	Ministry of Housing and Urban-Rural Development (China)
NDT	National Digital Twin (UK)
NTHS	Natural Terrain Hazard Study
O&M	Operation and Maintenance
OGCIO	Office of the Government Chief Information Officer
PDfMA	Platform Design for Manufacture and Assembly
PNAP	Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers
PSI	Public Sector Information
QA	Quality Assurance
RFID	Radio Frequency Identification

RGE	Registered Geotechnical Engineer
RISC	Request for Inspection/Survey Check
ROI	Return on Investment
RSE	Registered Structural Engineer
RTLD	Real-Time Location System
SDO	Spatial Data Office
SLA	Singapore Land Authority
Smart AM/FM	Smart Asset and Facility Management
SME	Small and Medium-sized Enterprise
SPA	Swept Path Analysis
TAM	Technology Acceptance Model
TF-CD	Task Force on Construction Digitalisation
TFS	Technical Feasibility Statement
TIA	Traffic Impact Assessment
UMIS	Utility Management Information System
URA	Urban Renewal Authority
URIS	Urban Renewal Information System
UU	Underground Utilities
VR	Virtual Reality
XP	Excavation Permit

Contents

1. Executive Summary

Pathway to Smart Construction

The Architecture, Engineering, Construction and Operations (AECO) industry is set for changes. Moving from mere conceptualisation, digital construction and implementation is thriving in Hong Kong and around the world. A multitude of factors have been lined up for construction digitalisation: Government policies with increasing focus on smart construction; fast-growing Information and Communications Technology (ICT) investment in construction; and booming research and development. The AECO industry is on-trend for a digital revolution.

Many governments around the world have acknowledged the benefits and potential of digitalisation in construction. When studying different digitalisation policies, it is clear that government is the key player to lead and promote construction digitalisation.

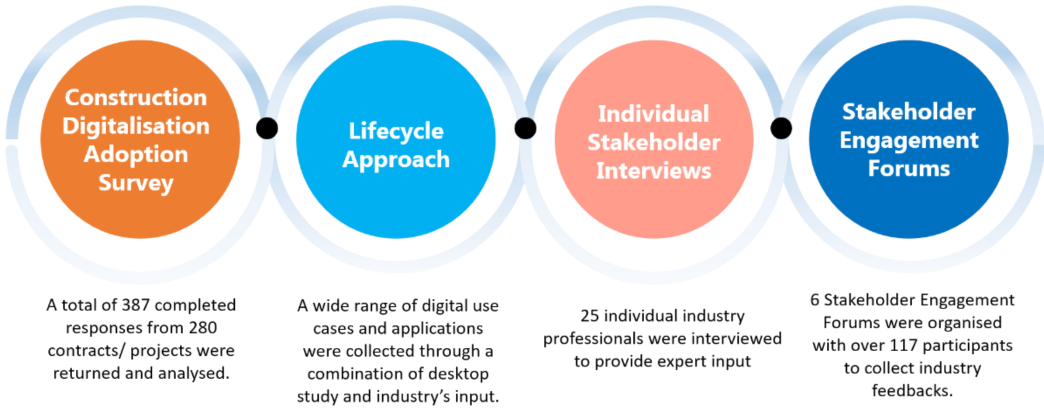
To lead Hong Kong's construction industry into a new digital era, the Construction Industry Council has worked with key industry stakeholders to prepare the Roadmap. The vision is set – SMART Construction Empowered by Digitalisation: all processes involved in the built asset lifecycle are streamlined and digitalised to continuously improve productivity and safety during planning, design, construction and operation, and sustainability for better quality of life.

Approach Taken to Develop the Roadmap

The Roadmap has been developed through extensive consultations with industry stakeholders. Between mid-2020 and early 2021, surveys, interviews and forums were conducted to gather ideas and create a consensus to drive digitalisation forward.

A construction digitalisation adoption survey was carried out. This revealed that a sizeable portion (48%) of construction contracts covered by the survey had already adopted digitalisation. The digitalisation adoption rate in public projects (78%) was much higher than in private projects (34%). There is huge potential for private projects to harness the benefits of digitalisation.

Expert input was sought from the stakeholder interviews and engagement forums to assess the value and readiness of digital applications across the whole lifecycle of built assets. Six high-value digital application areas (DAs) and nine strategies to support construction digitalisation have been identified and agreed by stakeholders.



9 Strategies to Support Construction Digitalisation

Policy- is the most critical factor in driving technology adoption as well as motivating changes in established yet inefficient and ineffective practices.

Changing Mindset- is often regarded as more important than the technology itself in the adoption of digital technology and digitalisation.

Standards & Reference Materials- are fundamental to the successful development of construction digitalisation.

Capacity & Capability Building- should always be the focus prior to and in parallel with any initiatives on construction digitalisation.

Funding Support- cannot be over-emphasised in construction digitalisation as technology adoption inevitably requires capital investment, and scepticism about Return on Investment (ROI) is understandable.

Research & Development- will provide ideas and solutions for the continuous improvement of the Hong Kong construction industry.

Data Protection & Cyber Security- are always priority concerns when implementing digitalisation.

Promotion & Showcasing- are the means to spread beliefs, ideas and best practices.

Global Competitiveness- should not be overlooked. One of the reasons to carry out construction digitalisation in Hong Kong is to provide a competitive edge over other countries/cities.

6 High-Value Digital Application Areas (DAs)

DA1 Smart Data Sharing- Integrated with BIM and GIS, Common Spatial Data Infrastructure (CSDI) and Common Data Environment (CDE) form the "core" of construction digitalisation.

DA2 Smart Planning and Design- Open up Government spatial data to facilitate site planning, engineering and environmental analysis, and collect 3D spatial and BIM data from the industry to build the 3D digital map of Hong Kong.

DA3 Smart Submission with BIM- Submission with 2D plans (paper or digital) generated from BIM models together with BIM to facilitate plan process by regulators.

DA4 Smart Offsite Fabrication and Delivery- Leverage digitalisation to shift onsite processes to a controlled offsite environment, and to achieve just-in-time delivery.

DA5 Smart Site Management- Systems of seamlessly-networked sensors, IoT devices and actuators for planning, monitoring and site record management.

DA6 Smart Asset and Facility Management- Use of digital technologies and integration with Building Management Systems for better asset and facility management and to achieve sustainability.

Along the journey of construction digitalisation regular reviews by the CIC and relevant stakeholders will be required to understand the changing circumstances, and will need to be sufficiently agile to realise that change will be essential to bring plans to pragmatic fruition. Nevertheless, one thing should remain unchanged - to keep dreaming of a Smart Hong Kong fully and seamlessly underpinned by construction digitalisation.

2. Our Vision

Our vision is clear – SMART Construction Empowered by Digitalisation.

The Government of the Hong Kong Special Administrative Region (HKSARG) strives to build Hong Kong into a world class smart city, through adopting the measures set out in the Smart City Blueprint for Hong Kong published in December 2017. The blueprint has six smart areas, namely "Smart Mobility", "Smart Living", "Smart Environment", "Smart People", "Smart Government" and "Smart Economy", some of which are closely related to construction activities.

One may wonder how construction digitalisation could empower a Smart Hong Kong as "Smart Construction" is not a smart area under the Smart City Blueprint for Hong Kong, but would it be possible to imagine a smart Hong Kong without buildings or infrastructure such as bridges, tunnels, reclamations, an airport and the railway and road systems? The answer is obvious.

In fact, the construction industry is one of the foundations of any smart city and inevitably contributes to the success of all the smart areas.

There will be no smart mobility without railway, road and public transportation networks, no smart living without a built environment to host 5G network and data centres, no smart environment without carefully-designed green and intelligent buildings, no smart people without nurturing young talent in construction digitalisation to design and construct our built environment, no smart government without streamlining statutory submissions and approval processes (and the government could not be called smart if the data acquired during the lifecycle of a built asset could not be open for public use), and there will certainly be no smart economy without the built environment. In summary, the more digitalised our construction industry, the smarter the construction and thus the smarter our city.

Ultimately, our vision of construction digitalisation is that all processes involved in the built asset lifecycle are streamlined and digitalised to continuously improve productivity and safety during planning, design, construction and operation, and sustainability for better quality of life.

" SMART Construction Empowered by Digitalisation "

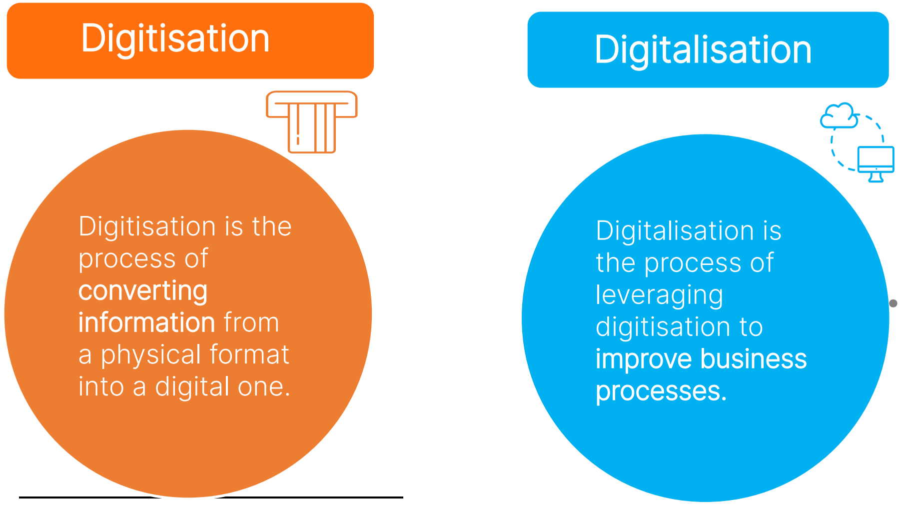
" All processes involved in the built asset lifecycle are streamlined and digitalised to continuously improve productivity and safety during planning, design, construction and operation, and sustainability for better quality of life. "

3. Definition of Construction Digitalisation

Construction Digitalisation

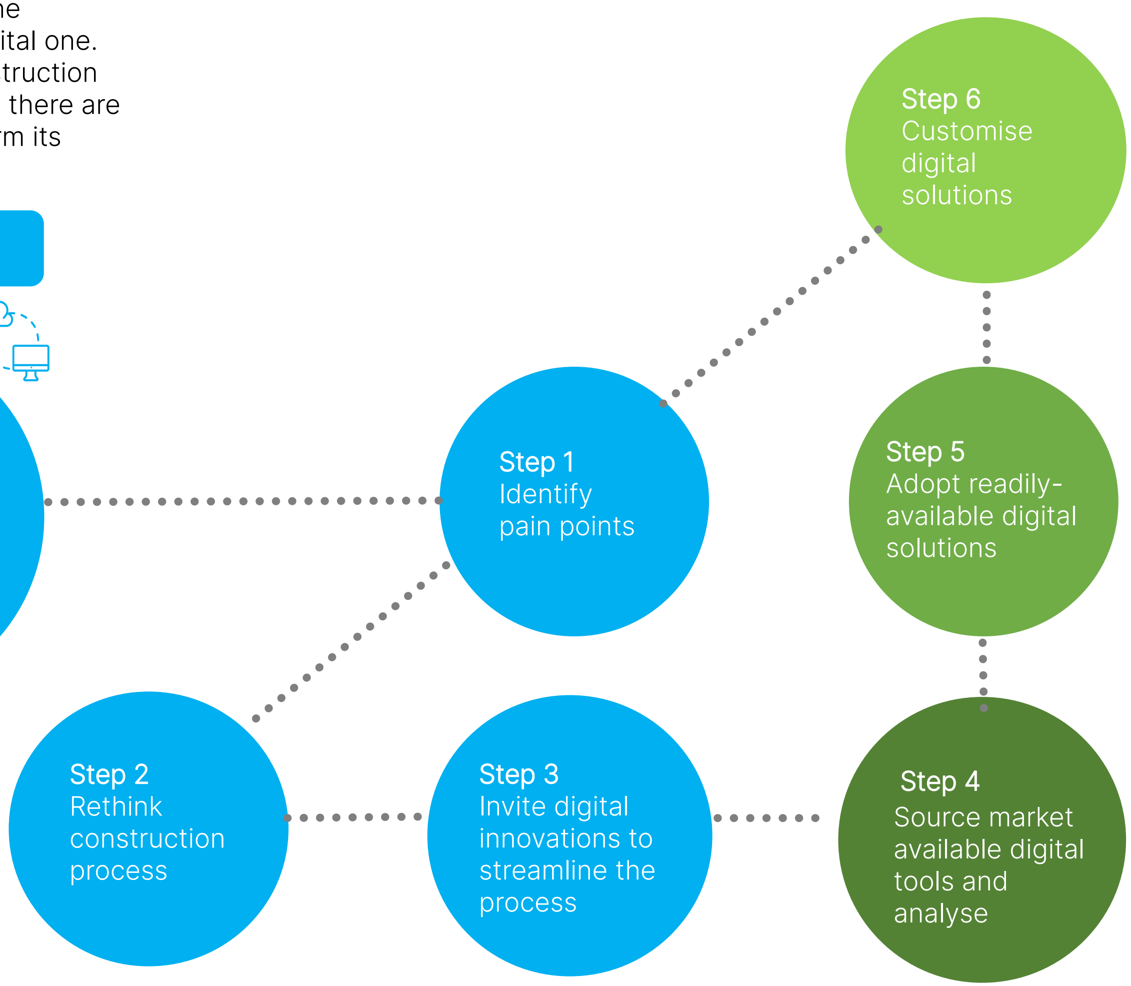
Construction Digitalisation is defined as the use of digital technologies to change a construction business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business[1] and leveraging digitisation to improve business processes.

It should not be mixed up with "Digitisation" which simply means the process of converting information from a physical format into a digital one. Digitalisation does much more as illustrated below. Whilst the construction sector as a whole is adopting process and technology innovations, there are also continuing challenges for the construction industry to transform its traditional construction process to digital.



Steps

For a digital transformation to be successful, executives and managers must start with a clear definition of how digitalisation will create value for the business, identify pain points, rethink construction processes and seek solutions.



[1] Gartner, Gartner Glossary: Information Technology Glossary.

4. Background

The Architecture, Engineering, Construction and Operations (AECO) industry is on-trend for a digital revolution. Digitalisation in the construction industry has been a growing trend for many years in Hong Kong and around the world. A multitude of factors have been lined up for construction digitalisation: Government policies with increasing focus on smart construction; fast-growing Information and Communications Technology (ICT) investment in construction; and booming research and development.

The path to construction digitalisation is not always a straight one. While the AECO sector is trying to adopt innovative technologies and processes, there are challenges when it comes to fixing the basics. In September 2018, the Government of the Hong Kong Special Administrative Region (HKSARG) launched Construction 2.0 – Time to change.[2] This stated that Hong Kong's construction industry has been facing challenges of low productivity, an increasingly ageing workforce, and a tendency to lag in innovation and advanced technology adoption. Adoption of digital technologies can create enormous opportunities for productivity enhancement in design, construction, operation and maintenance of the built assets. Similar issues have been observed worldwide. The construction industry ranked among the second-least digitalised and the least-digitalised in Mckinsey's Global Institute Industry Digitalisation Index in 2015[3] and 2020[4] respectively. This means that the construction industry still has huge potential for improvement.

The Construction Industry Council (CIC) has been relentlessly advocating innovation and digitalisation in the industry for improvement of construction productivity, safety and sustainability. Owing to its importance, construction digitalisation has been included as one of the CIC Magnificent Eight (M8) Initiatives, with a number of core action items to be implemented. As part of the M8 Initiatives, the Construction Innovation and Technology Application Centre (CITAC) Management Board established the Task Force on Construction Digitalisation (TF-CD) to develop the strategic implementation plan and set out the construction digitalisation roadmap at the industry level.

The Digital technology is ready

Digitalisation is seen as a crucial tool to help handle the increasing complexity in construction processes, and can be applied to the entire lifecycle of technical installations, from feasibility study to design to operation to maintenance. New possibilities delivered by digital technologies have exploded in recent years such as Data Analytics, Automation, 5G, Blockchain, Artificial Intelligence (AI), Machine Learning, etc. It is becoming easier, faster and cheaper to handle and extract large data streams.

The technology adoption survey 2021 conducted by the CIC to understand the current situation of construction digitalisation in Hong Kong showed that 48% of building and infrastructure works contracts are already implementing digitalisation (see Section 8 Approach). There are huge opportunities to transform the DNA of our industry, build capacity to recognise and harness disruption, and thereby achieve sustainability on planet Earth with smart living in a smart city.[5]

---

[2] Development Bureau (2018), Construction 2.0 Time to change.

[3] Mckinsey (2015), Digital America: A Tale Of The Haves And Have-Mores.

[4] Mckinsey (2020), McKinsey Global Institute analysis.

[5] Fung, A. (2019), Disruptive Technologies For Built Asset and Environment.

5. Introduction

The Construction Digitalisation Roadmap (hereafter known as "the Roadmap") serves as a reference material for industry practitioners to facilitate construction digitalisation in Hong Kong.

The Roadmap summarises the background, approach, strategies and action plans based on extensive industry consultations, and finishes with key milestones and a way forward regarding the development of construction digitalisation in Hong Kong.

Sections 2 and 3 of the Roadmap set out the ultimate goal first, provide our vision and define the meaning of construction digitalisation.

Sections 4 and 5 explain why the CIC developed the Roadmap and what it is about.

Sections 6 and 7 describe the current situation of construction digitalisation around the world and in Hong Kong and explain how construction digitalisation has contributed to smart city development.

Section 8 explains the methodology used in devising the Roadmap and high-value digital application areas and proposes actionable items. It summaries the results of the construction digitalisation adoption survey, individual stakeholder interviews and stakeholder engagement forums, conducted during the development of the Roadmap.

Sections 9 and 10 describe the 6 digital application areas, with details on their value, readiness and digital use cases, and present the 9 core strategies to guide the action plans.

Sections 11 and 12 highlight the key performance indicators, and what to expect in the next stage of construction digitalisation.

Digitalisation is about leveraging technologies to continuously improve business processes. The CIC will regularly monitor and review the implementation of the Roadmap.

6. Construction Digitalisation around the World

Overall, the construction industry's investment in digitalisation is low compared to other industries. Nonetheless, many governments around the world have acknowledged the benefits and potential of digitalisation in construction. Around 2010, different initiatives and public policies were rolled out to promote the use of digital tools and technologies in the sector. This section summarises the key initiatives of construction digitalisation taken in some representative countries and their lessons for Hong Kong.

6.1 Mainland China

One of the first mentions of construction digitalisation and informatisation by the Ministry of Housing and Urban-Rural Development (MOHURD) came in 2011. The "*2011-2015 Outline for the Development of Construction Industry Informatisation*"[6] established the overall objective to promote the adoption of Building Information Modelling (BIM), cloud-based collaboration and other advanced technologies in engineering. During that five-year period, the development of construction digitalisation in China was still at a conceptual phase, with only a few practical implementations of BIM and other digital technologies.

More concrete policies and BIM standards were rolled out in the next 5 years. The *"2016-2020 Outline for the Development of Construction Industry Informatisation"*[7] mentioned that development of the construction industry should complement strategic development of national informatisation and big data. The 2016-2020 Outline covered ideas concerning Innovation, Coordination, Green, Open, and Sharing (創新、協調、綠色、開放、共用的發展理念及國家大數據戰略).
Some of the specific missions were

- To accelerate the adoption of BIM and other technology in the survey and design enterprises,
- To promote the "Internet+" collaborative work model and digitalise the whole process,
- To develop a system for built asset digital delivery, submission and storage based on BIM,
- To promote applications of information technology in construction site environmental monitoring, energy monitoring and waste management,
- To strengthen and develop construction informatisation standards, and
- To research and develop applications of different information technologies including big data, cloud computing, Internet of Things (IoT), 3D printing and AI.

Echoing the outline, in 2020 the MOHURD published the *Guiding Opinions on Promoting the "Coordinated Development of Intelligent Construction and Building Industrialization"*.[8] The MOHURD listed guiding principles of "market-led, government-guided", cross-industry integration and collaboration, and sustainable development in the document.

Lessons learnt

[6] 住房城鄉建設部 (2011), 2011-2015 年建築業信息化發展綱要.

[7] 住房城鄉建設部 (2016), 2016-2020 年建築業信息化發展綱要.

[8] 住房城鄉建設部 (2020), 住房和城鄉建設部等部門關於推動智慧建造與建築工業化協同發展的指導意見.

As indicated in the Outlines and Opinions documents, the MOHURD provided a high-level strategic plan and overview on the development of construction digitalisation in China. The Central Government, however, only maintains a guiding role on top-level design, layout planning, and policy formation. No detailed execution plans were offered. Part of the reasons is perhaps due to the China's large population and geographical area, as well as different levels of digitalisation maturity among provinces.

Nonetheless, rapid development of construction digitalisation was observed, in the strategic areas explicitly stated in the Outlines, led by a combination of provincial governments, state-owned enterprises and private companies. For instance, in August 2020, the Hunan Provincial Government published its first BIM submission standards and piloted the use of BIM submissions in all projects involving Grade A Construction Survey and Design Enterprises. With strong support from the Central Government, it is expected Mainland China will continue to thrive in its journey of construction digitalisation. Hong Kong should learn from this experience and take a strong government-led approach.

6.2 Singapore

Singapore published its Construction Industry Transformation Map (CITM)[9] in 2017. The CITM was developed based on extensive consultations with the industry, trade associations and chambers, institutes of higher learning and unions.

The vision of the CITM is:

"An advanced and integrated sector with widespread adoption of leading technologies, led by progressive and collaborative firms well-poised to capture business opportunities, and supported by a skilled and competent workforce offering good jobs for Singaporeans."

Three global trends shaping the built environment sector were identified in the CITM. These were Digital Revolution (smart building, new construction technology and digitalised work processes); Rapid Urbanisation (advanced technology to build faster and better); and Climate Change (demand for green building expertise).

According to the CITM, a total of 80,000 professionals will be trained, specialising in the following three key areas.

- Design for Manufacturing and Assembly (DfMA),[10]
- Green Building, and
- Integrated Digital Delivery (IDD)

In particular, the aim of IDD is to connect different industry stakeholders involved in construction projects through sharing of digital information. Such BIM-generated information will allow better integration of the entire project delivery process from design, offsite fabrication, and onsite assembly to operations and maintenance of buildings.[11]

The Building and Construction Authority (BCA) has also listed multiple benefits of the IDD approach, such as better coordination, faster construction, minimising mistakes, delays and rework, reducing environmental nuisance to neighbours around construction sites, and

[9] Ministry of National Development (2017), Construction Industry Transformation Map.

[10] DfMA can also refer as "Design for Manufacture and Assembly" in Hong Kong and many other countries.

[11] Building and Construction Authority (2017), Construction ITM Factsheet.

providing useful built asset information for future maintenance, retrofit and operation.

The BCA had also developed an IDD implementation plan with three key action items, namely implementing IDD through actual projects, developing an IDD ecosystem, solution and standards, and ramping up the competency level. It was expected that Singapore would achieve specific outcomes for each of the action plans by the end of 2020. Figure 6.1 describes four areas of IDD implementation.

Figure 6.1: IDD implementation (Source: BCA)

The Singapore Geospatial Master Plan outlines the vision, strategies and key initiatives to facilitate geospatial transformation and the development of "Geospatial-Powered Singapore". The aim of the Geospatial Master Plan is to leverage emerging technologies and to build geospatial competencies to address complex challenges and create opportunities. This aligns with the Digital Government Blueprint's strategy to raise Whole-of-Government's digital capabilities to pursue innovation, in support of Singapore's Smart Nation drive.[12]

As an initiative under the Geospatial Master Plan, GeoWorks was set up by the Singapore Land Authority (SLA) in 2018. GeoWorks brings together geospatial businesses including Multinational Corporations (MNCs), scale-ups and government agencies to promote business growth, drive innovation and build a diverse, well-connected geospatial community. Regular training sessions, and partner and community events are run by GeoWorks.

Lessons learnt

Both the CITM and IDD served as good references to development of the Roadmap. The IDD adopts a lifecycle approach and focuses on connecting different processes throughout the lifespan of a built asset. Different industry stakeholders from developers, consultants and contractors, to suppliers and facility managers are encouraged to collaborate through sharing of digital built asset information. It is worth mentioning that BIM is considered as a core component of the IDD as it is responsible for generating, collecting, analysing and sharing of digital information.

Successful use of the IDD in Singapore could be showcased to promote construction digitalisation in Hong Kong. Sharing of experience between the CIC and BCA would be greatly beneficial to both parties.

[12] Opengovasia (2018), Singapore Government launches mapping tech for smart living.

6.3 United Kingdom

The UK was one of the early adopters of BIM and construction digitalisation. In Construction 2025[13], prepared in 2013, the UK Government pledged to invest in smart construction and digital design. It forecasted that by 2030 the UK construction industry had the potential to achieve a share integrated city systems worth GBP 200 billion per annum. In addition, the industry and Government made a joint commitment to bring forward more research and innovation, and to developing a detailed BIM Programme.

Since 2016, the UK Government has mandated the use of BIM for all centrally-procured Government contracts. The Government also recognised the importance of BIM to successful implementation of a wider offsite manufacturing strategy. The UK has seen remarkable success in its commitment to construction digitalisation, as indicated by the substantial growth in BIM adoption. In 2011, 43% of surveyed industry professionals had never heard of BIM. By 2020, BIM awareness was nearly universal, and the BIM adoption rate had grown rapidly to 73%.

The Digital Framework Task Group was set up in 2018 with the ultimate goal of developing a national Digital Twin (NDT) by 2050. A "Digital Twin" is a realistic digital representation of assets, processes, or systems in the built or natural environment. What distinguishes a Digital Twin from any other digital model is its connection to the physical twin.[14] The Gemini Principle[15] outlined the vision for Digital Built Britain to enhance the natural and built environment, thus increasing competitiveness, productivity, as well as quality of life and wellbeing of the general public. Nine simple principles were proposed to guide the development of information management framework and the NDT, as illustrated in Figure 6.2.

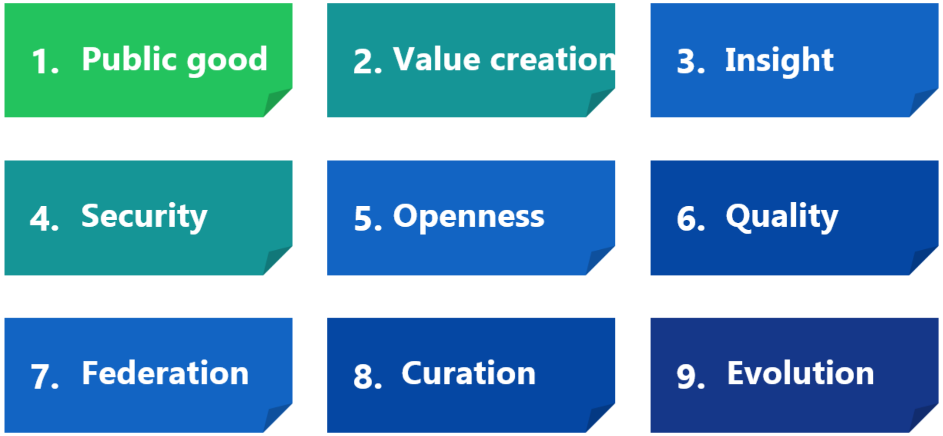


Figure 6.2: The Gemini Principles (Source: CDBB)

[13] HM Government (2013), Construction 2025.

[14] Centre for Digital Built Britain (2018), The Gemini Principles.

[15] See 14.

Effective information management and data sharing bring tremendous value to the country. For example, in 2018, it was estimated that through digitising asset information of the UK's rail network, up to GBP 770 million could be saved in the following eight years.

In the Roadmap to the Information Management Framework for the Built Environment[16], five streams of interconnected components are identified for the delivery of the NDT.

a) Approach - coordinated and aligned activity across the whole NDT
b) Governance - structures and processes for managing the framework
c) The Commons - necessary support for effective information management via guidance, specifications and standards
d) Enablers - prioritised and proactive programme to enable changes
e) Change - facilitating adoption across the whole ecosystem of the built environment, particularly amongst early adopters and the early majority

Lessons learnt

The success of the UK rides on commitment from the Government, and long-term vision and planning. It provides a good role model for construction digitalisation. Hong Kong has a late-mover advantage to learn from the UK's experience.

The NDT is one of the more far-reaching projects aimed at enabling effective information management by harnessing the power of digital technology, data capture and analytics. As mentioned in the Digital Built Britain Initiative, the digital economy, modern construction methods and convergence of smart infrastructure have all presented growing opportunities for a better quality of life. Depending on the development of the Common Spatial Data Infrastructure (CSDI), a Digital Twin for Hong Kong may also be achievable in the near future.

[16] Centre for Digital Built Britain (2019), Roadmap to the Information Management Framework for the Built Environment.

6.4 Other Digitalisation Initiatives around the World

Germany

Germany first introduced the concept of Industry 4.0 in early 2010s. Industry 4.0, or the Fourth Industrial Revolution, refers to the intelligent networking of machines and processes for industry with the assistance of ICT.[17] Industry 4.0 converged the digital design and simulation, with real-world productions and manufacturing. It provides flexibility and agility, allowing much more customised solution and production line.

Five working groups were created in 2015 under Plattform Industrie 4.0. They are:

1. Reference Architectures, Standards, and Norms
2. Research and Innovation
3. Security of Networked Systems
4. Legal Framework, and
5. Work, Education and Training

Japan

Building on the idea of Industry 4.0, in 2016 Japan announced a new industrial strategy known as Society 5.0. It sets out a vision of a human-centred, highly-connected, "super-smart" society that fully incorporates technological innovations. Aligned to the UN's Sustainable Development Goals, it bets on advanced manufacturing, ICT, IoT and AI to tackle a series of challenges, including Japan's declining birth rate, ageing population, infrastructure, education, greenhouse gas emissions, and resource depletion.[18]

Dubai

In 2013, the Smart Dubai Project was initiated, which contained more than 100 initiatives to make Dubai a smart city by 2030. Smart Dubai initiatives aim to let the public obtain real-time kinematics, so that its government can formulate policies based on analysis of different data, with a view to making it the world's happiest city. Through the all-round city information platform, Dubai Pulse, the public can access information on public projects and events, such as the status, estimated expenditure and completion time of construction works in various city locations.

United States

Geospatial technologies play an important role to enhance efficiency and effectiveness of different business functions and services. Since 2012, the US GeoPlatform.gov provides cross-agency shared infrastructure and services. One of the chief mission is to support management, discovery, and exploitation of key data and services such as remotely sensed imagery, address data, infrastructure, and other geospatial resources of national significance. Data sharing and interoperability standards are promoted to reduce duplicated effort.[19]

---

[17] Plattform Industrie 4.0, [What is Industrie 4.0?]

[18] Innovate UK (2019), Japan Transforming Construction 2019.

[19] GeoPlatform.gov, [GeoPlatform.gov].

6.5 Hong Kong

Hong Kong is making significant progress in its transformation to becoming a smarter Digital City.

Hong Kong has long been considered one of Asia's leading and best-connected cities in a worldwide context. This reputation is affirmed by the city's status as a global financial services centre and gateway where "East meets West", and as an entry point to one of the world's fastest growing economies, Mainland China. In developing this global reputation, the construction industry has played a significant role in literally building the foundations and physical structures that have supported the success and development of Hong Kong's economy and community.

Hong Kong has recently been undergoing a digital transformation to ensure the city's competitiveness, sustain a strong economy, and ultimately improve people's quality of life.

Digital strategies

In December 2020 the HKSARG published the Smart City Blueprint 2.0 for Hong Kong (the "Blueprint"), containing more than 130 smart city initiatives arranged under six smart areas (i.e., "Smart Mobility", "Smart Living", "Smart Environment", "Smart People", "Smart Government" and "Smart Economy"), with a view to addressing the challenges of city management and improving people's livelihood through innovation and technology (I&T). The vision of the Blueprint is "Embrace innovation and technology to build a world-famed Smart Hong Kong characterised by a strong economy and high quality of living".[20]

Conventionally, a "smart city" refers to a city that utilises Information and Communications Technology (ICT) to make its components, infrastructure, utilities and services more efficient and interactive with people in the city.

The Planning Department (2016) stated that "Our robust ICT infrastructure, coupled with Hong Kong people's readiness to use technology, provides a favourable environment for Hong Kong to take further strides as a smart city."[21]

The first step to create a smart city is to make sure the components of the city are smart and digitalisation is therefore the foundation of a smart city. Industries such as manufacturing, health care, service deliveries, etc., have already adopted digital processes to become smarter, whereas the construction industry has so far remained an industry characterised by manual processes and traditional non-digital methods.

Figure 6.3: Hong Kong Smart City Blueprint (Source: HKSARG)

[20] HKSAR Government (2020), Hong Kong Smart City Blueprint 2.0.

[21] Planning Department (2016), Hong Kong 2030+: A Smart, Green and Resilient City Strategy.

The Challenges and Construction 2.0

The industry is facing a challenging future and urgently needs a strategy to carry it forward. Arguably the most significant challenge the industry faces is the high level of construction activities projected in the next few years. This has raised questions about the capabilities and resources of the construction industry in its current form. Costs are high, the workforce is ageing and productivity is declining. There is also a lag in innovation and adoption of new technologies. Furthermore, the industry has witnessed a series of undesirable incidents related to a number of mega-projects in recent years, including budget overruns, delays, site accidents and alleged quality and site supervision problems.

All these have led to heightened levels of media scrutiny, impaired public confidence and shortage of new recruits. In response to these challenges, the HKSARG launched the Construction 2.0 – Time to change in September 2018[22] .

The initiative rests on three key pillars: Innovation, Professionalisation and Revitalisation.

Figure 6.4: Construction 2.0 (Source: DEVB)

Innovation is the key to improving capability and enhancing performance. The global economy is experiencing a huge and lasting impact from technological advances and innovation. An industry culture that embraces change, innovation and new technology is necessary to drive forward productivity, efficiency and enhanced project delivery outcomes. With Construction 2.0 on the agenda, construction is progressively adopting digitalised processes and buildings and infrastructure are becoming sources of data for a smarter Hong Kong.

Building Information Modelling (BIM)

In Hong Kong, it was mandated by the Government in 2017 that starting in 2018, BIM must be used on all capital works projects with a budget of HK$30 million or more. This is a positive step for the industry because if used properly, BIM has the potential to play a significant role in enhancing the quality of information and decision-making in construction time-and-cost monitoring, operation and maintenance planning and long-term asset management.[23] In 2012 Construction Industry Council (CIC) has been taking up the role as a coordinator in BIM development and digital construction in Hong Kong, set up a BIM Taskforce, and published a Roadmap for BIM implementation in 2013/14. In 2017, the CIC established the Committee on BIM to formulate strategies for market transformation, promote the use and facilitate the application of BIM, digital construction, and related technologies in the construction industry. The CIC distinguishes itself as a Centre of Excellence for BIM, develops standards, specifications, and common practices for BIM. The CIC also promotes good BIM practices and takes a lead in the local BIM certification and accreditation as well as R&D and funding support.

[22] Development Bureau (2018), Construction 2.0 Time to change.

[23] Development Bureau (2017), Technical Circular (Works) No. 7/2017.

Offsite construction

Offsite construction inevitably leverages digital technologies and digitalised processes to automate, monitor and operate fabrication in a highly controlled environment off the site. In Hong Kong, major benefits are anticipated in construction activities related to residential housing and accommodation, hospitals and healthcare facilities and other built assets involving multi-level repetitive forms of design. At a more specific level and as detailed in Development Bureau (DEVB) Technical Circular (Works) No. 1/2016[24], offsite prefabricated rebar products may be used in a capital works contract if the contractor opts to engage a yard on the Civil Engineering and Development Department's (CEDD) List of Approved Steel Reinforcing Bar Prefabrication Yards for Public Works to supply prefabricated rebar products for the works under the contract. This represents another big step forward in Hong Kong's adoption of offsite construction methodologies.

To capture the full benefits from offsite construction technologies and to promote the adoption of MiC, DEVB issued Technical Circular (Works) No. 2/2020 in March 2020 on the adoption of MiC in suitable building types.

Related HKSAR Government (HKSARG) Initiatives

The following table summarises the government's key initiatives related to construction digitalisation as at April 2021.

Start Year	Government Bureaux/ Departments	Initiative	Short Description
2016	BD	BIM submissions for building proposals	General guidelines on BIM submissions for building proposals as supplementary information to facilitate plan processing by the BD.[25]
2017	The CIC	Establish Construction Innovation and Technology Application Centre (CITAC)	An innovation and technology application centre to provide a platform for introducing innovative technologies into the industry to enhance productivity.[26]

[24] Development Bureau (2016), Technical Circular (Works) No. 1/2016.

[25] Buildings Department (2016), PNAP ADV-34 on Building Information Modelling.

[26] HKSAR Government (2017), Policy Address para. 130 (2017).

Start Year	Government Bureaux/ Departments	Initiative	Short Description
2017	HKSARG	Open Up Government Data	Expedite the opening up of government data for use as raw materials in technological research, innovation and the development of a smart city.[27]
2017	EMSD	BIM-AM	Develop the EMSD BIM-AM System, BIM modelling standard, coding standard and information requirement for Electrical and Mechanical (E&M) systems and assets at handover stage for building operation.

Start Year	Government Bureaux/ Departments	Initiative	Short Description
			Deploy BIM for asset management in various government-owned and public bodies-owned venues and buildings.[28]
2017	HKSARG	Smart City Blueprint	The first Smart City Blueprint for Hong Kong set out 76 initiatives under six smart areas, namely Smart Mobility, Smart Living, Smart Environment, Smart People, Smart Government and Smart Economy, to address the challenges of city management and improving people's livelihood through I&T.[29]

[27] Legislative Council (2017), Administration's paper on policy initiatives of the Innovation and Technology Bureau.

[28] Electrical and Mechanical Services Department (2017), Building Information Modelling for Asset Management (BIM-AM) Standards and Guidelines Version 1.0.

[29] HKSAR Government (2017), Hong Kong Smart City Blueprint.

Start Year	Government Bureaux/ Departments	Initiative	Short Description
2018	DEVB	Adoption of BIM for the Government Capital Works Projects	Capital works projects with project estimates more than $30 Million shall use BIM technology.[30]
2018	HKSARG	Construction Innovation and Technology Fund (CITF)	Establish a $1 billion Construction Innovation and Technology Fund (CITF) to encourage wider adoption of innovative technologies and stimulate the provision of cutting-edge solutions by local I&T enterprises for industry enhancement.[31]
2018	HKSARG	Annual Open Data Plan	Set out the datasets to be released on the Public Sector Information (PSI) Portal. Examples of datasets include Real-time Data, Open Data, Geospatial Data and 3D Models, etc.[32]
2018	BD	Electronic Submission Hub (ESH)	Electronic Submission Hub (ESH) for centralised processing of electronic building plans and documents, as well as other applications under the Buildings Ordinance (Cap. 123) (BO), as an alternative to the present paper-based system.[33]

[30] Development Bureau (2018), Technical Circular (Works) No. 18/2018.

[31] HKSAR Government (2018), Policy Address para. 145.

[32] Legislative Council (2018), Administration's paper on open data policy.

[33] Legislative Council (2018), Administration's paper on implementation of Electronic Submission Hub.

Start Year	Government Bureaux/ Departments	Initiative	Short Description
2019	DEVB	Common Spatial Data Infrastructure (CSDI) - 3D Pedestrian Network	The 3D Pedestrian Network was introduced/implemented to support navigation services and meet the special needs of people with physical disabilities.[34]
2019	DEVB	Common Spatial Data Infrastructure (CSDI) - 3D Visualisation Map Datasets	The 3D Visualisation Map shows topographical and exterior features of terrain, buildings and infrastructure that supports visualisation and other geospatial applications.[35]
2019	OGCIO	Smart Government Innovation Lab	The Office of the Government Chief Information Officer (OGCIO) set up a Smart Government Innovation Lab and invited the industry to put forward proposals on I&T applications and product suggestions for various public services. Trials and technology testing were being arranged for suitable proposals, allowing government departments to formulate more effective innovative measures to improve public services such as municipal services, crowd control and cargo clearance. This initiative also creates more business opportunities for local start-ups and

[34] Legislative Council (2019), Administration's paper on development of Common Spatial Data Infrastructure and 3D Digital Map.

[35] See 34.

Start Year	Government Bureaux/ Departments	Initiative	Short Description
			small and medium-sized enterprises (SMEs).[36]
2019	CEDD	BIM Horizontal Harmonization for BIM/GIS Integration	An aligned BIM guideline is being formulated for the works departments under the Development Bureau.[37]
2020	DEVB	Digital Works Supervision System	Capital works contracts, with pre-tender estimate exceeding $300 million, shall adopt the DWSS with an aim of enhancing the standard and efficiency of works supervision as well as the quality and safety of works.
			Bureaux/Departments are encouraged to adopt the DWSS in other works contracts, such as maintenance and term contracts, with a view to strengthening works supervision.[38]
2020	DEVB	Adoption of MiC for new building works under Capital Works Programmes	MiC shall be adopted for new building works of suitable building types. Project teams shall consider adoption of MiC in preparing the Technical Feasibility Statement (TFS).[39]

[36] Office of the Government Chief Information Officer, Smart Government Innovation LAB.

[37] Civil Engineering and Development Department (2020), BIM Horizontal Harmonization for BIM/GIS Integration.

[38] Development Bureau (2020), Technical Circular (Works) No. 3/2020.

[39] Development Bureau (2020), Technical Circular (Works) No. 2/2020.

Start Year	Government Bureaux/ Departments	Initiative	Short Description
2020	HKSARG	Smart City Blueprint 2.0	The blueprint 2.0 includes initiatives under implementation, or of an ongoing nature, such as open data and on-street parking meters supporting remote payment. There are also over 60 new initiatives, such as developing a Traffic Data Analytics System to enhance traffic management and efficiency, and setting up the Smart Traffic Fund to promote research and application of vehicle-related I&T under the Smart Mobility area. Some construction-related initiatives from Smart City Blueprint 2.0 include: a) Establish a "Digital Twin" of the Hong Kong International Airport to provide a 3D airport model in virtual reality to enable more effective facilities and construction planning as well as better operation management (Smart Mobility) b) Mandate the adoption of Building Information Modelling (BIM) in major government capital works projects starting from 2018, develop BIM standards and continue to provide assistance to the construction industry on BIM adoption (Smart Government) c) Employ Building Information Modelling - Asset Management/ Facility Management (BIM-AM/FM) Platform for improvement of

Start Year	Government Bureaux/ Departments	Initiative	Short Description
			building facility management (Smart Living) d) Develop Common Spatial Data Infrastructure and Establish Geospatial Lab (Use of I&T in Combating COVID-19) e) Develop the Electronic Submission Hub for processing building plans (Smart Government) f) Develop an automated system for concrete cube testing (Smart Government) g) Promote digital works supervision systems to strengthen supervision and management of capital works projects (Smart Government).[40]
2021	LandsD	BIM Data Repository	Establish a Cloud-based BIM Data Repository for centralised management and sharing of BIM information across Works Departments.[41]
2021	LandsD	3D Indoor Map	Pilot Project on Creation of 3D Indoor Maps for Smart City under the TechConnect set up by the Innovation and Technology Bureau in 2020.[42]

[40] See 20.

[41] Lands Department, BIM Data Management.

[42] Lands Department, 3D Indoor Map.

Start Year	Government Bureaux/ Departments	Initiative	Short Description
2020	LandsD	Hong Kong Geodata Store- alpha version	Provide over 36 000 digital maps and aerial photos to over 4 300 corporate clients and members of the public.[43]
2021	DEVB	Common Spatial Data Infrastructure (CSDI) - Geospatial Lab	Provide a Geospatial Lab platform for the Government to reach out to the wider community, in particular the younger generation and start-ups including application developers, for promoting use of spatial data in developing useful mobile applications.[44]

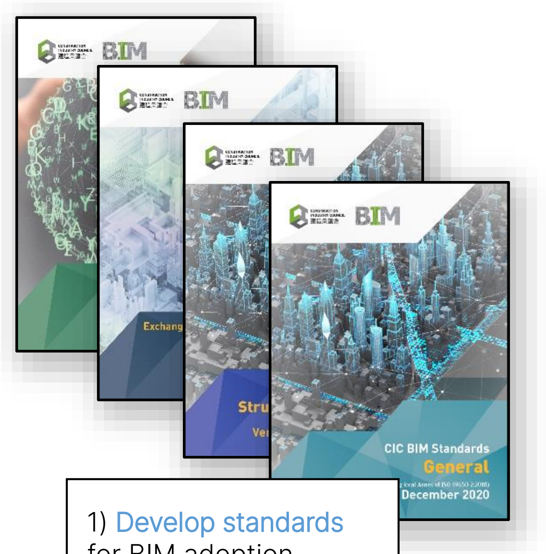
More detailed information can be obtained from the websites of the related government bureaux/ departments.

[43] Lands Department, HONG KONG GEODATA STORE (alpha version)

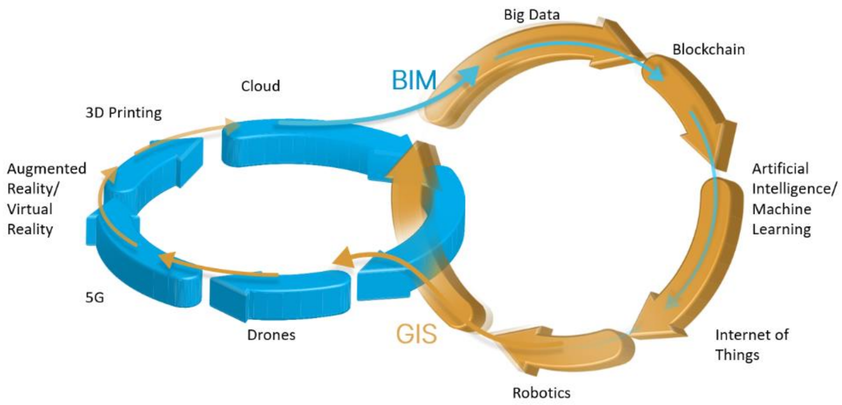
[44] HKSAR Government (2020), LCQ10: Common Spatial Data Infrastructure.

6.6 Similarity of the Development of Construction Digitalisation

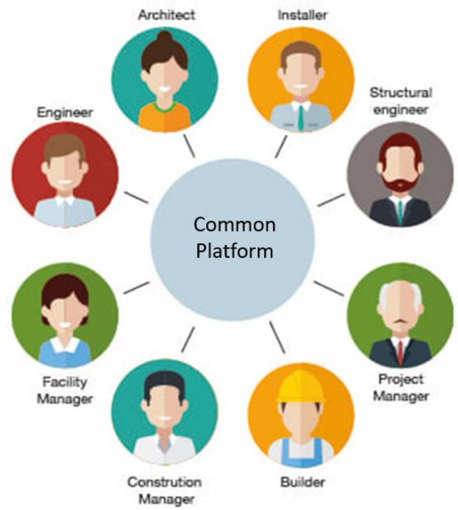
This section summarises key digitalisation initiatives taken in different cities/ countries. A pattern emerges when comparing these policies and initiatives side-by-side. Government is the key player to lead and promote construction digitalisation. To fully reap the benefits of construction digitalisation, the top priority should be to develop a holistic understanding of how different technologies and digital tools revolutionise the AECO industry, as well as how these fit into the bigger picture of national digital strategies. The three-step approach illustrated in Figure 6.5 serves as a good reference point. Firstly, standards and guidelines should be made ready to facilitate BIM adoption. Secondly, a collaborative and computerised construction process should be encouraged by integrating BIM, GIS and other digital technologies. Thirdly, collaborative platforms should be established which enable data sharing across the full built asset lifecycle. This third stage marks a watershed moment for construction digitalisation - a fully collaborative and interoperable data environment combining BIM, GIS and other digital technologies.



1) Develop standards for BIM adoption.



2) Develop a collaborative/ fully computerised construction process by integrating BIM, GIS and different digital technologies.



3) Develop collaboration platforms which enable data sharing across the full asset lifecycle.

Figure 6.5: Approach for construction digitalisation

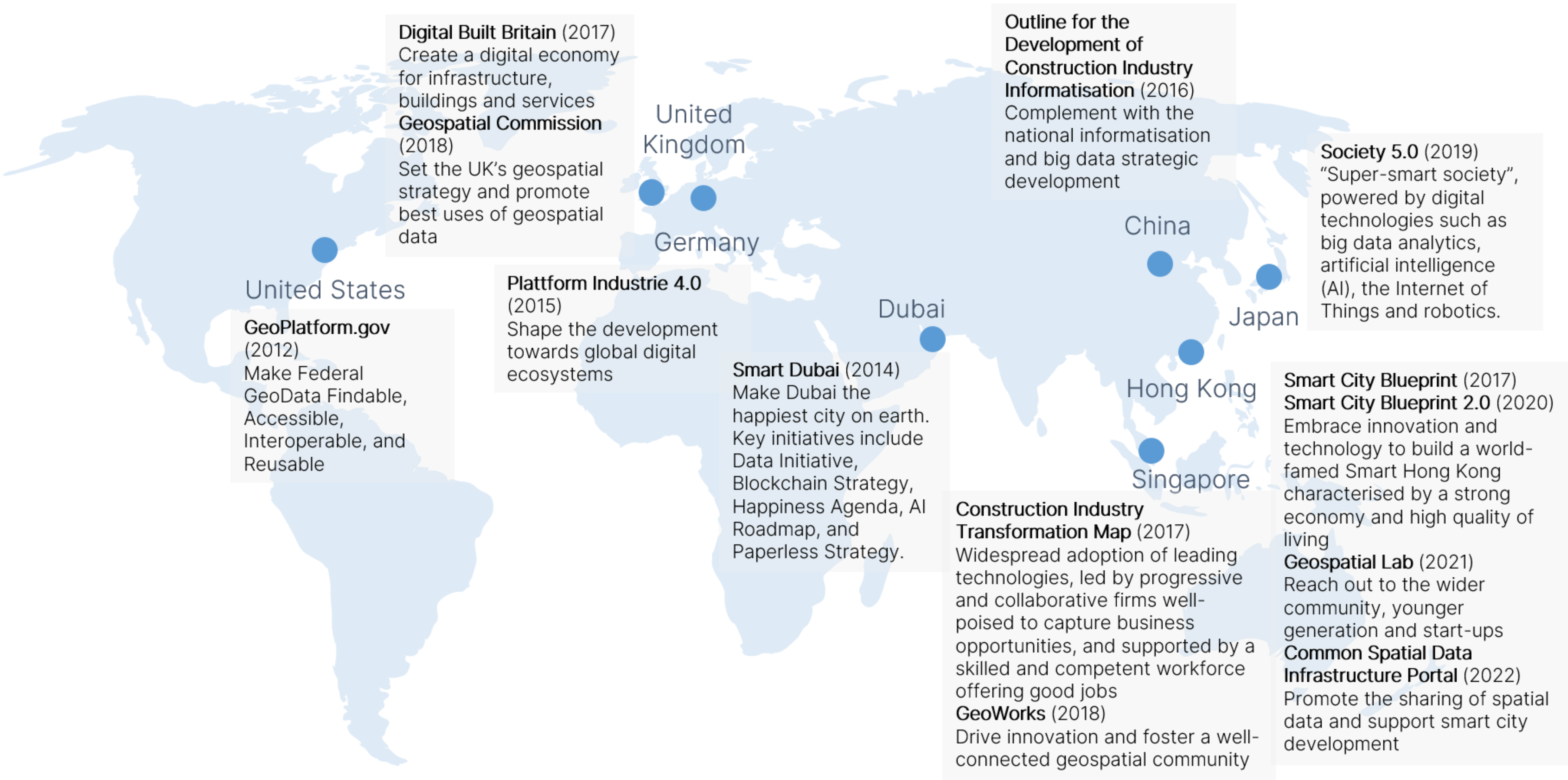


Figure 6.6: Recent digitalisation initiatives around the world

7. Construction Digitalisation and the Smart City

With "Construction 2.0" and many other smart initiatives as listed above on the agenda, construction in Hong Kong is progressively adopting digitalised processes whereby buildings and infrastructure are becoming the sources of data for a smart city.

This digital transformation has enabled a renewed focus in the industry on what is most important – high-quality work, safely and efficiently done. Due in part to these technologies, practitioners are becoming better professionals and bringing more value to the city.

Construction digitalisation is a key foundation for smart city development. Despite not being a separate topic or smart area in the Smart City Blueprint, "Smart Construction" is undoubtedly one of the key pillars of any smart city. Almost every single area of a smart city is directly or indirectly influenced by the existing collective construction and building data, as well as new construction methods. The adoption of Smart Construction helps to achieve the objectives of a Smart City as shown in the table below.

Smart Areas	Objective (from the Smart City Blueprint[45])	How Smart Construction Contributes
Smart Mobility	Enhance people mobility through efficient and targeted capital deployment models and infrastructure investments.	Through digital planning, design and construction of infrastructure, urban transportation can be enhanced with improved connectivity, quality and efficiency. Better transportation infrastructure planning and traffic monitoring.
Smart Living	Enhance the overall living experience of the people of Hong Kong, across age groups and demographics.	Better quality of life and liveability through better building design, the adoption of innovative and sustainable construction materials, digitalised construction processes and innovative construction methods, etc.
Smart Environment	Change how the Government manages Hong Kong's built and natural environment in the interest of improving Hong	Improved sustainability and reduced carbon emissions through Smart Construction.

[45] Office of the Government Chief Information Officer (2017), Report of Consultancy Study on Smart City Blueprint for Hong Kong.

Smart Areas	Objective (from the Smart City Blueprint[45])	How Smart Construction Contributes
	Kong people's everyday life and quality of living.	Improved construction site environment through adoption of innovative and digital construction technologies.
Smart People	Transform the way that people access public and private sector services in their capacity as individuals, businesses, parents, investors, employees and employers, and facilitate retooling of talents and lifelong learning.	By encouraging a creative and innovative mindset, and promoting cross-collaboration between ICT and the AECO industry. Promoting community participation and involvement (e.g. via Geospatial Lab). Equipping students and practitioners with knowledge and a skillset of digital technologies.
Smart Government	Change how the Government manages the city and serves its stakeholders through the deployment of supporting infrastructures that collect, collate, analyse and present city data in the ways that can best support the stakeholders, leading to a more vibrant, dynamic and safe community.	Visualisation of city and building information allows data-driven decision making and better administration (e.g., CSDI for land records, utility management and disaster management). Streamlining of submission and approval processes leveraging

Smart Areas	Objective (from the Smart City Blueprint[45])	How Smart Construction Contributes
		digitalised processes and automation.
Smart Economy	Transform and strengthen Hong Kong's economy by improving the overall business climate, city attractiveness for start-ups, investors and growing the economy in a sustainable manner.	Improved competitiveness of the AECO industry. Generation of new business opportunities and potentials to export construction services outside Hong Kong.

Construction data and Smart City

Construction data and the Smart City are intertwined. Various construction and building data, from BIM, GIS, CAD, IoT, point clouds, drone imagery, satellite imagery, 3D raster and vector data, can all contribute to a Smart City. A City Information Model (CIM) provides a platform to integrate different types of data to develop a 3D information complex for the whole city. CIM can be used by Government, architects and planners for better urban planning and management. Different applications can be supported across sectors such as census, logistics and environmental management, to name just a few. It is estimated that 80% of information are associated with spatial information[46]. With the aid of GIS, big data in a Smart City can be visualised from a geospatial perspective to reveal patterns, trends and relationships. Geospatial analysis can further improve the accuracy of big data analytics, and help solve problems more easily by visualisation through maps. It is the vision of the Lands Department's BIM Data Repository Project[47] to harmonise smart construction data and spatial data in an open format. In this respect, it is intended that all spatially-related DEVB datasets, as a single source of information, will be gradually shared on the cloud and opened up for public use.

Digital Twins

Digital Twins set the foundation on which smart services can be planned and developed to serve the physical city. As digital replicas of real-world infrastructure, the potential benefits are easy to grasp: a direct application of computing power to complex, tangible problems in the physical world, bringing greater accuracy, control and predictability to a range of challenges across different industries.[48]

Data are everywhere in the built asset lifecycle, but currently are not being utilised efficiently nor effectively in the construction industry as traditional forms of construction data are unstructured, sparse, scattered and often not machine-readable. Through construction digitalisation, those unstructured data could be digitalised to gain valuable insights for project management and decision making, as well as enabling preventive or predictive measures for facility management. On a city level, data and information collected during construction could be put to much greater use and help to enrich and support the development of Smart City Hong Kong, e.g., leveraging real-time digital data for monitoring the performance of existing public services, improving city planning, and optimising decision making among policy makers, etc.

Construction digitalisation serves as one of the fundamental building blocks of a Smart City. It covers the lifecycle of a built asset at all stages (planning & design; construction; operation & maintenance). Different digital uses or applications can be identified from the cycle. The next section explains the methodology used to define high-value digital applications and proposes actionable items to pave the road to a Smart Hong Kong empowered by construction digitalisation.

---

[46] Esri China (HK) (2020), Big Data and Smart City.

[47] Lands Department (2020), The Establishment of A Territory-wide BIM Data Repository.

[48] Lands Department, Survey and Mapping Office (2020), CIC Webinar on BIM Talks [Webinar].

8. Approach

The development of the Roadmap has come about through extensive consultations with industry stakeholders. Between 2020 and 2021, surveys, interviews and forums were conducted to gather ideas and create a consensus to drive digitalisation forward, as explained in Figure 8.1.

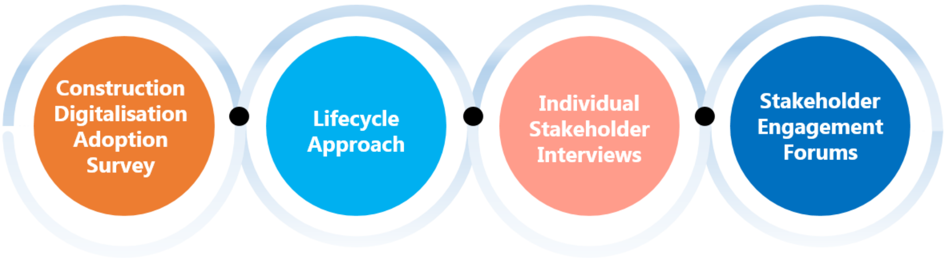


Figure 8.1: Approach for the development of the Roadmap

8.1 Construction Digitalisation Adoption Survey

In early 2021, the CIC commissioned a construction digitalisation adoption survey[49] to understand the current status of construction digitalisation adoption, through the use of digitalisation technologies or tools in recently completed and ongoing contracts, and to evaluate the perceived benefits and obstacles in adopting construction digitalisation. A total of 387 completed responses from 280 contracts/ projects were returned and analysed. The main findings of the survey are summarised:

a) The survey results align with the expectations of industry experts, showing a sizeable portion of project/ contracts have already implemented or are planning to implement digitalisation. 48% of the projects with the survey completed have adopted digitalisation overall. The digitalisation adoption rate in public projects (78%) is much higher than that in private projects (34%). There is huge potential for private projects to harness the benefits of digitalisation.

Figure 8.2: Digitalisation adoption rate

[49] Construction Industry Council (2021), Survey on Adoption of Digitalisation in Construction Projects 2020.

b) In terms of digital tools and technologies, BIM (89%) is the most common type of digitalisation tool implemented (from those who answered they have adopted digitalisation in the project surveyed). As illustrated in Figure 8.3, other tools and technologies which have gained some adoption are Common Data Environment (CDE) (50%), drones (48%), laser scanning (38%) and Digital Works Supervision System (DWSS) (35%). 3D printing and 5G are well known but yet to be widely adopted. While practitioners show an overall high awareness of the technologies, more effort is need to seize the opportunities and convert the awareness to adoption in workflows.

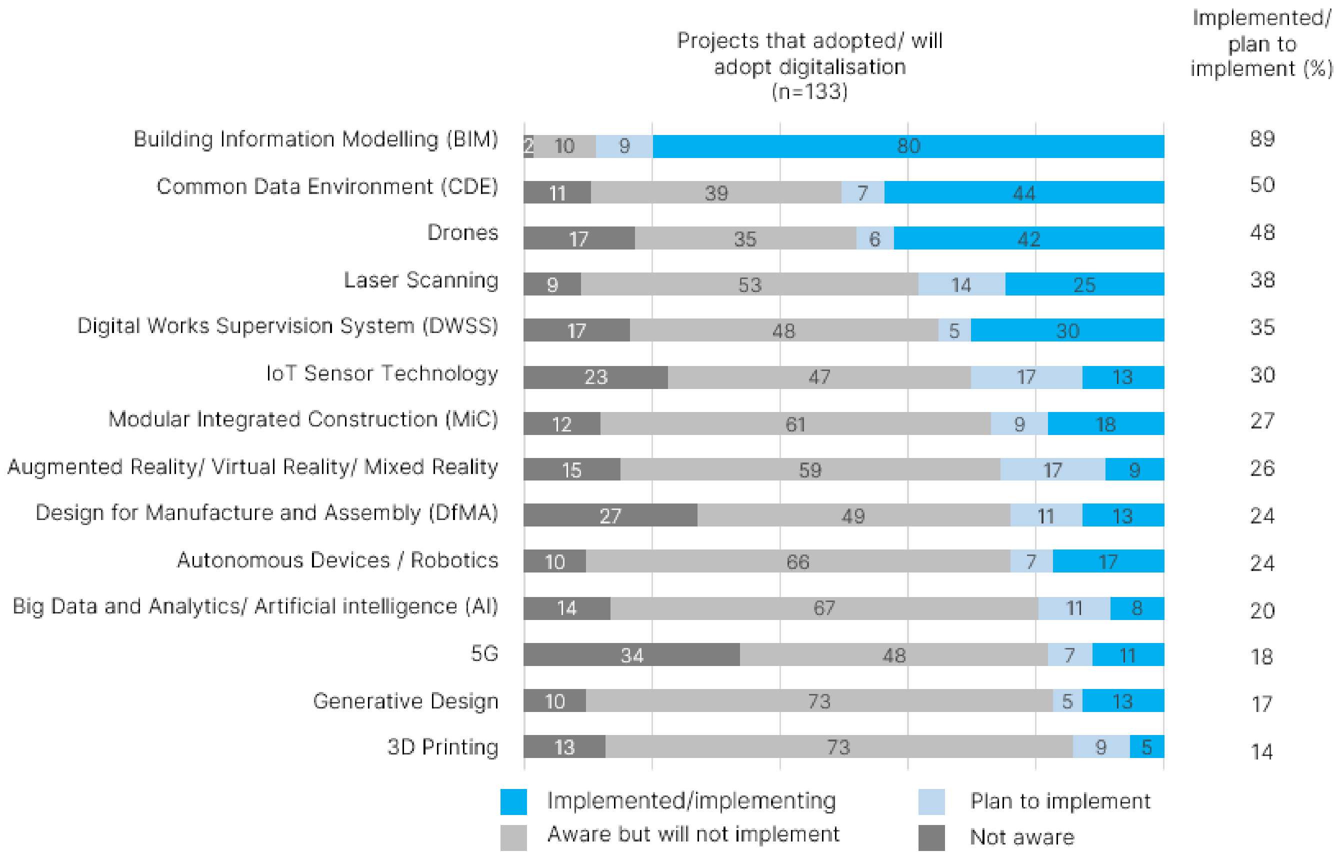


Figure 8.3: Types of digitalisation tools that have been / will be adopted in the project/ contract

c) The current drive for digitalisation is mainly meeting client/ contract requirements (68%) and government policy (63%), as shown in Figure 8.4. Obtaining support from senior leadership (53%) and endorsement from successful cases (46%) also can trigger practitioners to push forward. Heavy competition (34%) is also a catalyst to boost adoption by contractors, particularly in private projects. Government/ Regulators should take these observations into account when developing further policies and measures to promote and facilitate digitalisation.

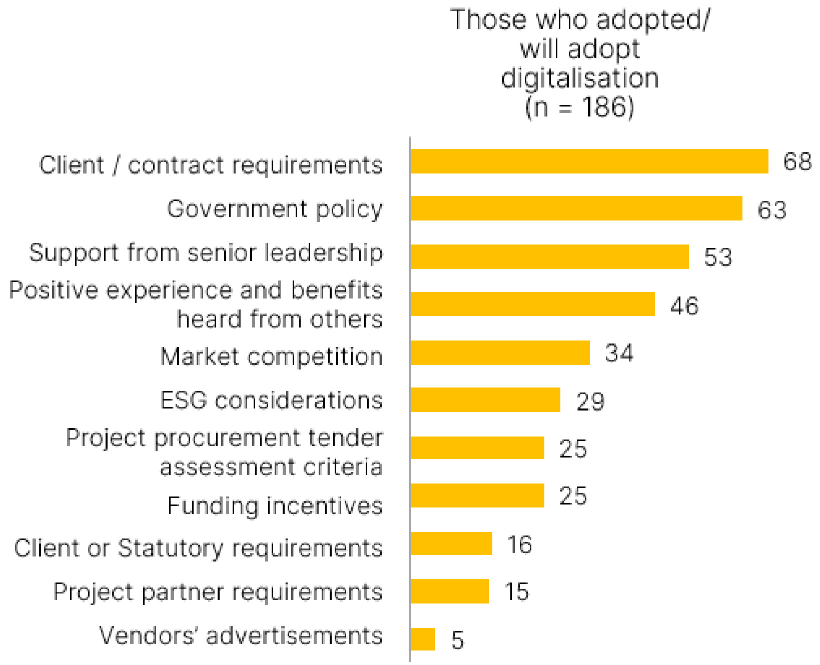


Figure 8.4: Reasons for adopting digitalisation

d) As shown in Figure 8.5, not being a client requirement remains the biggest obstacle in adopting digitalisation (42%). Other main reasons for hindering progress are a reluctance to change the current workflow (35%), lack of talent (35%), training (34%) and capital (32%). Boosting client-driven demand for construction digitalisation may be a viable strategy.

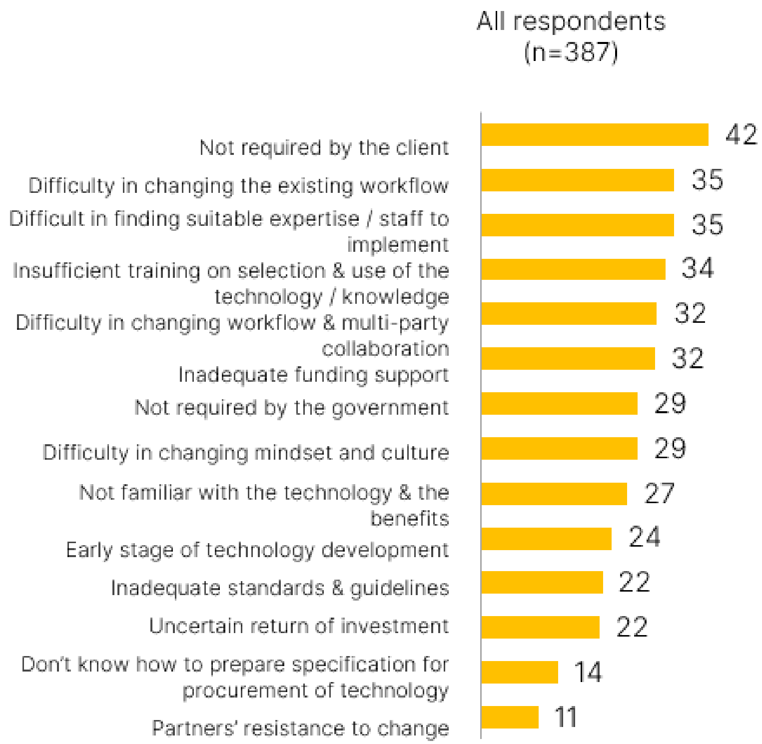


Figure 8.5: Perceived obstacles in adopting digitalisation

8.2 Lifecycle Approach

In-depth desktop research elaborated in the previous sections was conducted to review overseas and local practices of construction digitalisation. This revealed a global convergence towards the adoption of Information Technology in different sectors.

Different information theories were also studied to help formulate a strategic plan in the Roadmap. Innovative technologies will inevitably shift the landscape of the AECO industry. The Hype Cycle[50] illustrates the ups-and-downs of emerging technologies. It provides an overview of how technologies can potentially solve real business problems and exploit new opportunities. It also demonstrates the difficulties in predicting the impact of new innovations and disruptive technologies to the AECO industry in long run.

With reference to the Chartered Institute of Building (CIOB) Code of Practice[51] illustrated in Figure 8.6, the Roadmap opts for a lifecycle approach with three interconnected stages, namely planning and design, construction, and operation and maintenance. Instead of individual technologies, emphases are placed on which decisions and what applications are the most appropriate for different processes of the built asset lifecycle. Digitalisation ameliorates almost every process in the lifecycle through enhanced visualisation, improved cooperation and communication, risk mitigation and standardisation. Another key feature of the built asset lifecycle is the positive feedback loop. Data and information obtained during the operation and maintenance stage (building performance) can influence the decisions to be taken in the planning and design stage of later phases in multi-phase projects, or of new projects (e.g. selection of building materials).

Figure 8.6: Processes of construction project management (Source: CIOB)

---

[50] Gartner (2020), 5 Trends Drive the Gartner Hype Cycle for Emerging Technologies.

[51] Chartered Institute of Building (2014), Code of Practice for Project Management for Construction and Development pp. 7

A wide range of information on digital applications has been collected through a combination of desktop study and the industry's input, with a view to facilitating discussions and demonstrating the potential of construction digitalisation. Figure 8.7 displays a non-exhaustive list of digital applications during a built asset lifecycle.

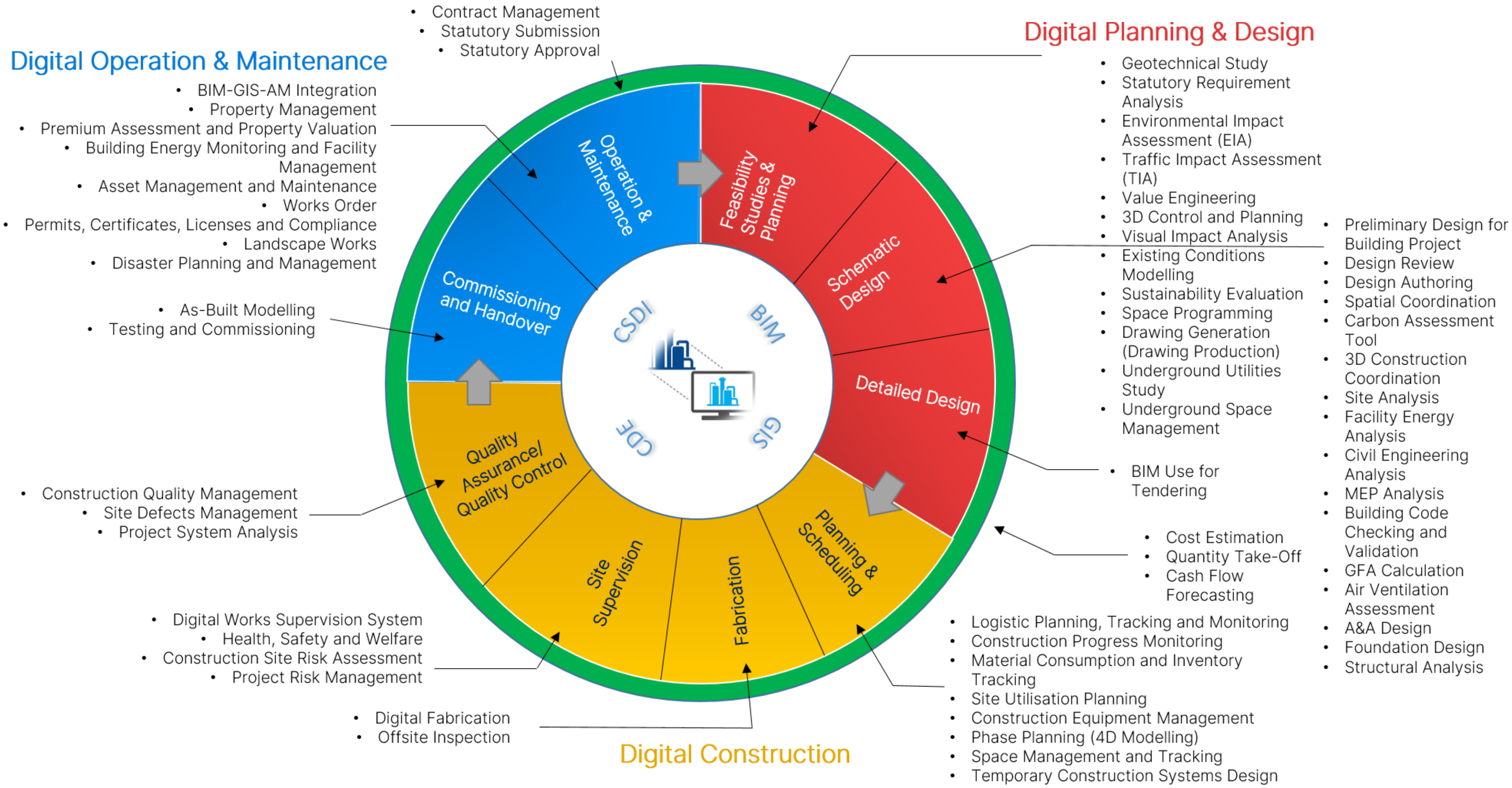


Figure 8.7: Digital applications during a built asset lifecycle

8.3 Evaluation Matrix

A sound evaluation system is needed for prioritisation and determining focus areas of the Roadmap. Here, the Technology Acceptance Model (TAM)[52] developed by Fred D. Davis is referenced. The TAM is a commonly-used information system theory for testing users' acceptance toward new technology. Davis proposed two key beliefs: perceived usefulness, which is defined as "the degree to which an individual believes that using a particular system would enhance his or her job performance"; and perceived ease of use, which is defined as "the degree to which an individual believes that using a particular system would be free of physical and mental effort." The TAM provides a theoretical basis for explaining the causal relationships between usefulness, ease of use, and technology adoption.

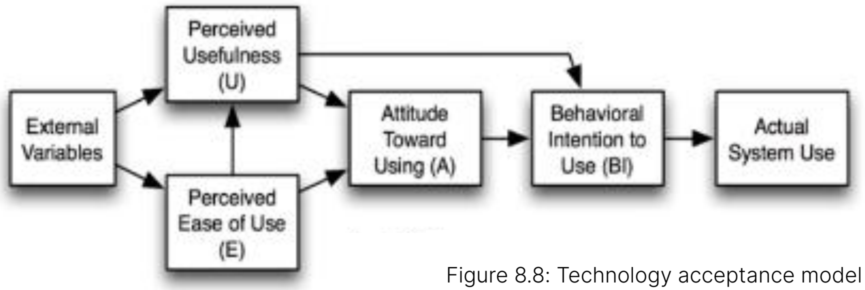


Figure 8.8: Technology acceptance model

The parsimonious TAM model[53] has inspired the evaluation matrix used in the Roadmap. Each digital application was assessed and rated for Value (based on perceived usefulness, to indicate the benefits and extent of usefulness) and Readiness (based on perceived ease of use, to indicate the state of preparedness).

Value was grouped into four levels: Society, Industry, Organisation, and Project, while Readiness was categorised into five macro-environmental levels: Policy, Resource, Solution, Process, and Market. The table below lists factors to be considered for each level and provides an overview for assessing corresponding conceptual variables.

Value	Factors to be considered
Society Value	• Contribution to smart mobility, smart living, smart people, smart government, smart environment and smart economy?
Industry Value	• Development of innovation, professionalisation and revitalisation? • Improvement to industry safety, sustainability, productivity and quality? • Business opportunities and increased global competitiveness?
Organisation Value	• Positive impact on organisation image? • Bringing in new business opportunities? • Increased competitiveness? • Better resource management?
Project Value	• Improvement to project time, cost and quality? • Better project risk management?

[52] Davis, F. D. (1985), A Technology Acceptance Model for Empirically Testing New End-User Information Systems.

[53] A parsimonious model explains data with a minimum number of parameters, or predictor variables.

Value	Factors to be considered
Readiness	Factors to be considered
Policy Readiness	• Policy in place? Required by owners? • Standards/ guidelines/ specifications available? • Recognised best practices?
Resource Readiness	• Adequate skilled/competent persons? • Appropriate training courses available? • Funding schemes available?
Solution Readiness	• Off-the-self software/ plugins available? • Relevant technology/ hardware developed? • Open source platform available?
Process Readiness	• Clear workflow for the process to be digitalised? • Commonly-agreed processes in place?
Market Readiness	• Demand/ level of interest in the technology/ product? • Potential penetration rate achievable? • Acceptable price range? • Willingness to pay at various price points?

With these measurements in mind, each digital application was then reviewed and fine-tuned according to industry experts' comments. Different digital applications tend to have some degree of overlap in their actual functionalities. This is to be expected as they may be addressing the same underlying problems from the perspectives of different professions. As a result, some digital applications were modified or merged to reflect actual construction practice. After deliberation, the following six high-value digital application areas were chosen as the focus areas of the Roadmap:

- Smart Data Sharing
- Smart Planning and Design
- Smart Submission with BIM
- Smart Offsite Fabrication and Delivery
- Smart Site Management
- Smart Asset and Facility Management

In summary, essential digital application areas were first identified in the lifecycle of a built asset. The Value of each digital application area was then evaluated to determine the priorities. The Readiness of each digital application area was subsequently evaluated to identify "Quick Wins", medium and long term goals and actions. The six selected high-value digital application areas are elaborated in detail in Section 9.

8.4 Individual Stakeholder Interviews

25 individual industry professionals were interviewed to provide expert input in the fourth quarter of 2020. The interviewees were from different disciplines and organisations, including Government Bureaux/ Departments, professional bodies and learned societies. In the interview, stakeholders were asked to share their vision on construction digitalisation and which of the digital application areas listed in the above diagram are of high value. The results of these interviews are summarised as follows:

a) Different digital applications were brought up when the interviewees shared their assessment on the Value and Readiness of the highlighted applications. In addition, some digital applications were either added, removed, renamed, or merged to reflect the uses in actual construction practice and aligned in the context of the Roadmap.

b) Several interviewees mentioned the nature of Hong Kong's construction industry as highly fragmented with a low level of integration. Networking with other global institutes and implementing global standards (e.g., ISO 19650) can alleviate part of this problem and it is considered crucial to develop a unified standard or platform.
c) The interviewees also shared their views on pain points throughout the different processes in the built asset lifecycle. During early design stages, the lack of a centralised platform to collect utility data commonly resulted in double handling and had a negative impact on the efficiency of resource allocation. During the construction stage, smart site management can help to achieve a more efficient paperless and automated system, e.g. through the use of RFID tagging, Digital Twin, drones, and IoT.
d) One recurring theme of the interviews is the importance of digitalisation for the whole built asset lifecycle. BIM and GIS should serve as a backbone infrastructure of digitalisation. Use of digital information and technology should be outcome-driven. Companies should change their mindset to utilise these technologies and digitalise all essential processes.

8.5 Stakeholder Engagement Forums

In March 2021, 6 Stakeholder Engagement Forums were organised to collect industry feedback and attracted a total of 117 participants. Findings from the previous individual interviews were presented. Stakeholders provided their comments and participated in polling on the preferred strategies, focus areas and action items of the Roadmap. To facilitate discussion and encourage experience sharing, the 6 Forums were divided as follows, based on various stages of the built environment lifecycle as well as specific professional perspectives:

- Design Stage
- Construction Stage/ As-built Stage
- As-built Stage/ Operation Stage
- Government Perspective
- Developer/ Quasi-Government/ Utility/ IT Perspective
- Academic Perspective

The main findings from the engagement forums were:

a) Stakeholders agreed on the proposed directions of the Roadmap and the CIC's core strategies to support construction digitalisation. In particular, stakeholders overwhelmingly ranked Policy, Standards & Reference Materials, and Changing Mindset as the top 3 most important strategic areas.
b) The vast majority of industry stakeholders (>90%) agreed on the proposed 6 focus areas of the Roadmap. Stakeholders supported Smart Data Sharing as the foundation of construction digitalisation, and perceived other digital applications as capable of riding on and utilising CSDI, CDE, BIM, and GIS.
c) Stakeholders also shared experiences and benefits on real-life applications of construction digitalisation, such as BIM-FM integration at Hong Kong International Airport Terminal One, which highlighted the adoption of smart site technology to enhance health and safety.
d) A few stakeholders expressed concerns on the implementation and potential drawbacks of digitalisation, such as data ownership, security, accuracy, legal liability, extra workload, etc. These concerns are well reference material and will be addressed when developing the CIC's future strategies and work.

After consolidating expert inputs from the stakeholder interviews and engagement forums to assess the Value and Readiness of Digital Application Areas (DA), 6 high-value DAs were identified, as illustrated in Figure 8.9.

A DA is not necessarily limited to one particular stage of the built asset lifecycle. As an example, digital technologies can smoothen logistics workflow from planning to manufacturing to delivery and on to installation.

Smart Data Sharing is the "core" of construction digitalisation. Both Common Spatial Data Infrastructure (CSDI) and Common Data Environment (CDE) can facilitate collaboration among all stakeholders on a city or project level. Every stakeholder can contribute information to and extract information from the central portal. By enabling a seamless flow of information among stakeholders across the built asset lifecycle, Hong Kong's construction industry will transition to a new digital era and the industry know-how will be continuously built up.

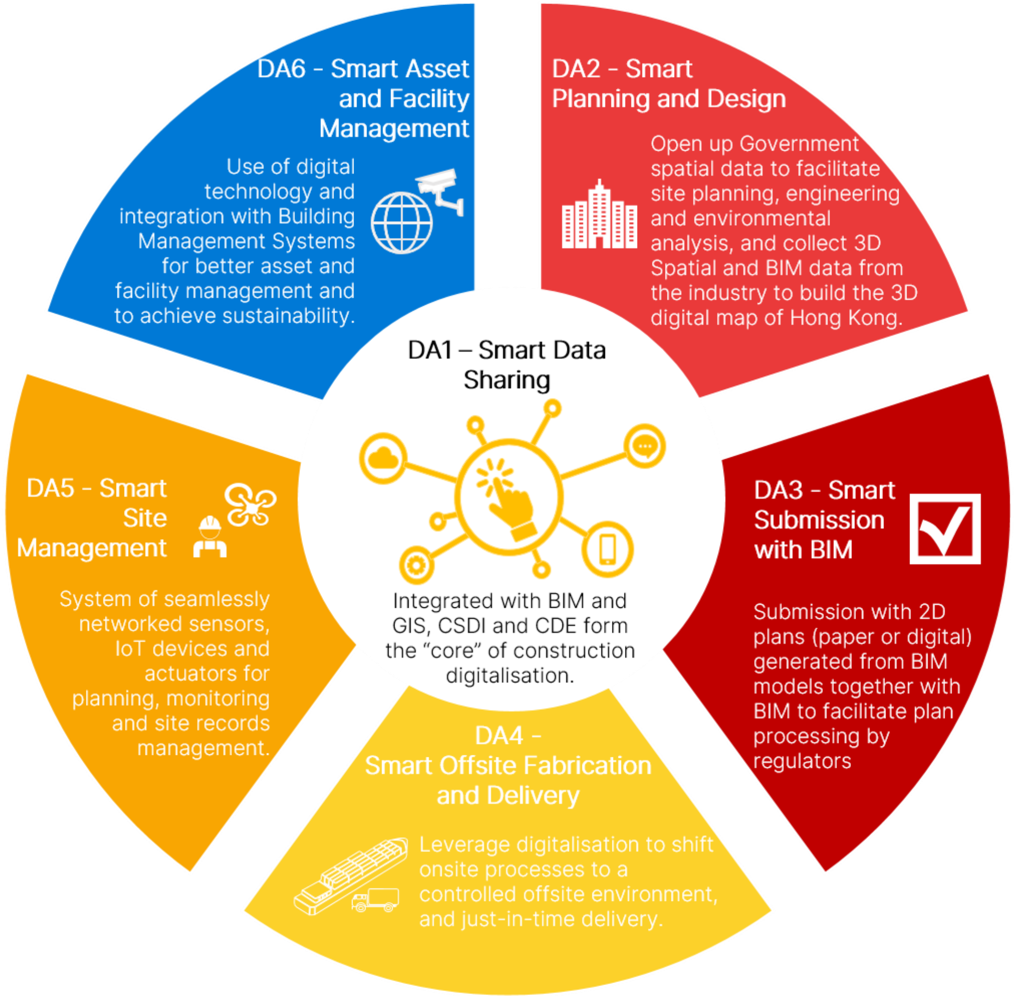


Figure 8.9: 6 High-value Digital Application Areas (DAs)

8.6 Impact Diagrams for Digital Application Areas

A tailored impact framework[54] was created for delivering the vision of the Roadmap. The framework provides a structured and consistent approach to define actions and deliverables. The steps used in creating the framework are summarised as follows:

1) Identifying Vision and Goals

Section 2 defines our vision as "all processes involved in the built asset lifecycle are streamlined and digitalised to continuously improve productivity and safety during planning, design, construction and operation, and sustainability for better quality of life." The goals offer achievable targets or milestones, and help to identify "quick wins". The proposed action plan needs to have a direct impact on the goals.

2) Identifying Actions and Deliverables

With clear impact goals, different strategies such as "Funding Support", "Research & Development" and "Capacity & Capability Building" help in devising associated action items.[55] Identifying actions and deliverables enables the CIC and other action parties to better prioritise their time and resources.

3) Monitoring and Reflection

As time progress, new information will come to light which may create positive (or negative) impacts. Regular monitoring and reflection allows for flexibility and facilitates changing action items where necessary in light of the latest developments.

A sample impact diagram is shown in Figure 8.10. The boxes and arrows in the figure demonstrate how actions can be inter-related and contribute to the ultimate vision. An impact diagram sets out specific actions which should take the industry closer to achieving the vision of the Roadmap. The impact diagrams and proposed action items for each DA set out in Section 9 will be continuously updated and supplemented as the Roadmap is taken forward.

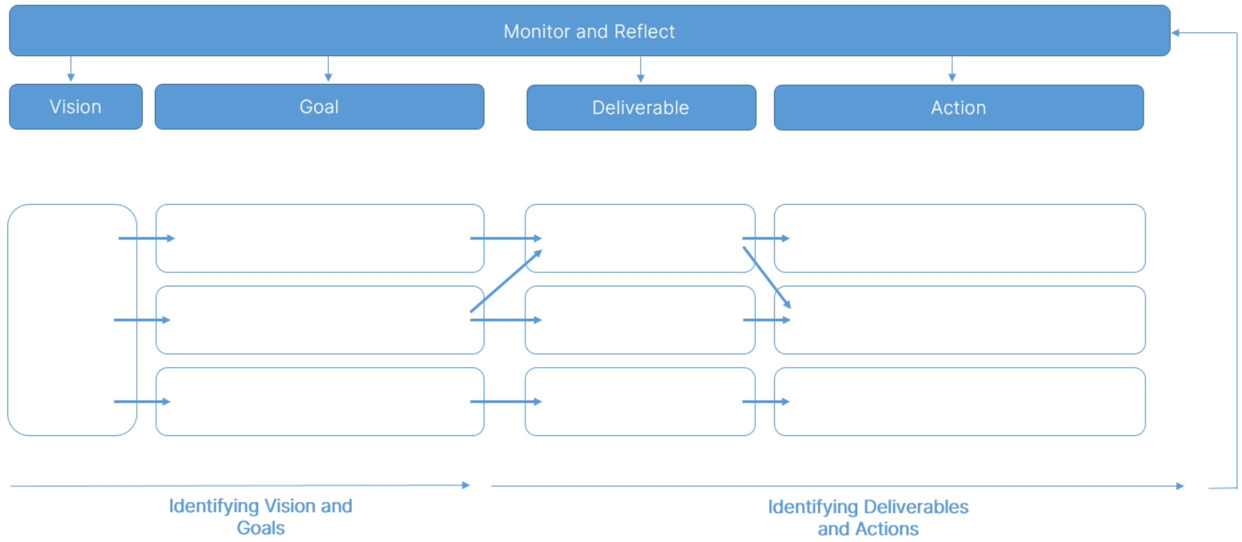


Figure 8.10: Sample Impact Diagram

[54] Godsell, J., Kaya, L., Glass, J., Plante, D., Hanselmann, L., McGilvray, J. (2020), Creating Impact from Research, Transforming Construction Network Plus.

[55] Nine core strategies to support construction digitalisation are elaborated in Section 10.

9. Digital Application Areas

9.1 DA1: Smart Data Sharing

Overview

Common Spatial Data Infrastructure (CSDI) is an information infrastructure to promote the sharing of spatial data and support the development of various smart city applications. It facilitates linkage and integration of spatial data from various government departments and that of the whole territory. It provides a common platform for integration and exchange of geospatial information, which is conducive to the provision of reliable spatial data services for the efficient use of resources, development of a smart city and sustainable development.

Common Data Environment (CDE) allows integrated and cross-disciplinary access to federated BIM (building data from built asset lifecycles), GIS (spatial and geographic data) and other data. The data are exchanged through an agreed and standardised protocol, while remaining under the control of the respective owners. The ISO19650 standard defines CDE solutions and workflows for managing information during asset management and project delivery.

Project CDEs can contribute to the development of CSDI by providing simplified BIM data covering features, including walls, ceilings, floors, stairs, lifts, common corridors, indoor routes, and textual attributes. BIM geo-spatial data such as spatial information, views, site information, statutory planning restrictions, development parameters and floor uses, can also be retrieved from the BIM models and CDE.

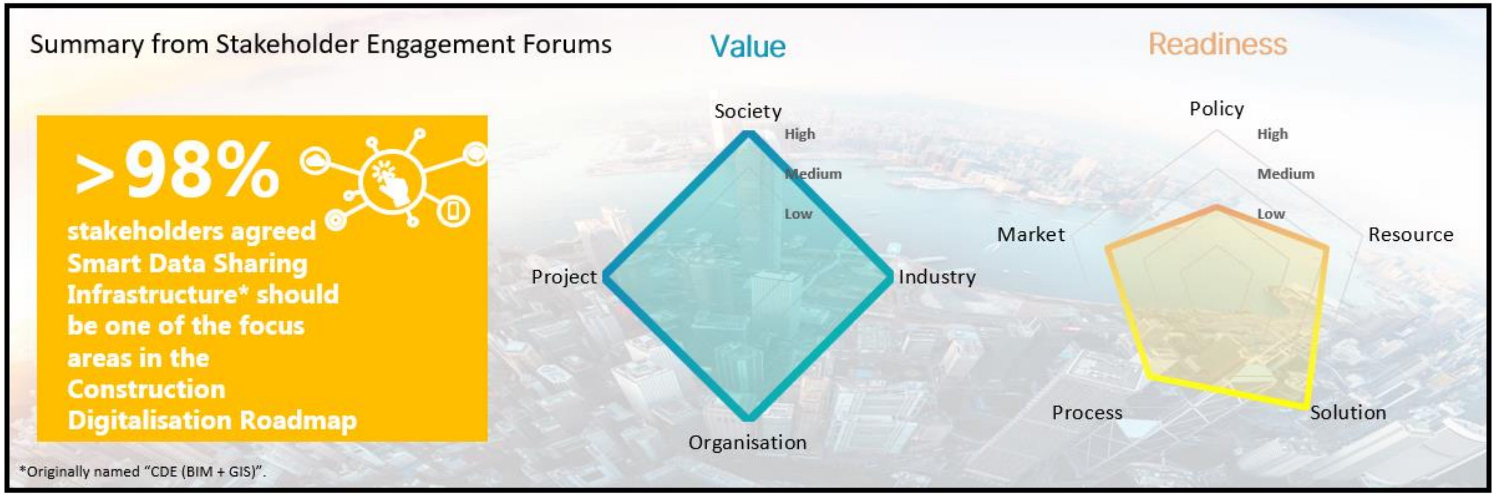


Figure 9.1: Summary from stakeholder engagement forums (Smart Data Sharing)

Digital Use Cases

9.1.1 Common Spatial Data Infrastructure (CSDI)

The CSDI portal is one of the key digital infrastructures underpinning smart city development in Hong Kong. It gathers all data related to people's livelihood on a single platform and facilitates innovation.

Currently, different government departments and individual public and private organisations collect and maintain their own sets of spatial data, despite some of the data being made available for public use. In the 2019 Budget, the Financial Secretary earmarked $300 million for setting up a common spatial data infrastructure (CSDI) and three-dimensional (3D) digital map, with $150 million for each of the two initiatives. The Government aimed to launch the full operation of the CSDI portal, with a number of standardised spatial datasets for public use, by the end of 2022. Ultimately, this should facilitate wider use by the general public and improve efficiency in city management.

"In addition to the benefits of the application in the approval processes, the CSDI can also facilitate the availability of spatial data for government, business, academia, and the general public. Potential applications benefiting the government could be Smart Living and Smart Government. For the wider community, the examples shall extend to Smart Mobility, Smart Environment and Smart Economy".[56]

9.1.2 Common Data Environment (CDE)

"A CDE solution and workflow support the information management process. It can include both a database management capability to manage information container attributes and meta-data, and a transmittal capability to issue update notices and maintain the audit trail of information handling."[57] [58] A CDE reduces time and cost in producing coordinated information and ensure data accuracy, thus complementing to the development of CDSI (e.g. ensuring the data quality of as-built information contributing to the CSDI). The ISO 19650 standards give detailed explanations on the organisation and digitisation of information, as well as on the delivery and operation phases of assets.

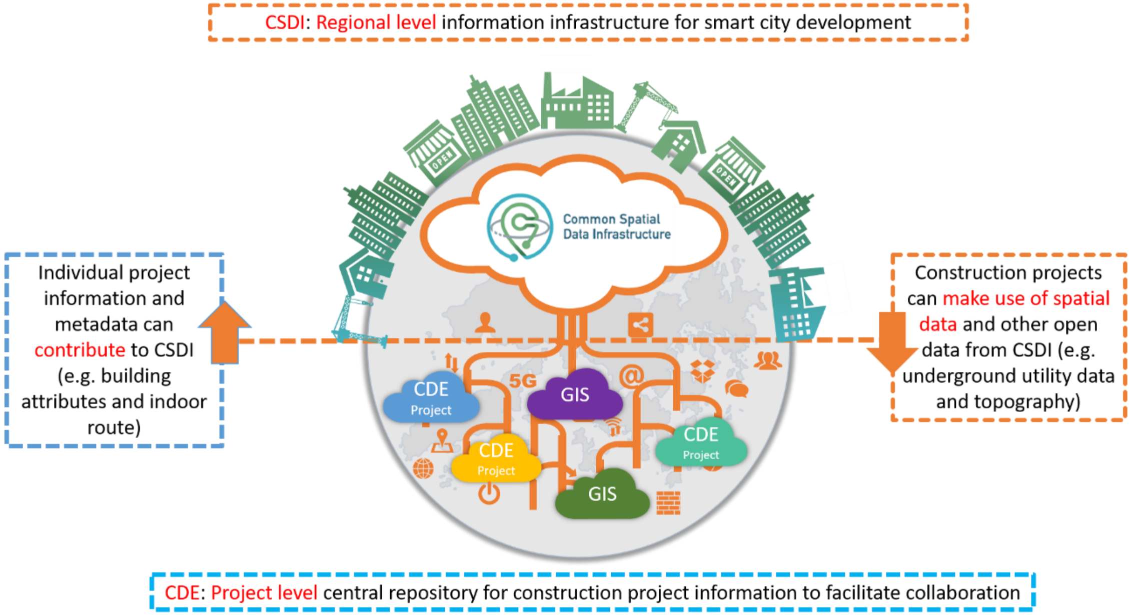


Figure 9.2: Synergies between CSDI and CDE

[56] Construction Industry Council (2021), A Practical Systems Approach for Hong Kong to Re-invent itself as a Leader in Construction Productivity, Innovation and Expertise.

[57] British Standards Institution (2018), BS EN ISO 19650-1:2018.

[58] For more information on CDEs across different lifecycle stages, please refer to Construction Industry Council (2020), CIC BIM Standards - General (Version 2 - December 2020) p.101.

9.1.3 Open Data

Despite the abundance of data, previously there was no mechanism or guidelines to share these data for smart planning and design. The CSDI rectifies the issue by providing a centralised platform to host and share the data, particularly data from the public sector. The Government also announced an open data policy in 2018 to promote smart city development. Under the policy, an increasing volume of data from the public sector will be gradually released for free public use on the Public Sector Information (PSI) Portal to facilitate innovation and research, bring benefits to the public, and promote economic development, unless there are justifiable reasons such as involving personal privacy. As an example, over 1,351 datasets have been shared by the Development Bureau and the six Works Departments as of the end of 2020[59], as summarised in the following table:

Data Provider	Number of Datasets	Number of APIs
Architectural Services Department	40	0
Civil Engineering and Development Department	32	0
Development Bureau	32	4
Drainage Services Department	87	0
Electrical and Mechanical Services Department	864	0
Highways Department	28	6
Water Supplies Department	268	2

[59] Office of the Government Chief Information Officer (2021), List of Datasets for Open Data.

9.1.4 Data Standard

As the industry migrate to digitalisation, data standard, data quality and data management should not be ignored.

A data standard describes how data should be stored or exchanged for consistent collection and interoperability of the data across different systems, sources, and users. Ideally, data and information shared should be in an open machine-readable and standardised format (e.g. BIM information should align with the CIC BIM standards, BIM model format should align with the Industry Foundation Classes (IFC); GIS information should align with the CityGML). Use of APIs allows different platforms, applications and systems to be connected and to share information with each other. The CSDI serves as a clearing house and gateway portal for dissemination, discovery and API access of spatial data.

The Civil Engineering and Development Department (CEDD) has commissioned a study on BIM horizontal harmonisation for BIM/GIS integration under the First Phase Development of the Kwu Tung North and Fanling North New Development Area (KTN and FLN NDA). The objective is to carry out the BIM harmonisation and to setup a BIM Data Repository in this study to identify the technical specification, requirements and other related business mechanisms for BIM adoption. In the long run, the standardised BIM and GIS data could be potentially shared at the CSDI.

9.1.5 Challenges in Data Sharing

At present there is a lack of incentive for industry practitioners or data owners to share data, as it may incur additional operational costs and many stakeholders do not understand the benefits of sharing data. For private practice stakeholders, common platforms or repositories for data sharing are lacking because of the perceived high upkeep cost. Private organisations may not be willing to host a platform storing data provided by other business competitors. Neutral data agents for individual disciplines may be required to overcome these obstacles. Moreover, most data available in the industry do not include metadata, which creates uncertainty and accuracy issues for both data providers and users. In return, data providers are less inclined to share data. These issues, such as data ownership, accuracy, legal liability and security of shared data, are challenging and deserve to be carefully considered in further development and promotion of digitalisation initiatives.

9.1.6 BIM and GIS Data for CSDI and CDE

The CSDI is a single integrated platform for the storage of important data from various sources and has the potential to greatly improve efficiency and reliability for design and approval. Collaboration and continuous communication amongst government bureaux and departments to identify data-sharing opportunities is a key to success. The CSDI is formed using many types of information provided by the public, such as city infrastructure, landscape, building information, construction project data, etc., and has much potential for solving major problems common to every metropolis, e.g. traffic congestion, urban redevelopment and the heat island effect.

The CSDI and CDE have beneficial relationships that complement one another. The combination of CSDI, 3D digital maps, GIS and BIM, along with IoT technology and 5G networks, will lay the foundation for Hong Kong's digital transformation, according to HKIS experts.[60] For instance, GIS can show many different kinds of data on one map, e.g. streets, buildings, and landscape, while BIM can provide building information for indoor and outdoor maps and escape route information to the CSDI, with all the data defined to a unified set of terminology and taxonomy, effectively created in standardised formats, and stored and maintained within a CDE.

Imagine a BIM-based intelligent fire prevention, alarm and escape routing system in action: when a fire is detected somewhere in the building, the system will immediately signal the property manager and the local fire station, pinpointing the exact location where the fire first broke out. It will also send alerts to the building occupants' smartphones, showing them the shortest and safest escape route. Integrating these messages within a single system facilitates fire rescue and control efforts, and enhances overall building safety and disaster response capabilities. BIM can also be integrated with asset management, resource management and project management to help building owners devise further models to enhance asset management as well as provide better customer service.[61]

Integration of BIM and GIS is further elaborated in Section 9.2.

6 action items (and 2 action items related to data protection and cyber security) are recommended in the Roadmap to support the development of Smart Data Sharing (DA1) as illustrated in Figure 9.3.

[60] Shiu, W. (2020), Surveyor Times Vol. 29 (2020).

[61] ibid.

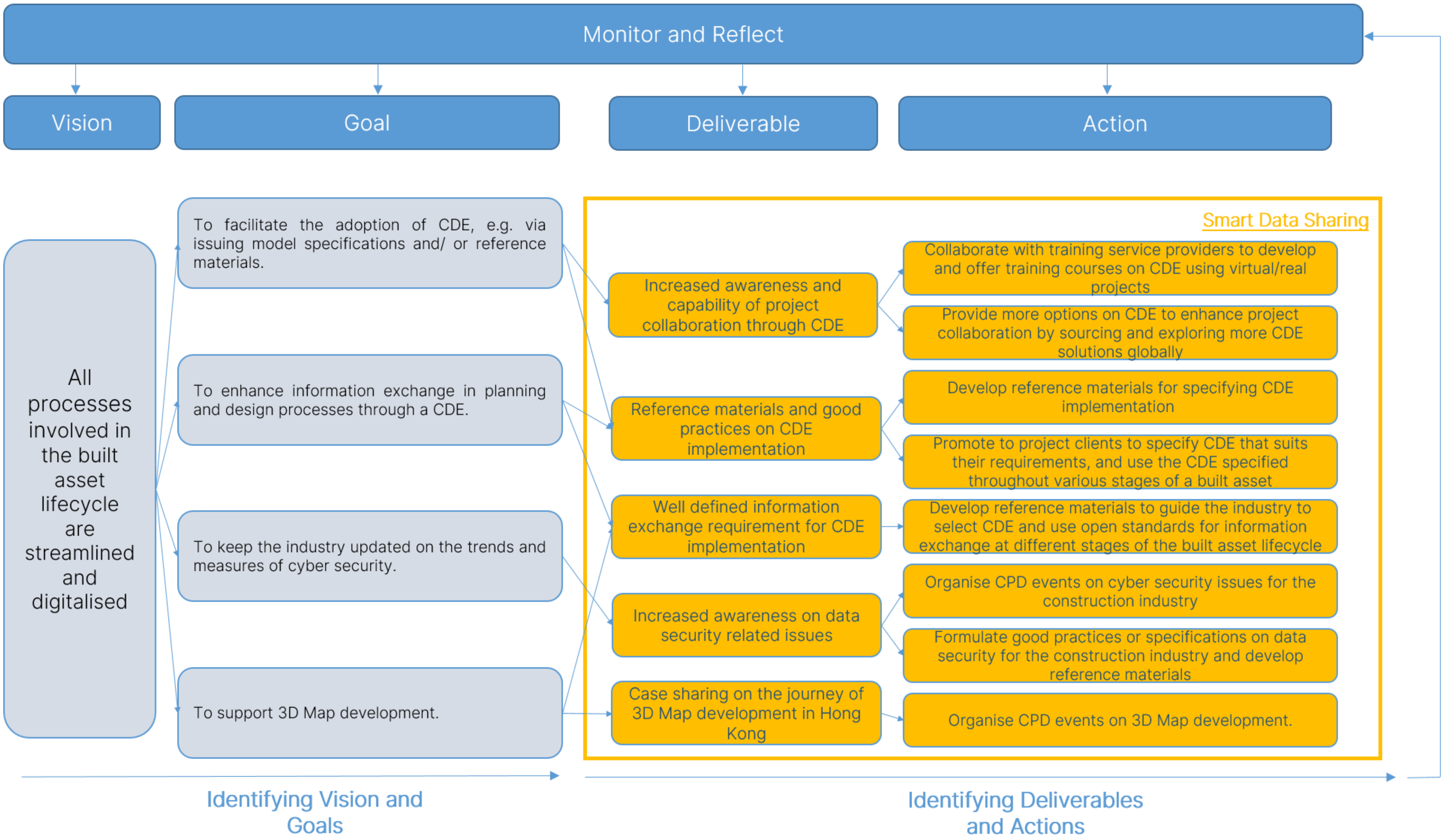


Figure 9.3: Impact Diagram for DA1: Smart Data Sharing

9.2 DA2: Smart Planning and Design

Overview

For planners, architects, and engineers, the use of digital tools to assist environmental and engineering analysis has already become a common practice. In 2020, the CIC commissioned a "Consultancy Study on the 3D Spatial and BIM Data Use Case Requirements of the Hong Kong Construction Industry" (hereafter known as the "Digital Hong Kong Study"), by identifying and collecting different 3D spatial and BIM data use case requirements from the local construction industry. Use cases of BIM, GIS, 3D spatial data and other kinds of geospatial data are covered by the study, which aims to facilitate 3D spatial and BIM data sharing, BIM and GIS integration, and development of a 3D Map representing the built environment for the Digital Hong Kong.

These 3D spatial and BIM data can be further leveraged through a series of engineering and environmental analysis software and tools. Accurate and reliable data can open up new opportunities for digital planning and design, e.g. for simulation and automation of design processes, and design optimisation given different parameters and constraints. Therefore, releasing open public sector data, and collecting geospatial and BIM data from the industry, form the two cornerstones of smart planning and design.

Digital Use Cases

To successfully address those digitalisation of construction, it should start from the planning and architectural design stage for the development of buildings and infrastructure projects. In the beginning, topographic and survey data on 3D-GIS platform are used with support of geospatial technologies for land use planning and building design with the aim of addressing the development parameters - physically, environmentally, economically and societally.

With BIM and related technologies (such as virtual and augmented reality tools), a wide range of design options can be generated for evaluation with the use of digital analytics tools prior to construction in terms of building performance validation, environmental assessments (ventilation, lighting and acoustic), circulation studies (vehicular and pedestrian), risk analysis (health, security, fire, flooding, emergency, etc.), buildability in construction (including logistics and supply chain management) ,property valuation (budget and return of investment) and sustainability (waste management, carbon emission).

The as-built information after project completion of the development can be used for facility or asset management. The as-built models combining with other building blocks and infrastructures in the region will help to build the base for the development of a smart city, such as urban space planning for activities, preservation of historical buildings, monitoring of parking facilities, reduction of carbon emissions, thermal property of the region, wind tunnel and street canyon effect in

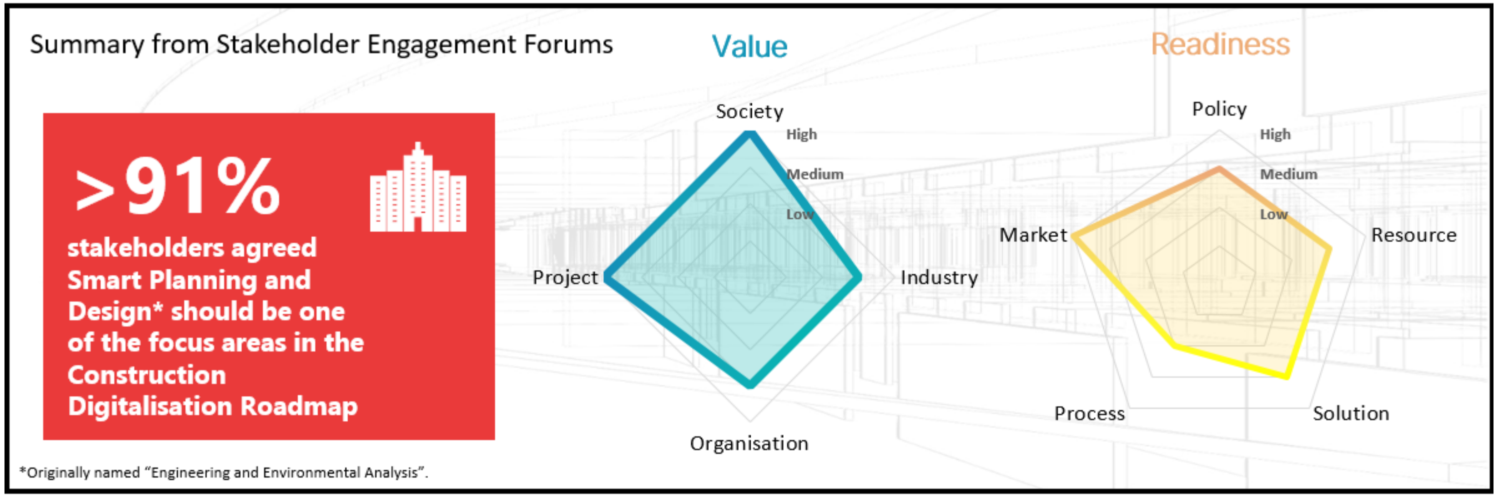


Figure 9.4: Summary from stakeholder engagement forums (Smart Planning and Design)

the surrounding, noise abatement measures, waste treatment, city management, etc., in the built environment.

Overall, digitalisation will create better design outputs for clients and achieve benefits of lowering project costs (both design, construction and future operation and maintenance), saving development time, increasing productivity, facilitating better collaboration and information coordination, meeting sustainability and construction safety requirements, thus providing better built environment for quality living and supporting businesses.

Planning and Design is a very broad area, with numerous options and possibilities to take advantage of 3D spatial and BIM data. This section summarises the results and major findings of the above-mentioned “Consultancy Study on the 3D Spatial and BIM Data Use Case Requirements of the Hong Kong Construction Industry” (hereafter known as the “Digital Hong Kong Study”).[62]

9.2.1 BIM-GIS Integration for Engineering and Environmental Analysis

Various types of 3D or BIM data are generated during different stages of the built asset lifecycle. Use of design and construction data with a geospatial context provides better situational awareness. Through analysing broader environmental, demographic, and economic factors surrounding building locations, understanding of initial conditions can be improved. This in turn should allow more efficient planning, operation, maintenance and performance evaluation.

A geographical workflow can also be established to enhance visualisation and communication, allowing stakeholders to understand the impacts of structures in the built and natural environment. BIM-GIS enables collaborative workflows that minimise data loss and reduce inefficiencies. In this way architects, engineers, BIM and GIS teams can make more informed decisions to accelerate project delivery and improve overall operations, and this also helps to remove information silos.

In UK, the complex £15 billion Crossrail project uses BIM and GIS to manage hundreds of simultaneous programmes of work and account for millions of new assets. The organisation responsible has created a range of web, mobile and 3D GIS apps that help manage cost efficiency, ensure site safety and share information securely. BIM and GIS data has been a key building block in all phases of the project.

In Hong Kong, the Lands Department is spearheading the development of BIM-GIS integration to support government applications by defining the specifications and standards for BIM-GIS integration, providing professional and technical advice on data sharing, and developing the adoption of international open standards for BIM and GIS.

9.2.2 Underground Utilities Study and Space Management for Planning and Design

Improved knowledge and management of Underground Utilities (UU) data is one of the top wishes from stakeholders in the Digital Hong Kong study. Hong Kong’s underground space is becoming increasingly congested due to rapid growth of underground works over the past decade. Engineers and contractors often conduct extensive UU surveys to collect information on the prevailing underground conditions. The objectives of UU surveys are to avoid damage to existing utilities, delays in emergency repairs and excavation works, and improper use of space. Currently, master plans submitted for land licence applications and road opening plans submitted for Excavation Permit (XP) application do not show detailed records of UU

[62] Construction Industry Council (2020), Consultancy Study on the 3D Spatial and BIM Data Use Case Requirements of the Hong Kong Construction Industry.

installations. Even the Highways Department (HyD) may not possess sufficient UU information to assess whether sufficient underground space is available and determine whether new excavation works should be allowed.

Reliable UU records, especially in 3D-GIS format, can enable designers to conduct clash analysis and network tracing. Using various proprietary software, the 3D geometry of as-built UU can be compared with proposed new design installations. Spatial coordination can be performed to ensure an optimal design that maximises space efficiency, design performance, and avoidance of damage to existing UU. At the moment, most UU records are not kept in 3D format, in particular the depth of the UU. The lack of precise data on depths and sizes of existing UU risks errors and uncertainties when designing new UU installations or excavation works.

As-built records of UU are usually available as 2D drawings shared in PDF format, which is not computer decipherable. The absence of a universal drawing standard poses difficulties when designers attempt to examine the as-built underground condition.

The Audit Report 70 Chapter 4[63] recommended Government to explore the development of an effective management and control system over underground space occupation. An essential first step toward the said recommendation involves developing geo-enabled utility data models and IT system for enabling data interoperability and integration. The essential foundation allows geo-enabled data to be created, shared, and integrated seamlessly for many different domains and applications. Highways Department (HyD) engaged an IT contractor to develop a prototype to prove the concept of such a system, and HyD's IT contractor has submitted the final report for the prototype of the Utility Management Information System (UMIS) by the end of 2020. Riding on the prototype, LandsD takes forward the initiative of developing the UMIS.

The Digital Hong Kong Study recommended establishing a centralised data sharing platform in Hong Kong in the long run. With appropriate supporting policy and standards, workflows for sharing and accessing UU data can be simplified and streamlined while ensuring data quality.

Ideally the UU data platform should support 3D as-built data. Pilot areas such as New Development Areas could become early data sources of 3D as-built UU models in order to build up a library of 3D UU data in Hong Kong. Existing UU records, after appropriate digitisation and data quality assurance, could also be shared across the centralised platform.

9.2.3 Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA) provides information on the nature and extent of the environmental impacts of new construction and operation to the surrounding environment during the planning stage of a project. An EIA will usually include a mitigation plan to minimise and control any adverse impact on the environment. Alternative design options and improved technologies are also taken into account during EIA so as to minimise risks and impacts on people and the environment. Common examples of EIA include assessments of air quality impact, noise impact, water quality, and landscape and visual impact.

Visualisation of parts of EIA presentations (e.g. during terrestrial ecology assessment) allows clients to gain a better understanding of the negative impacts of proposed construction processes on the environment and can leave a deep impression. Moreover, non-technical members of the audience and the public can readily appreciate the likely impacts on the surrounding

[63] Legislative Council (2018), Report Of The Public Accounts Committee On Report No. 70 Of The Director Of Audit On The Results Of Value For Money Audits (2018).

environment. This enhances public engagement and helps to create mutual benefits for relevant stakeholders.

With the use of digital tools and new technologies, there is much potential for digitalisation of EIA to streamline the process of data collection and EIA production. Digital EIA allows better collaboration and engagement, provides transparency in work processes and promotes a culture of collaboration between stakeholders. It also enhances efficiency by reducing time spent on tracking changes. Digital EIA enables better environmental planning, mitigations and modifications to be taken to minimise adverse impacts and enhance sustainable development. By ensuring the design is in compliance with environmental standards, digital EIA can reduce the likelihood of penalties being imposed and loss of credibility. Costs of remedial treatment and compensation to society could also be minimised.

In the long run, the Digital Hong Kong Study recommended the creation of a centralised data sharing platform where all stakeholders can access, contribute and exchange raw data during the EIA process and help to improve the information flow for new projects.

9.2.4 Geotechnical Study

Through obtaining information on the physical properties of the existing ground and proposed earthworks, such as soil and rock conditions, geotechnical studies provide an essential basis for smart planning and design of proposed developments. Geospatial data also enables risk assessment for estimating the consequences of geotechnical failures, including consequence to human life and economic consequence. Appropriate mitigation strategies will then be proposed to minimise landslide risk, through studies such as Natural Terrain Hazard Studies (NTHS), which assess the landslide hazard types and scale and the impact on the population, nearby roads and infrastructure of existing and new development, and Man-made Slope Stability Assessments, which assess potential landslide risks from man-made features such as cut slopes, fill slopes and retaining walls that affect developments.

An open platform "GEO Data for Public Use" was launched in 2020 by GEO, CEDD.[64] As illustrated in Figure 9.5, this platform hosts digital and GIS data such as Ground Investigation (GI) and Laboratory Test (LT) records, GEO raingauge data, and locations of landslide incidents, to name a few. The data are available in formats such as FGDB and CSV for public download. LiDAR topographic data can also be obtained upon request due to the large file size. More geological and other site investigation-related data is expected to be shared on the platform in the near future.

Figure 9.5: GEO Data for Public Use (Source: CEDD)

[64] Geotechnical Engineering Office, Civil Engineering and Development Department, GEO Data for Public Use.

9.2.5 Traffic Impact Assessment (TIA)

Traffic Impact Assessment (TIA) examines the potential impacts of development projects on the transport, efficiency and safety of adjacent roads. It is integral to traffic management plans that help to minimise externalities and mitigate traffic congestion. Aside from traffic impacts on the efficiency and safety of the road network, a TIA also considers impacts on all road users including public transport users, pedestrians, and cyclists, etc. Both operational and physical impacts on transport infrastructure are studied in a TIA.

Conventional approaches to temporary traffic arrangements during construction projects can be improved with better utilisation of 3D spatial data, especially in terms of modelling reality and visual communication. Swept Path Analysis (SPA) is a prime example of demonstrating the benefits of transitioning to a 3D workflow in TIAs. In a 3D simulation, temporary traffic arrangements can be easily identified, and LandsD's 3D spatial building and terrain data can be used to present the effects of nearby buildings, terrain and infrastructure. Also Modular Integrated Construction (MiC) truck data can be customised in design software, with dimensions of MiC modules provided by the contractor. The 3D animations can be directly generated from 2D Swept Path Analysis.

With Z-values (height) introduced in 3D simulations, the height of MiC trucks can be checked against height limits posed by existing footbridges and road junctions, as illustrated below. 3D simulation allows accurate representation of traffic and related data, and has the potential to identify problems in the early phases of planning and design. Furthermore, time and costs can be saved by maximising loads per ride within the allowable limits for different roads. 3D simulation is more realistic than 2D simulations in traffic assessment and facilitates effective communication between engineering professionals, other decision makers, and the general public.

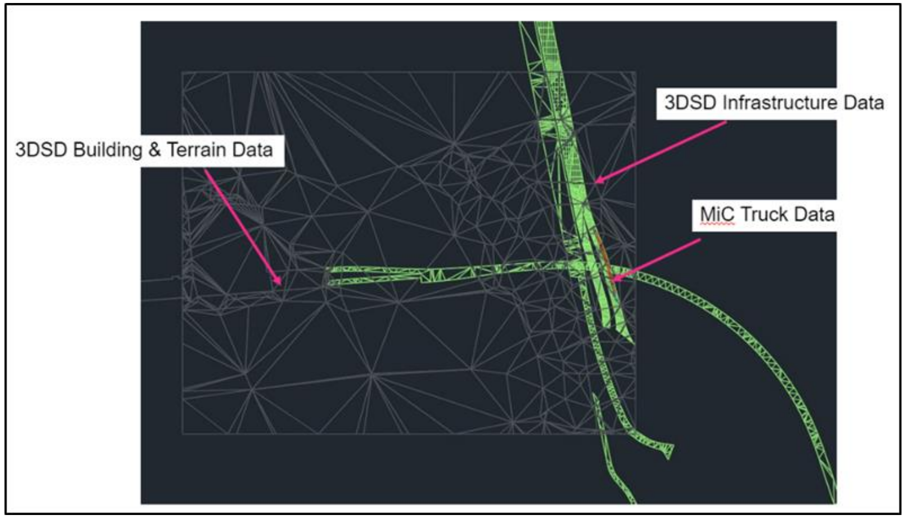


Figure 9.6: Swept Path Analysis Demonstration

9.2.6 Foundation Design

Up to the present, GEO, CEDD has stored in the Civil Engineering Library data over 370,000 ground investigation (GI) stations across Hong Kong, 82% of which are from government projects and 18% from private projects, and over 23,000 are in AGS Data Format (.ags). The AGS data can be obtained by both government and public users.

The GEO, CEDD has developed an Internet Geotechnical Information Infrastructure (GInfo) platform, which stores a wide range of geological and GI-related data. Both public and private project clients and their service providers can view and download the data via the Internet GInfo or the terminals in the Civil Engineering Library.

Online accessibility to GI data via the Internet GInfo allows designers to make the best use of available information related to ground and groundwater conditions, thus allowing foundation design to be done more easily and cost effectively.

For instance, the use of complete digital GI data would allow preliminary foundation design and option assessment to be carried out in an automatic manner using BIM and GIS. With the ability to visualise pile design in 3D, the number of trials for each design option could be greatly reduced and the accuracy improved. The final design can then be determined by professional geotechnical interpretation of all relevant site-specific GI data, including from any confirmatory GI carried out during the construction stage.

Completed BIM models not only facilitate 3D design and visualisation of the project, the data could also potentially contribute to the development of CSDI.[65]

The greater use of 3D and spatial data in planning and design of projects can bring immense benefits to the construction industry. More applications and cases of smart planning and design can be found in the Digital Hong Kong Study.

3 action items are recommended in the Roadmap to support the development of Smart Planning and Design (DA2) as illustrated in Figure 9.8.

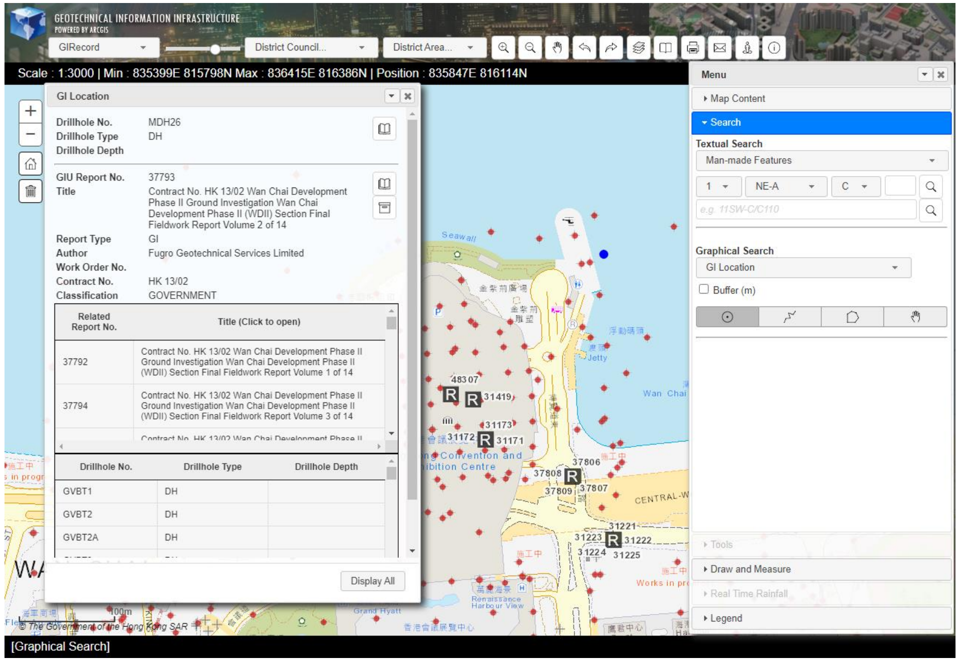


Figure 9.7: Internet GInfo (Source: CEDD)

[65] See 62.

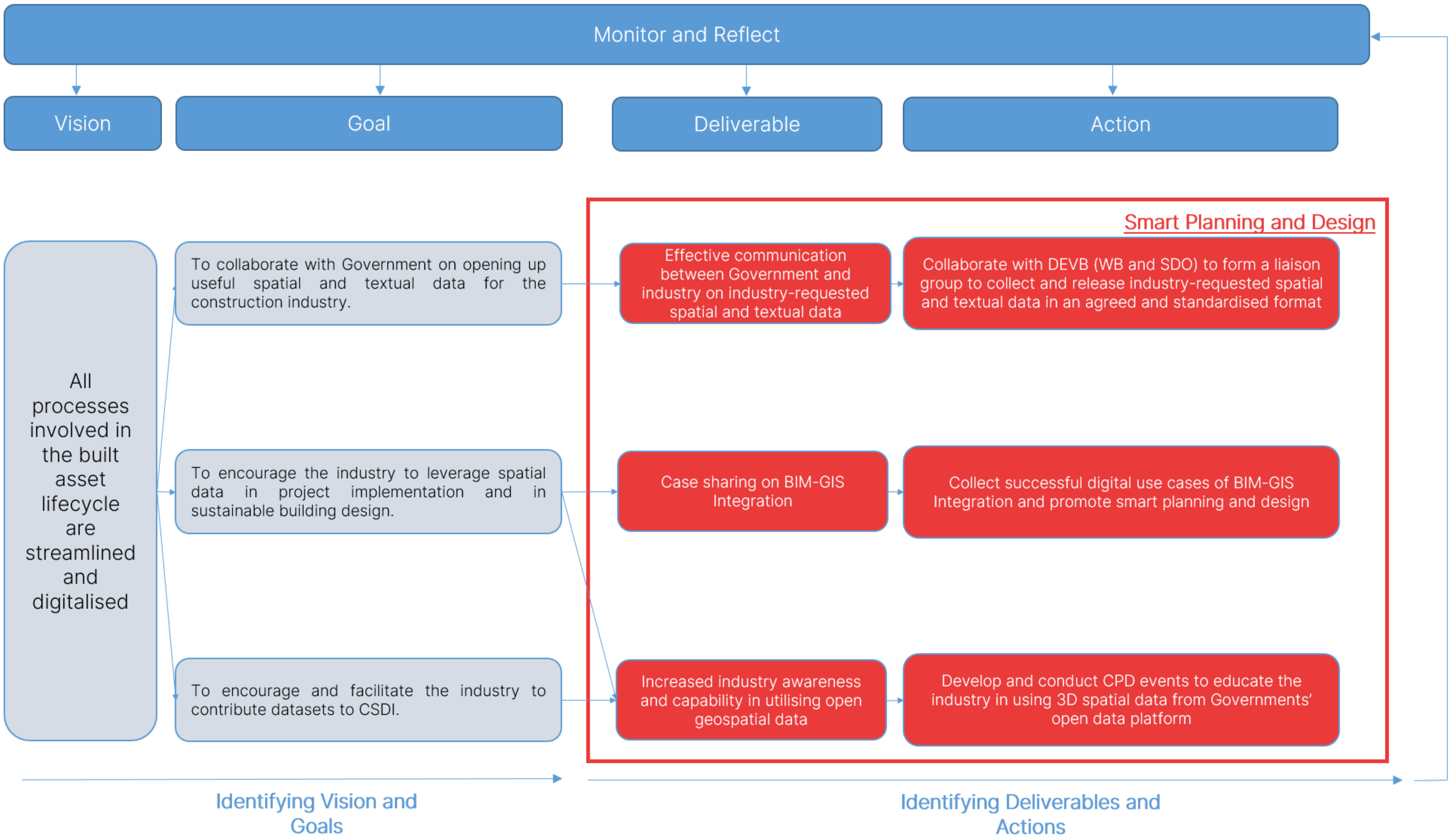


Figure 9.8: Impact diagram for DA2: Smart Planning and Design

9.3 DA3: Smart Submission with BIM – Submission with 2D plans (paper or digital) generated from BIM models together with BIM to facilitate plan processing by regulators

Overview

Since publication of the CIC "Roadmap for Building Information Modelling Strategic Implementation in Hong Kong's Construction Industry" in 2014, BIM has been readily picked up by the industry, with multiple proven benefits in the design and construction process. It is the ultimate goal of the DEVB to adopt BIM in preparing contractual documents and to use it for tendering purpose. The Roadmap advocates that the industry should be prepared for wider use of BIM throughout the built asset lifecycle by implementing statutory submissions with BIM. As in Figure 9.9 this initiative received strong support in the stakeholder engagement forums.

The Buildings Department (BD) is responsible for the building approval process of private projects. Its mission is to set and enforce safety, health and environmental standards for private buildings. In a typical project, the Authorized Persons (AP), Registered Structural Engineers (RSE) and Registered Geotechnical Engineers (RGE) are required to submit different types of plans, such as the general building plans (GBP), superstructure plans, and others. 2D drawings generated from BIM models together with the BIM model can fully realise the benefits of BIM so as to:

1. Improve the understanding of submissions by regulators, especially for large or complicated projects;
2. Accelerate the checking and approval process through the use of automated checking tools in the long run, e.g. checking of GFA calculations by BD and LandsD; and
3. Collect BIM models from public clients and private developers to help LandsD build the 3D digital map and contribute to the development of Digital HK and HK as a Smart City under the HKSAR Government policies.

The proposed BD Electronic Submission Hub (ESH) will serve as a digital platform for submission and processing of plans under the Buildings Ordinance (BO). By 2025, the ESH is expected to accept all types of plans electronically.

Digital Use Cases

9.3.1 Using BIM in General Building Plan (GBP) Submission

The BD encourages APs, RSEs and RGEs to consider adopting BIM in their building projects. In 2019, the BD published "Guidelines for Using Building Information Modelling in General Building Plans Submission" to set out general guidelines and recommended good practices for enhancing the standard of submissions.

At present BIM is submitted as supplementary information for reference only, and PNAP ADV-34 gives examples

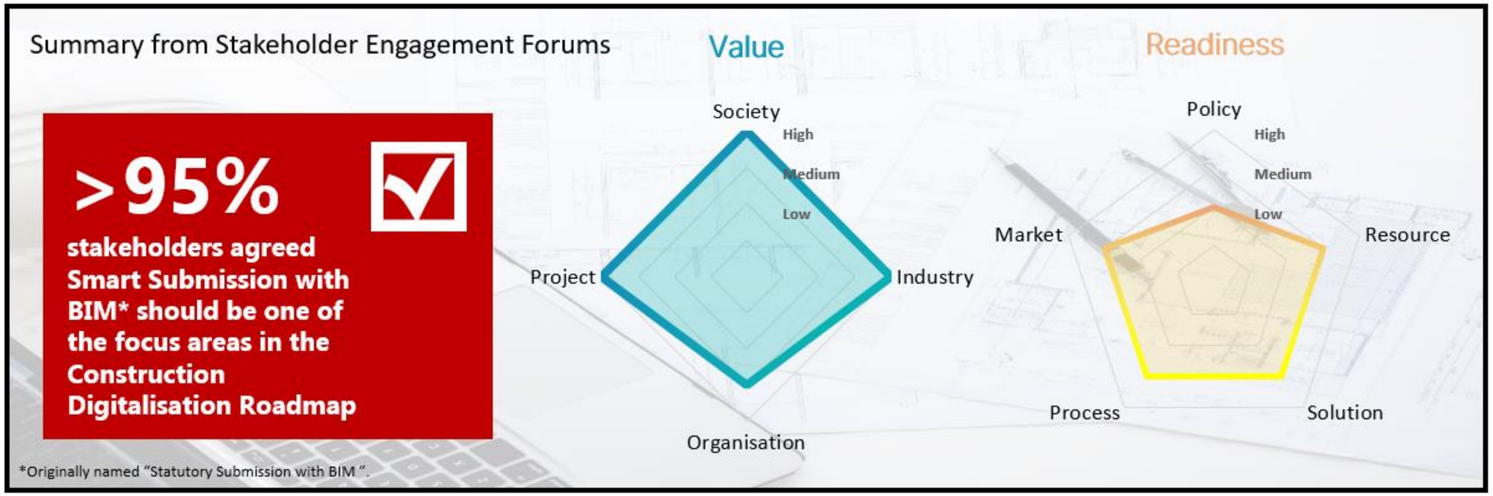


Figure 9.9: Summary from stakeholder engagement forums (Smart Submission with BIM)

of applications of BIM to supplement plan submissions. The BD processes approval of plans under the BO solely based on the information contained in the plans.

In Singapore, BIM was introduced and mandated for e-submission in a phased approach. The BCA began accepting voluntary BIM e-submissions since 2010 and mandated BIM e-submissions for all projects with GFA above 5,000 square metres with effect from 2015. The BIM e-submissions are permitted to be in native BIM and a lightweight format, to help achieve collaboration among regulatory agencies and accelerate the industry's rate of adoption of digitalisation. Benefits gained from using the e-submission platform include streamlining the approval process and reducing the number of iterations of submissions.

Figure 9.10: Codes of practice for BIM e-submission (Source: BCA)

To facilitate the preparation of GBP submissions generated from BIM in Hong Kong, the CIC Task Force on BIM submissions to BD has identified 9 pilot projects for pilot submissions with BIM to BD to support statutory 2D plan approval and consent applications to tackle practical challenges, such as different presentation formats for drawings produced by BIM and 2D Computer-aided Drafting, non-compliant BIM software, and issues related to training and resource allocations, etc. In addition, in 2020, the CIC published its BIM Standards for Preparation of Statutory Plan Submissions to increase the industry's readiness. The Standards include a written software-neutral set of BIM standards, software-specific templates, user guides, sample models, sample drawings and a summary of BIM object presentation.

9.3.2 Building Code Checking and Validation

Building Code Checking and Validation is a process of reviewing compliance with building codes and regulations that apply to the project through one or more Information Models.[66] The process of building code checking and validation can be digitalised and streamlined through automated checking tools.

Automated design and as-built checking tools as BIM plugins could supplement statutory submissions generated from BIM models and serve as a first screening of design submissions. The automation tools can rapidly check through the plan submission and objectively identify major deficiencies, errors, or non-compliance items. The tools also enable self-checking by the design team to enhance the quality of submissions, reduce approval processing time and alleviate possible peaks in demand.

[66] Construction Industry Council (2020), CIC BIM Standards - General (Version 2 - December 2020).

Although automated code checking and validation is currently in its infancy in Hong Kong, an increasing number of research projects have been dedicated to rule-based model checking tools. For example, the CIC commissioned a CIC Research and Technology Development Fund (R&D Fund) project on "BIM-automation of Gross Floor Area Calculation, Fires Safety and Prescribed Checking for General Building Plans Preparation". Coincidentally, in October 2020 the LandsD and BD issued the "Tender for Provision of Services for the Implementation of Tools for Facilitating Automated Checking Process on Electronic Building Plans to the Lands Department and the Buildings Department". These two projects provide a glimpse on the potential use of BIM in the design and statutory submission process. By explicitly rationalising how a building component or system affects the overall project with respect to building codes and regulations, the quality of the building model can be greatly improved and the statutory submission and approval processes can be streamlined.

4 action items are recommended in the Roadmap to support the development of Smart Submission with BIM (DA3) as illustrated in Figure 9.11.

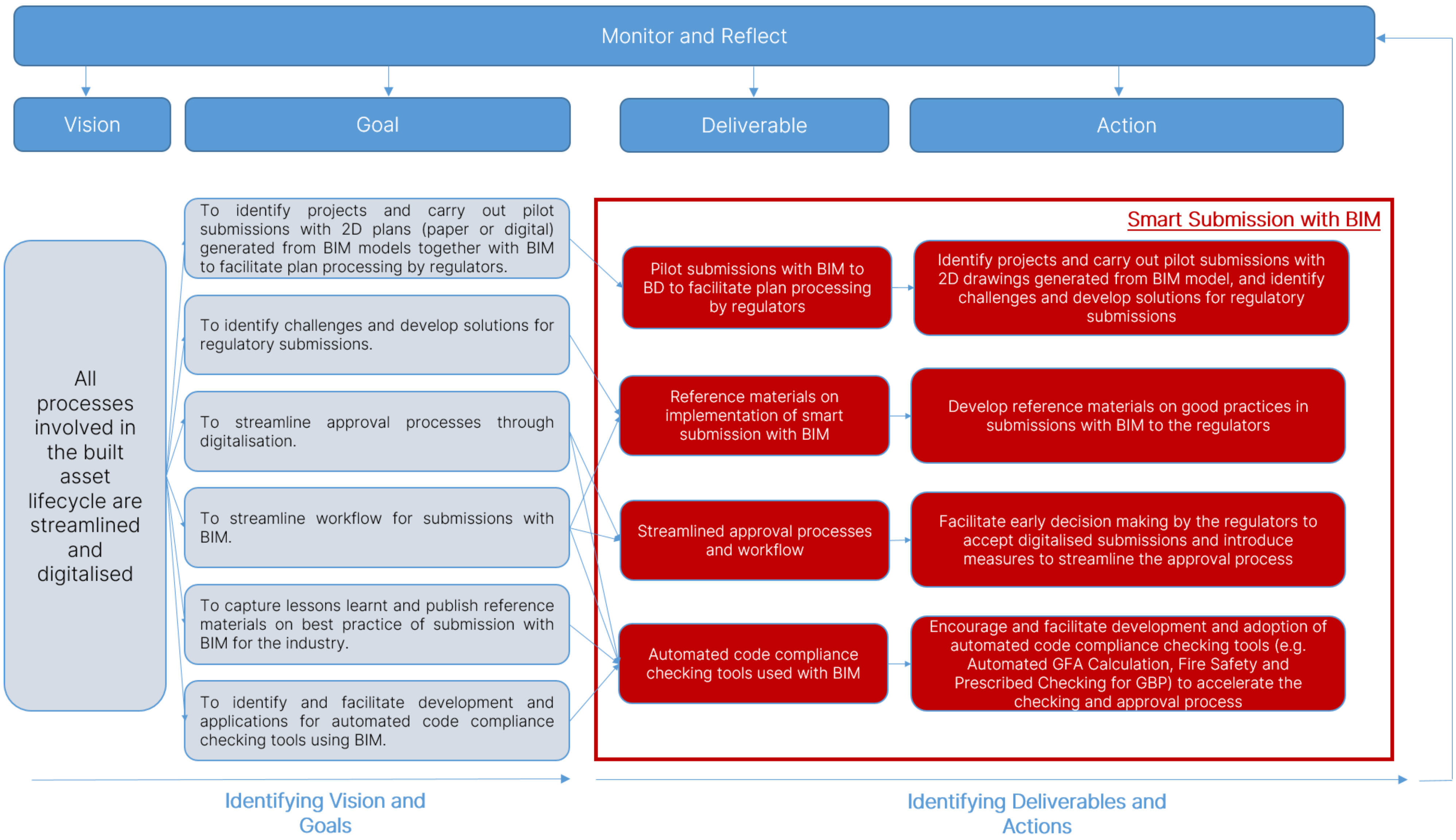


Figure 9.11: Impact diagram for DA3: Smart Submission with BIM

9.4 DA4: Smart Offsite Fabrication and Delivery

Overview

Offsite construction refers to shifting of onsite construction processes to a controlled offsite environment. An example of offsite construction is use of the Design for Manufacture and Assembly (DfMA) approach as illustrated in Figure 9.13.

Digitalisation is regarded as one of the key enablers of offsite construction, and was strongly supported as an initiative by the stakeholder engagement forums as shown below in Figure 9.12. Digital representation of DfMA practices and quality assurance can be achieved through adoption of technologies with higher accuracy and efficiency. For instance, by adopting BIM for DfMA, downstream DfMA activities (such as procurement, fabrication, transport and installation) through which projects are delivered onsite can be comprehensively linked to upstream activities (such as briefing, options appraisal and concept design).

Digital tools can also improve offsite construction and delivery through better logistics management, near-real-time information flows, and end-to-end supply chain transparency, etc.

Digital Use Cases

9.4.1 Offsite Design and Manufacturing

Computational design is the application of programming to the design process including but not limited to design generation and task automation[67]. Utilising data from BIM models and other sources (e.g. 3D-GIS Map), offsite manufacturing design tools can be used for to support regulatory compliance checking, to support rebar prefabrication, or to facilitate generation of a buildable design.

BIM could facilitate Platform Design for Manufacture and Assembly (PDfMA), which can enhance productivity and cost effectiveness. The term 'Platforms,' most commonly used in manufacturing, refers to a process whereby sets of components or assemblies can be put together in many different ways to create a multitude of different products.

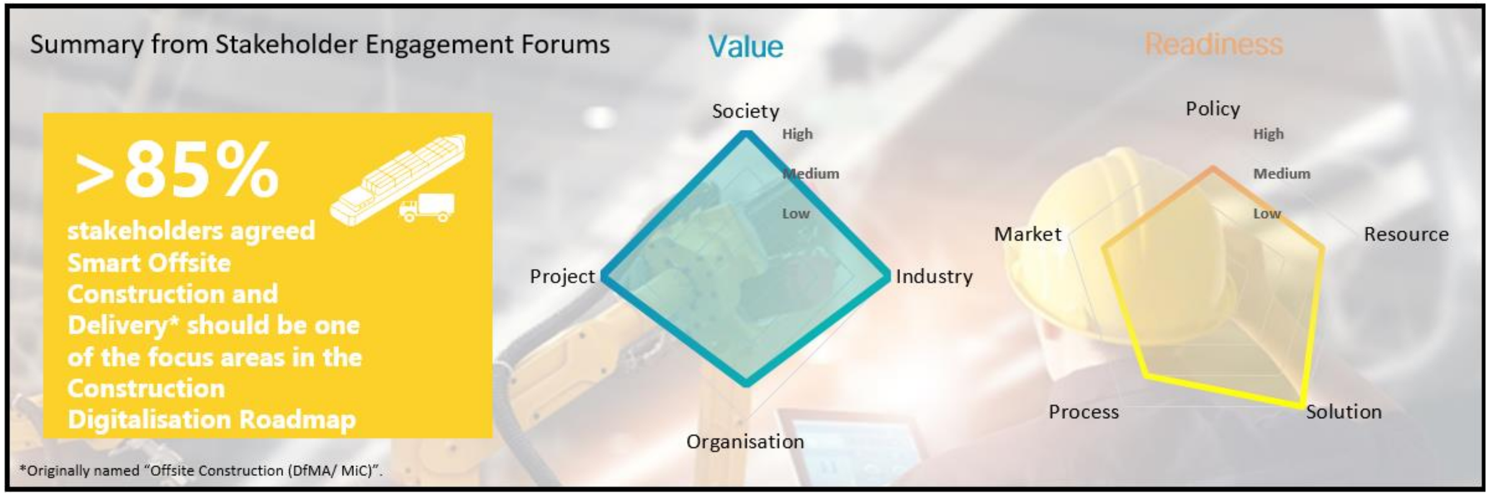
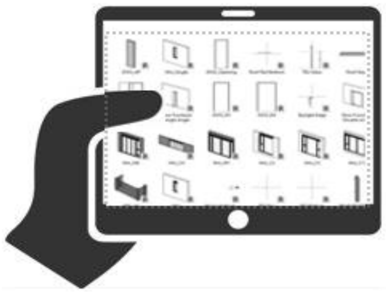


Figure 9.12: Summary from stakeholder engagement forums (Smart Offsite Fabrication and Delivery)

[67] Greenough, T., Smith, M., and Mariash, A. (2019), Integrating Computational Design to Improve the Design Workflow of Modular Construction.



Design for Manufacture and Assembly (DfMA)

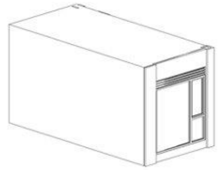
Design for manufacture and assembly (DfMA) is a game-changing design approach which involves construction components being designed for manufacturing offsite in a controlled environment, before being assembled onsite.[68]

Platform Design for Manufacture and Assembly (PDfMA)

The term "Platforms," most commonly used in manufacturing, refers to a process whereby sets of components or assemblies can be put together in a multitude of different ways to create a multitude of different products.[69]

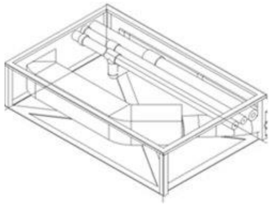
Kit of Parts

It is used to describe the notion of organising the individual parts of a building into assemblies that are capable of being manufactured offsite, and which are conceived in a way that allows them to be efficiently assembled on site.[70]



Modular Integrated Construction (MiC)

A construction method that employs the technique of having free-standing volumetric modules (with finishes, fixtures, fittings, etc.) manufactured offsite and then transported to site for assembly.[71]



MultiTrade Integrated MEP (MiMEP)

DfMA for MEP (Mechanical, Electrical and Plumbing) works in construction projects (i.e. MultiTrade Integrated MEP, MiMEP)[72]

E-Inspection

The process of the periodic supervision checks by the supervision personnel can also be digitalised. The supervision personnel can make the check online via the e-platform. The inspection data/ records (e.g. photo, video, voice, etc.) will be transmitted in real-time for reviewing by the supervision personnel.

Figure 9.13: Terminologies for DA4: Offsite Construction and Delivery

[68] Building and Construction Authority, Design for Manufacturing and Assembly (DfMA)

[69] Bryden Wood, Platform Design for Manufacture and Assembly (PDfMA): using lean construction to create a smarter, more sustainable future

[70] Construction Industry Council (2021), DfMA Guidebook on MEP Works.

[71] Buildings Department (2017), PNAP ADV-36 on Modular Integrated Construction.

[72] Construction Industry Council (2021), DfMA MiMEP Tradeshow 2021.

In the context of the built environment, the fundamental objective of construction platforms is to drive value within the sector - by applying lessons of manufacturing to construction, quality, efficiency and productivity can be enhanced. Multiple benefits of DfMA[73] are shown in Figure 9.14.

Figure 9.14: Benefits for DfMA (Source: Bryden Wood)

[73] Bryden Wood, Platform Design for Manufacture and Assembly (PDfMA)

9.4.2 Design for Safety

Safety is not only enhanced by removing construction activities from the site to a controlled factory environment, but detailed construction planning using digital tools can also identify, assess and mitigate safety risks at the site. A good example is the design for rigging, levelling and hoisting modular structures, as shown in Figure 9.15.

The offsite production and fabrication process begins after completion of the computational design and analysis. By utilising digital tools such as BIM and digital information to facilitate the production of precast components and prefabricated modules in a controlled environment, accuracy is also enhanced by ensuring consistent, up-to-date recording of revisions of fabrication models/ drawings, as well as tracking changes made to files (e.g. who, when, what) and tracking the approval processes. Moreover, as the production time is greatly reduced, using 3D volumetric modules can typically deliver 20-50 percent schedule compression.[74]

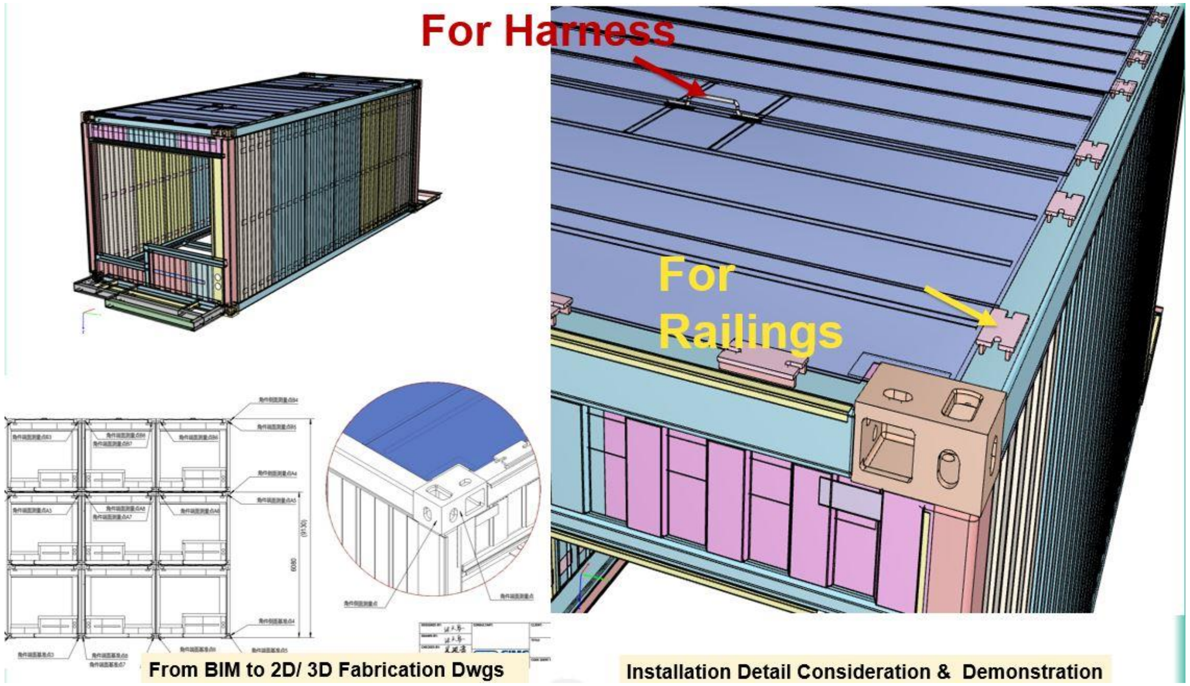


Figure 9.15: Design for safety (Source: Hip Hing Engineering Limited and Hong Kong Science & Technology Parks Corporation)

[74] Mckinsey (2019), Modular construction: From projects to products.

9.4.3 Offsite Delivery

After digital engineering and optimising the building process through DfMA, other processes in the delivery chain can also benefit from digitalisation, for example:

1. Digital tools can help with logistics planning by visualising and analysing the relationship between the physical environment and construction site.
2. Planning how to deliver offsite components just-in-time.
3. Monitoring the component production schedule.
4. Tracking delivery to the site.
5. Installation of the prefabricated components.
6. Extraction of production, delivery and installation data for digital dashboarding is also useful for project management.

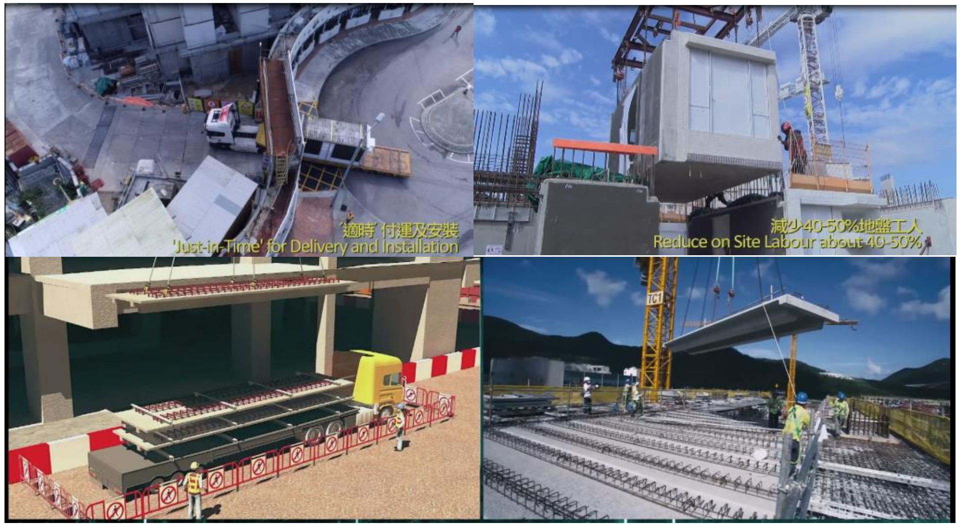


Figure 9.16: Just-in-time delivery and installation (Source: Yau Lee Construction and Gammon Construction Limited)

9.4.4 Digital-enabled Assembly and Installation

Digital tools can simulate construction schedules, method statements, designs and also show the assembly and installation sequence of prefabricated components. Videos and animations can assist installation of building components onsite, step-by-step installation sequences, and locations and logistics can be clearly shown to onsite supervisors and workers. Digital-enabled assembly and installation processes can reduce construction time and enhance quality control.

Figure 9.17: Step-by-step installation sequences (Source: Paul Y. Engineering Group Limited)

9.4.5 Offsite Quality Assurance and Quality Control Inspection

In offsite construction, it is essential to assure the quality of components produced in a remote factory. However, carrying out inspections across the Mainland boundary, e.g. in the Greater Bay Area (GBA), may add to cost and time requirements due to the need to travel to prefabrication sites. In such cases online inspection platforms/systems are helpful for managing and tracking defects and rectification. 360-degree cameras and scanners allow automatic capture of images and the data required for inspection and remote acceptance of prefabricated products. Remote contract and regulatory acceptances can be made possible with the help of digital technologies. As stipulated in PNAP ADV-36 and PNAP APP-143, AP and/ or RSE and AS of RGBC and their respective TCPs should visit the offsite factories to conduct supervision. Owing to the cross-boundary control arising from COVID-19, a temporary special arrangement was launched on 7 February 2020, in which the adoption of videotelephony to conduct supervision to offsite factories is allowed with some conditions. While such special arrangement is on a temporary basis, BD would conduct a review on its effectiveness and explore the way forward in respect of the quality supervision in offsite factories. For project management, all component information and related records can be clearly shown in digital checklists and dashboards, e.g. which party to follow up, due dates, payment status, etc. Online inspection platforms/ systems pre-approved by the CITF for funding subsidies are now available. Figure 9.18 shows how data and inspection reports are created in a digital platform via e-inspection.

6 action items are recommended in the Roadmap to support the development of Smart Offsite Fabrication and Delivery (DA4) as illustrated in Figure 9.19.

Figure 9.18: Digital platform and e-inspection (Source: Hip Hing Engineering Limited)

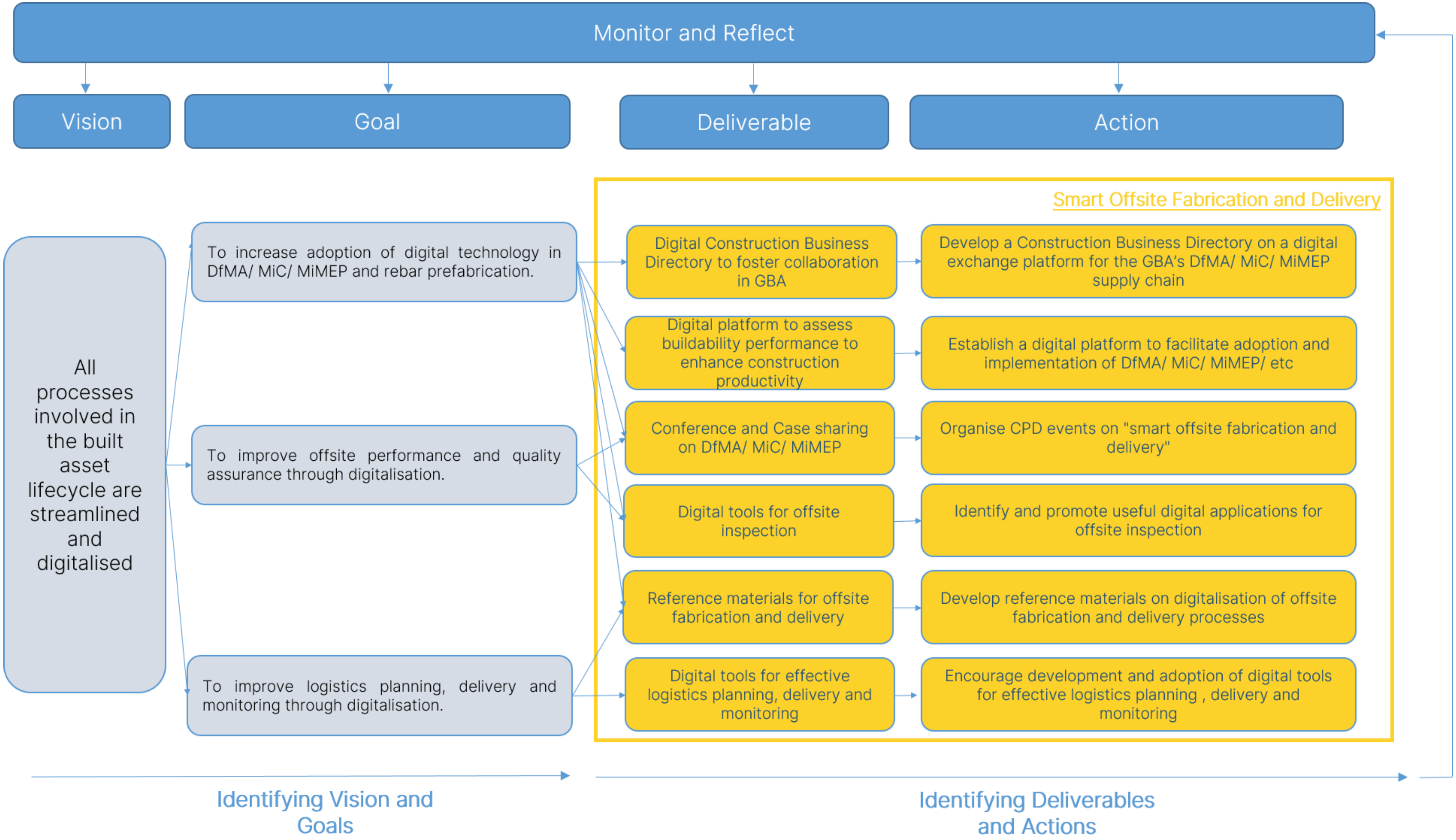


Figure 9.19: Impact diagram for DA4: Smart Offsite Fabrication and Delivery

9.5 DA5: Smart Site Management

Overview

Unsatisfactory site safety performance, declining productivity, and a lack of creativity innovation are some of the core challenges described in Construction 2.0. Improving transparency of what is happening on site and planning ahead are important and helpful for project managers.

A smart construction site is composed of a system of seamlessly networked sensors, displays and actuators for planning and monitoring site activities. There was unanimous support for the smart site management initiative in the stakeholders' engagement forum, as shown below.

By analysing data collected from the sensors, project managers may optimise working efficiency on site, and monitor the progress and quality of the project and/ or detect safety issues for prompt action.

The vision of a smart site management is conveyed in this quotation: "the physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network" (Weiser et al., 1999)

Digital Use Cases

9.5.1 Digital Site Preparation

Surveying is the translation of the contractor's set of plans into an actual representation of the project site. The surveyor is responsible for surveying the site and demarcating the exact areas where the infrastructure or buildings are to be constructed. It can be used to locate specific items shown on drawings, such as hanger points, building works holes, equipment locations, lighting fixtures, and practically anything that can be identified in the model/ drawings. Survey solutions such as robotic total stations and laser scanning allow the import of a BIM model for facilitating accurate and reliable layout and measurement on the construction site, hence reducing manpower, saving time via the automation process, as well as producing better-quality information that can be shared with other stakeholders.

Figure 9.21: Checking vertical and horizontal level (Source: Yau Lee Construction Company Limited)

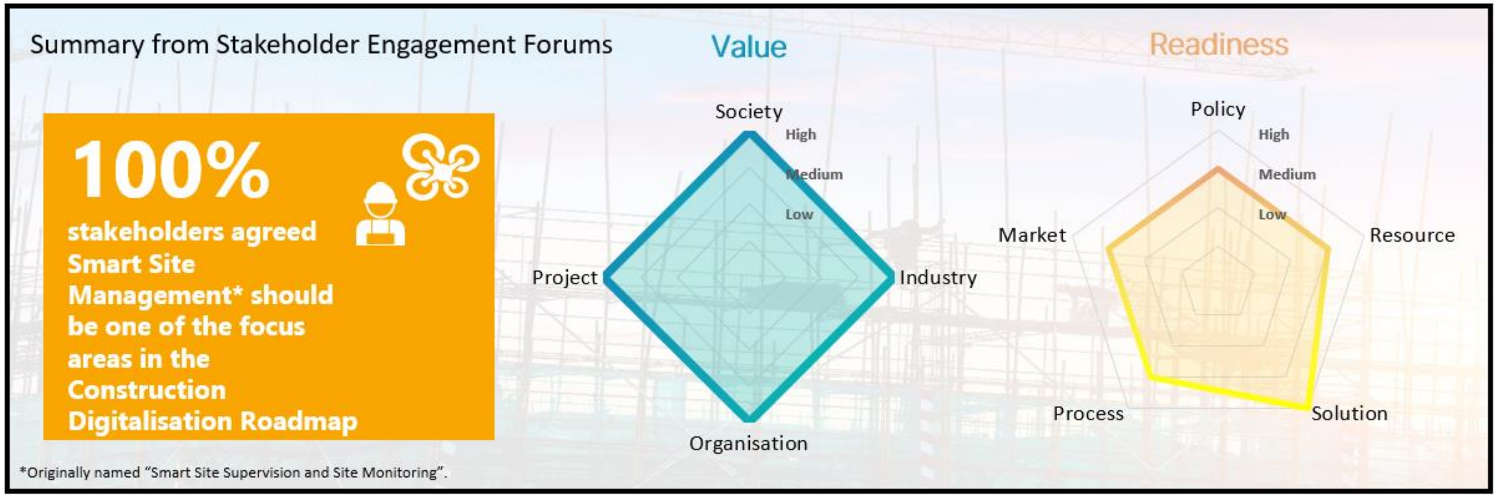


Figure 9.20: Summary from stakeholder engagement forums (Smart Site Management)

9.5.2 Digital Planning, Sequencing and Monitoring

Whatever its size, every construction project needs to start with a business case that lays out the feasibility of the project and what it is going to take to get the job done. Digital planning and sequencing simulation to plan construction activities, such as 4D time-based simulations and sequencing models can achieve better streamlining activities for architectural, structural, and MEP (Mechanical Electrical and Plumbing) disciplines. The models generate information about the schedules of building works and create a step-by-step visualisation of the development, allowing different building components to be incorporated with time-related information such as lead time, construction, and installation time, etc. For sustainability, efficient digital dashboards from sequencing simulations integrated with computer-aided tools can be used by project managers and environmental officers to monitor, control, and optimise the generation and transmission performance of the working environment in terms of noise, dust, air pollution control, CO_2 emissions, lighting, equipment, and onsite energy generation. The technology enables efficient utilisation of energy and resources, with respect to people's needs at different times and occasions, leading to reduced CO_2 emissions and better environmental protection.

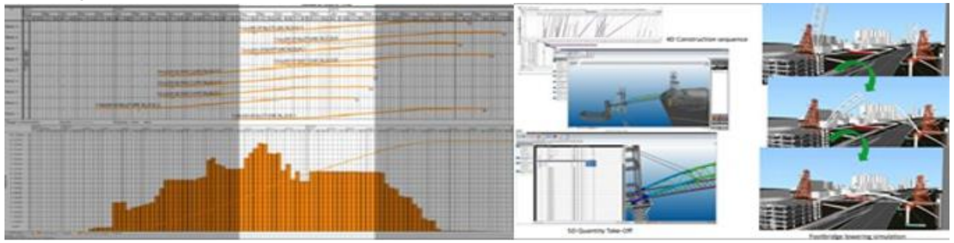


Figure 9.22: 4D time-based sequencing and simulation model (Source: Yau Lee Construction Company Limited)

After planning and sequencing is completed, monitoring of site progress then becomes important. Sensors enabled by IoT technology are now inexpensive and can be easily set up for site use. Technologies of scanning/ recording/ collating data on site progress by internet-connected sensors are able to collect various types of data about activity, performance and conditions on the building site. The data are automatically connected to a central dashboard, meaning many more aspects of construction sites can be monitored in real-time and the data analysed to help make decisions on site management. This has direct implications for safety, security, productivity, and cost reduction.

Figure 9.23: Wearables, sensors, and display or computational applications

Construction materials typically account for 50-60% of the total cost in construction projects (Song, 2005: Nasir, 2008)[75], hence proper management of materials is crucial for successful project completion. Despite the high material costs, time is still commonly wasted on building sites searching for materials every day.

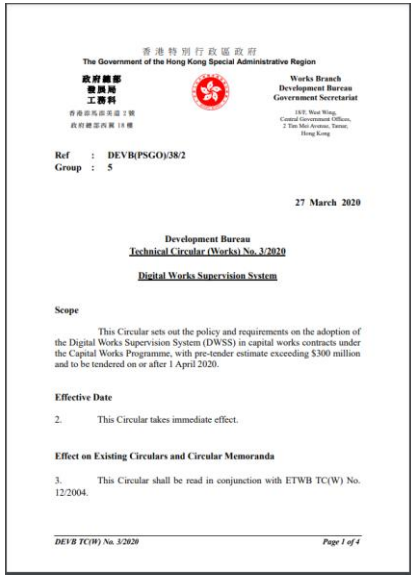
IoT devices are a potential solution to make improvements to resource management on construction sites. Not only materials but also workers can be internet-connected with an IoT device, allowing managers to locate them immediately. The potential cost and time savings are significant. For instance, labourers currently underemployed can be quickly redeployed to support other tasks. A pre-approved list of movement sensors in CITF can identify the location and activity status of a wide variety of vehicles and other assets.

9.5.3 Digital Quality Assurance and Quality Control Inspections

In traditional construction contracts in Hong Kong onsite inspection is typically required to carry out quality assurance, quality control, and approvals of construction materials and workmanship. However, this generates high peaks of manpower demands on inspection personnel (involving layers of personnel from subcontractors, the main contractor, resident site staff, and client representatives), and often leads to prolonged periods required for regulatory inspections.

One particular smart site management application is the use of a Digital Works Supervision System (DWSS) for digital site supervision. A DWSS is a workflow-enabled application system that facilitates the digital processing of forms and records and management of site activity workflows within a centralised data repository to enhance efficiency, safety and quality performance.

The Development Bureau's Technical Circular on Digital Works Supervision System (DWSS) (ref. DEVB TC (W) No. 3/ 2020) requires capital works projects with a value exceeding HK$300M to adopt the DWSS from April 2020 onwards. In the CIC's project technology adoption survey carried out in early 2021, the DWSS adoption rate in projects was 35% (among those adopted digitalisation). The adoption of DWSS can enhance regulation and quality assurance for the industry by digitising forms and inspection records such as Request for Inspection/ Survey Check (RISC) forms.


香港特別行政區政府
The Government of the Hong Kong Special Administrative Region

政府總部
發展局
工務科

Works Branch
Development Bureau
Government Secretariat

18/F, West Wing,
Central Government Offices,
2 Tim Mei Avenue, Tamar,
Hong Kong

Ref : DEVB(PSGO)/38/2
Group : 5

27 March 2020

Development Bureau
Technical Circular (Works) No. 3/2020

Digital Works Supervision System

Scope

This Circular sets out the policy and requirements on the adoption of the Digital Works Supervision System (DWSS) in capital works contracts under the Capital Works Programme, with pre-tender estimate exceeding $300 million and to be tendered on or after 1 April 2020.

Effective Date

2. This Circular takes immediate effect.

Effect on Existing Circulars and Circular Memoranda

3. This Circular shall be read in conjunction with ETWB TC(W) No. 12/2004.

DEVB TC(W) No. 3/2020 Page 1 of 4

Figure 9.24: Technical Circular on DWSS (Source: DEVB)

DWSS systems can be further connected with sensors dotted around a building site for quality assurance, with IoT continually feeding back information about conditions in construction sites. For example, sensors can monitor unusual vibrations on a piece of machinery for timely planning of maintenance work. They can detect increases in concrete temperature and compressive strength which will help inspection teams in assessing concrete strength maturity. A consultancy study under Committee on Productivity of CIC titled "Application of Maturity Method for

[75] Song, J. (2005). Tracking the Location of Materials on Construction Projects. University of Texas: PhD Thesis. Song, J., Haas, C. T., & Caldas, C. H. (2006). Tracking the Location of Materials on Construction Job Sites. Journal of Construction Engineering and Management, 132(9), p. 911-918.

Determination of Early-age Concrete Strength in Hong Kong Construction Industry" is being conducted. IoT monitoring devices can also help measure forces, underground water levels, inclinations, and environmental quantities such as temperature, humidity, barometric pressure, and air pollutant concentrations. The digital management process can then track defects and rectification using digital checklists and dashboards. All IoT data can be used for analysis at the project or organisation level.

Looking forward, the DEVB will implement an Integrated Capital Works Platform (iCWP) in phases to enable data integration and analysis of works information collected from different works projects for continuous monitoring and review of project performance with a view to enhancing the management of the Capital Works Programme. The DEVB will further explore the use of remote monitoring, wireless sensors networks, IoT and other innovative technologies in public works projects to push forward digitisation of works supervision system, reduce interpersonal contact and improve occupational safety and health on site.[76]

9.5.4 Digital Safety and Health Management

Wearable IoT devices have real potential for improving safety on construction sites. As an example, in the San Wai Sewage Treatment Works – Phase 1 project, the site team wore integrated smart safety helmets with embedded IoT technology with BIM to improve the safety management on site. Not only could the helmets detect workers' sudden falls or unusual body temperature and heart rate, the data feedback from the helmets also presented the location of the workers on the BIM model. This type of data could be further developed into an alarm system to avoid unauthorised entry to dangerous and restricted site areas, e.g. by sending automatic alerts to the site safety manager. Besides improving safety on site, this kind of data could additionally be used to renegotiate insurance premiums.

Other than sensors, Virtual Reality (VR) headset technology can also be used as a safety training tool. The major benefit is to bring trainees closer to real-world experiences without exposing them to real-world dangers. Trainees and workers can easily create memorable and interactive learning opportunities in a safe virtual environment. For example, for working at height, learners can practise the utilisation of safety harnesses, ladders and scaffolding. Fire safety is another example where there is scope to use the technology to fill the gap between theory and practical training. Virtual reality allows learners to simulate putting out fires and becoming familiar with the processes and equipment, and knowing the locations of fire extinguishers and escape routes, etc., before graduating onto the real-time practical exercises. DEVB and the CIC developed a VR Safety Training Software Download Platform and Virtual Reality Safety Training User Guide & Instructions[77] as shown in Figure 9.25.

6 action items are recommended in the Roadmap to support the development of Smart Site Management (DA5) as illustrated in Figure 9.26.

Figure 9.25: VR Safety Training Software Download Platform and Virtual Reality Safety Training User Guide & Instructions (Source: DEVB and the CIC)

[76] Development Bureau (2020), Initiatives of Development Bureau in the Chief Executive's 2020 Policy Address and Policy Address Supplement.

[77] Development Bureau, Construction Industry Council, VR Safety Training Software Download Platform and Virtual Reality Safety Training User Guide & Instructions

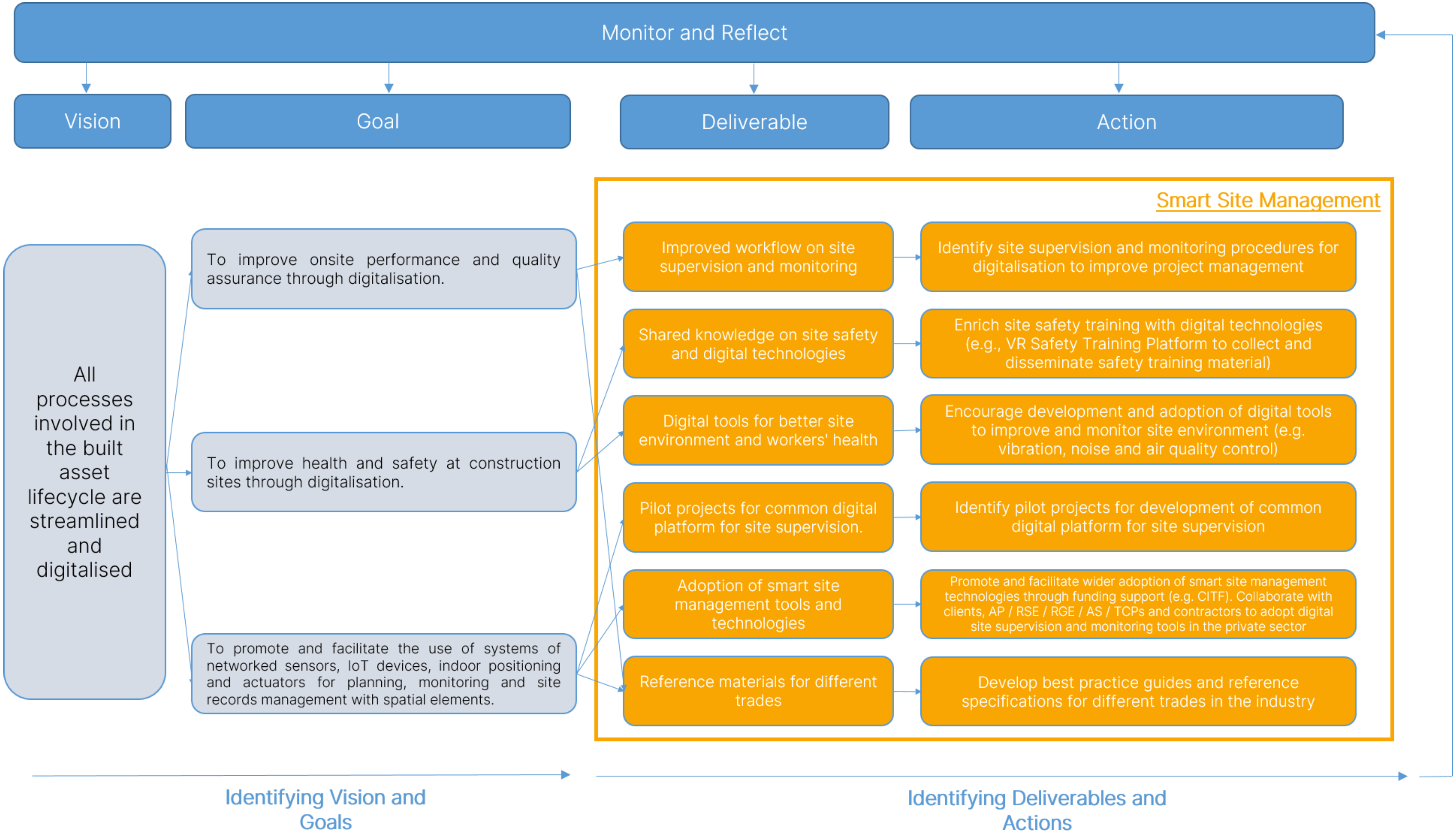


Figure 9.26: Impact diagram for DA5: Smart Site Management

9.6 DA6: Smart Asset and Facility Management (Smart AM/ FM)

Overview

Over the past years, owners and operators have shown increasing interest in adopting digitalisation to drive innovation and business transformation. The Operation and Maintenance (O&M) stage, which accounts for most of a building's lifespan, is one of the integral elements to achieve the full vision of digitalising and streamlining all processes in the built asset lifecycle. While early collaboration between facility management and the architect/ engineer team (A/ E team) is a critical success factor for Smart AM/ FM, different technologies and digital tools can also be utilised to improve the daily operation of built assets.

"Facility" should include civil infrastructure in addition to buildings. "Facility Management" is the organisational function which integrates people, place, and process within the built environment with the purpose of improving quality of life and the productivity of the core business.[78] "Asset" refers to an item, thing or entity that has potential or actual value for an organisation, while "Asset Management" refers to the coordinated activity of an organisation to realise value from assets.[79]

At a basic level, SMART AM/ FM encourages early collaboration of facility managers and end users during the design and construction process. Handover and integration of data is a key element of design and construction, while BIM and asset data should be fed into to a computer aided facility management (CAFM) system to enable O&M. The data should be maintained throughout the built asset lifecycle. At a more advanced level, SMART AM/ FM can be empowered by AI and big data analytics. It can assist in or automate different FM functions such as property management, facility security, sustainability, and work coordination. As a result, A/ E teams can make use of post-occupancy feedback and evaluation for future projects.

One of the tangible benefits of Smart AM/ FM is significant time and cost saving during operation of an asset. The PwC has

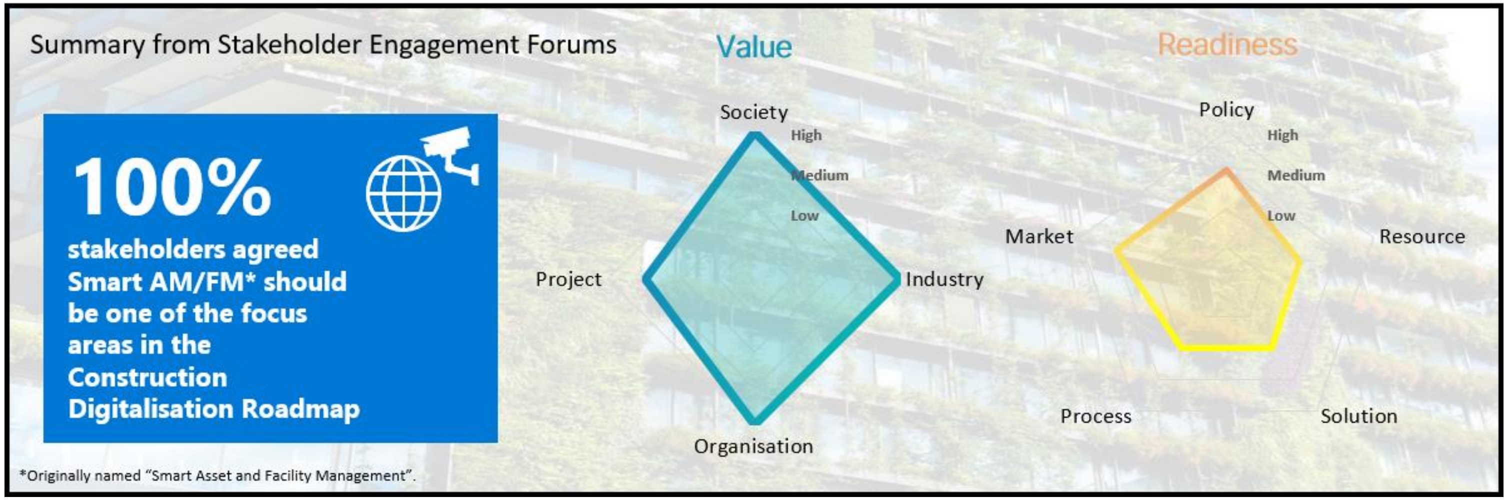


Figure 9.27: Summary from stakeholder engagement forums (Smart AM/FM)

[78] British Standards Institution (2017), ISO 41011:2017.

[79] British Standards Institution (2014), ISO 55000:2014.

developed a Benefits Measurement Methodology to quantify the potential benefits of applying BIM Level 2 in public sector infrastructure and capital assets. In the two studied assets, it was concluded that the present value benefit is equivalent to 5.5% and 6.5% of the total cost during operation (as compared to the cost without using BIM).[80]

Digital Use Cases

9.6.1 Scan-to-BIM, As-built Documentation and Digital Handover

Scan-to-BIM allows users to get the accurate digital representation of the as-is conditions on a project site. Such digital representation can be used for monitoring progress, augment the missing design, verifying the works and identifying any construction mistakes, and documentation as one of the project deliverables.

When construction is completed, the A/ E team should generate digital as-built information, which should contain any changes to the original models and drawings made during construction. The adoption of BIM can smoothen the commissioning and handover process. During commissioning, BIM could be used to simulate the designed performance of buildings and assess design outputs such as carbon emissions and energy consumption. The up-to-date BIM and AIM (Asset Information Model) could also speed up the handover process. With improved trust in the accuracy of asset information, FM could save costs in asset re-survey during handover.

Not all the rich data stored in BIM is relevant to FM. The BIM construction model may contain a high level of detail used only for construction. Thus, it is important to specify what data are needed and the appropriate data format.

Digital handover aims to establish connectivity between asset BIM models and organisational FM systems. Generally, the BIM model is really seen as a one-time hand-off process between construction and facility management. After the construction hand off, data will be maintained in the FM system instead of the BIM model. “Direct Integration” and “Data transfer through standard data format” are two common approaches to pass the information from construction to facility management. Owners and operators should choose an appropriate approach depending on their capability and operational needs.

9.6.2 Direct Integration of BIM, GIS and FM Systems

Direct Integration of BIM, GIS and FM systems enables better access to BIM data and better ongoing updates to buildings. A live BIM model (with GIS data) can be maintained and updated during occupancy. In this way owners could maintain an accurate record of the building as a base for potential remodelling and retrofitting.

In the Shanghai Street Project, the URA tailor-made a centralised BIM-FM platform which integrated as-built BIM, the Building Management System (BMS), the closed circuit television system (CCTV) and IoT devices to achieve efficient facility management. Information about assemblies and equipment such as details of manufacturers, cost and descriptions can be examined in the as-built BIM model. This reduces the effort needed in validating and “scrubbing” the data during handover.

During O&M, the URA BIM-FM system monitors all the equipment history layout change and status updates. The IoT systems are installed onsite and connected to the BMS, which can monitor and remote control all building facilities such as CCTV, pumping, lighting, and wireless door contact

[80] PwC (2018), BIM Level 2 Benefits Measurement Application of PwC’s BIM Level 2 Benefits Measurement Methodology to Public Sector Capital Assets.

information. As a result the effort expended in labour for the field team and operational maintenance costs can be reduced.

The centralised BIM-FM platform is expected to be expanded to all other URA projects and provide a scalable and sustainable solution for direct BIM and FM integration.

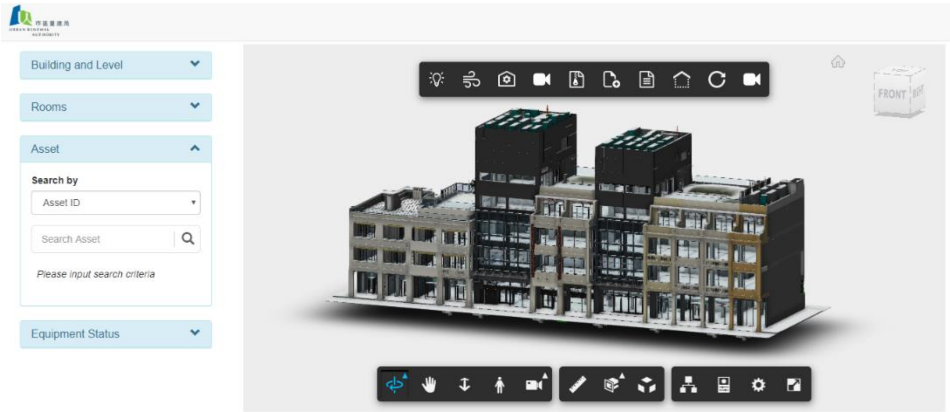


Figure 9.28: BIM-FM platform (Source: URA)

9.6.3 Data Transfer through Standard Data Format (COBie)

An alternative to direct integration is to transfer the data through an agreed and standard data format. The Construction Operations Building Information Exchange (COBie) is an international standard for exchange of building data. It contains information attributes required for building systems and is commonly used in product data handover from construction to operation. The COBie spreadsheet will contain data from design consultants, contractors and subcontractors, suppliers, and clients. COBie files serve as a vehicle to exchange space and equipment information between systems. Most FM systems nowadays support the import of COBie data.

Examples of asset information requirements include documents produced from information models, COBie data sets, room data sheets, suppliers and manufacturers, asset schedules/ product data sheets, warranties, spares and replacement, maintenance requirements and operation requirements, etc. Owners and operators can acquire BIM model information without direct BIM integration.

Some proprietary FM systems offer extensions or plugins to connect BIM models to FM data. A web-based service and an easy-to-use interface are usually provided to allow users transitioning to BIM technologies. In this way, owners and operators can obtain a full lifecycle view of an organisation and its processes. Moreover, COBie information can be synchronised between model and enterprise data with pre-set rules and workflows. This allows bidirectional data exchange and automatic updating of the BIM models.

9.6.4 Building Rehabilitation

By 2046, it is estimated about 326,000 private housing units in Hong Kong will be 70 years or older.[81] Smart AM/ FM can assist in building revitalisation and rehabilitation by providing data-driven insights on the condition and health of buildings.

The Urban Renewal Information System (URIS) is a GIS-based integrated and shared platform for effective and efficient information management and sharing within the URA. The URIS helps to streamline the operations in various stages of the urban renewal process. The URA collects onsite data for project engagement using GIS field applications, while the Operational

[81] See 21.

Dashboard allows real-time tracking of engagement progress and rapid presentation of preliminary survey results in the form of a 3D indoor map.

The URIS can help integrate different planning data in 2D maps for easy analysis, and also enables the visualisation of spatial data in 3D maps. The URA is developing a set of pilot high-resolution 3D indoor maps (with units, interests and external envelope, e.g. windows, and external walls) containing property information to build a Digital Twin, coupled with 3D applications for illustrating better ways to govern the implementation of urban renewal. A pilot project 3D Intelligent Map (3DiMap) has consolidated different types of business data such as building information and property valuation. This can help generate building rehabilitation works estimates and facilitate the vetting of owners' applications for subsidies in the future.

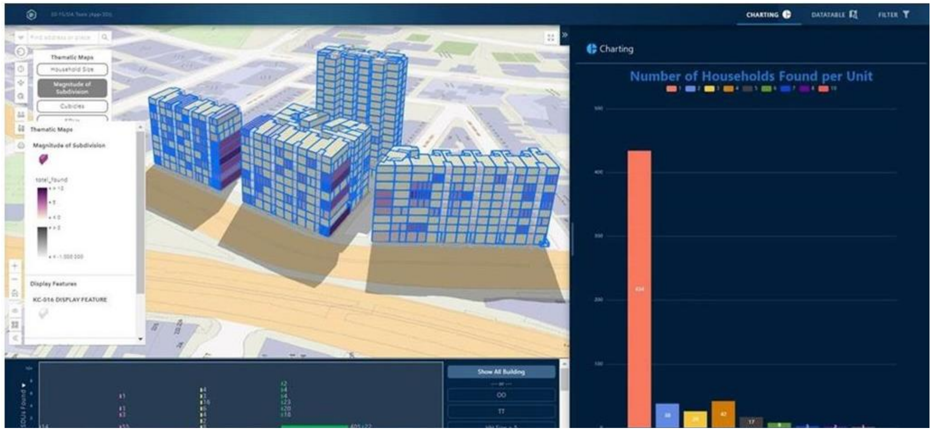


Figure 9.29: 3D freezing survey / social impact assessment tools (Source: URA)

9.6.4 Space Management in FM

SMART AM/ FM can also be applied to space management and maintenance management of both new and existing buildings. The "Digital Twin for The Hong Kong University of Science and Technology (HKUST) Campus"[82] initiative transforms the campus into a live laboratory and supports various innovative applications. It utilised digitalisation to create digital replicates of HKUST's physical assets and systems. The Digital Twin serves as a platform to bridge the physical and digital worlds and support various operational functions in HKUST, including indoor air quality management, engineering analysis, building management, maintenance management, indoor navigation, and space management.

During the first phase of the initiative, the HKUST converted original 2D records of campus buildings and student halls into 3D BIM models. The HKUST then conducted field surveys using a 3D laser scanner to obtain point cloud data of the campus and validate the BIM models.

In this case BIM serves as an enabler to other applications in FM. For instance, the indoor navigation function allows users to find the shortest path from a particular room to a targeted room in the campus. Assisted by Wifi and iBeacon, the existing position of users can be obtained whilst geospatial information can be extracted from the BIM model.

Space management can also be enhanced with the Digital Twin. Through better collection and integration of data, allocation and management of space at HKUST can be optimised based on existing and forecast requirements. The data on room masses provide graphical information on room size and dimensions for every room in the academic buildings. Additional non-graphical information, including room tags and attributes, are also added to the model. Together, the model provides essential information

[82] Construction Industry Council (2020), Experience Sharing and Way Forward from HKUST Digital Twin [Webinar].

for FM planning, analysis and management of physical space. Floor plan documentation can be created as a single source of truth to assist various FM functions, such as colour-coding and visualising the distribution of rooms and monitoring of occupancy information.

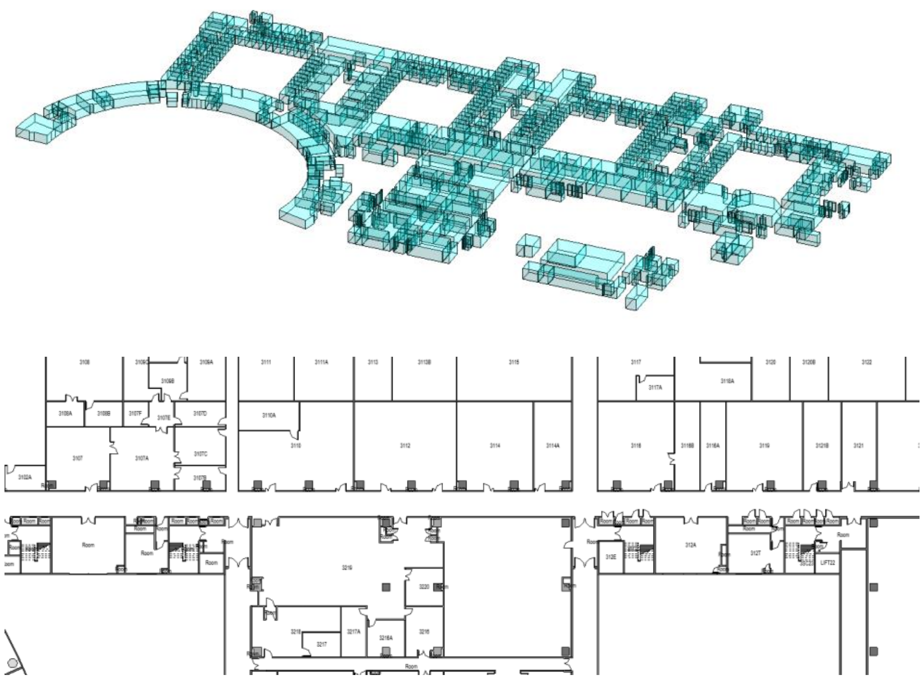


Figure 9.30: Room masses, room tags and attributes and room masses (Source: HKUST)

9.6.5 Maintenance Management

The EMSD has developed a BIM-AM system which integrates BIM with other O&M systems and tools, including the BMS, CCTV system, RFID scanning tool and real-time location system (RTLS). The BIM-AM system has been successfully employed in the EMSD headquarters building and also at the CIC Zero Carbon Park.

The integrated BIM-AM system creates synergies between different FM technologies. Major benefits include centralised records and management of works/ service orders, and faster response to incidents and emergencies. At the EMSD headquarters, the CCTV system allows remote monitoring of real-time E&M plant operation with pan-tilt-zoom cameras for effective incident handling. Sensors and IoT technology provide crucial information about the health and status of plant and equipment. Locating critical equipment and enquiring about asset information (e.g. maintenance records, static and dynamic O&M manuals, real-time sensor data and site images) are assisted by QR codes and RFID tags, with Ultra-Wide Band technology for precise positioning.

The BIM-AM system encourages collaboration between stakeholders. Real-time notifications of incidents are issued to the field teams and related parties. Queries and works orders can be directly created through the integrated system. With the help from AI and big data, predictive maintenance is made possible through real-time collection and analysis of operational data, allowing significant time and cost to be saved by avoiding unexpected failures and minimising the downtime of plant and machineries.

As early as 2015, the ArchSD has demonstrated innovative use of BIM in the heritage project of Victoria Peak Fire Station.

Heritage Information Modelling (HIM) utilises new technologies to digitalise buildings with physical, architectural, functional, social and cultural characteristics. It provides a new way of working in collaboration. In 2019, the ArchSD developed an HIM model for the Peak Police Station through the adoption of 3D laser scanning, UAV photogrammetry, panorama photography and historical research.

With the dimension of time (4D) introduced into the 3D models, architectural changes of the Peak Police Station's components were modelled to indicate this Grade III Historic Building's historic evolution. Different historical and cultural non-graphical information can be attached to its appropriate phases from 1886 to 2019. The ArchSD has also evaluated the existing physical conditions of the building and identified the maintenance requirements of different elements. Appropriate repair works can be performed to retain the cultural significance, thereby contributing to facilities upkeep and heritage conservation.

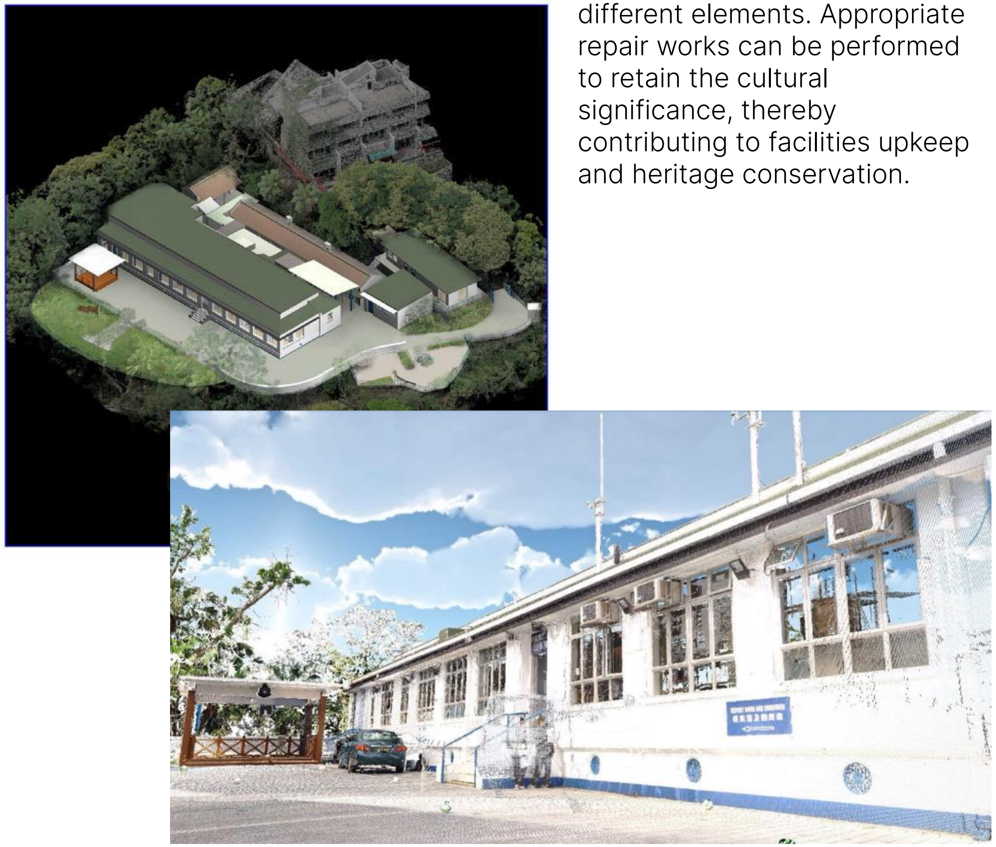


Figure 9.31: HIM model and 3D point cloud model (source: ArchSD)

9.6.6 Building Performance and Sustainability Management

Building activities account for 90% of electricity consumption and 60% of carbon emissions in Hong Kong. By adopting digitalisation, green building design, full lifecycle consideration, integration and management, the AECO industry could make a major contribution to the HKSAR 2050 net zero carbon emission goal.

Green building design is a practice to reduce the environmental impact of buildings and enhance the health and wellbeing of building occupants by planning throughout the lifecycle of a built asset or a community, optimising efficient use of energy, water, and other resources, adopting the use of renewable energy and eco-friendly materials, reducing waste production, and enhancing indoor environmental quality.[83]

The CIC Zero Carbon Park (CIC-ZCP) is a best-practice example of green building and sustainable management. The CIC-ZCP aspires to boost the neighbourhood's ecological value, and contribute as a living, breathing piece of infrastructure. There are more than 200 different varieties of flowers and trees at the CIC-ZCP. 3D images are captured by drone and used to generate a 3D mesh model of the facility. The number of trees is counted and their locations plotted, enabling spatial analysis for tree maintenance and asset management to be performed through the CIC-ZCP GIS platform.

"In addition, the energy-efficient active systems at the CIC-ZCP result in a 25% of energy saving compared to a similar building with a current standard design. During O&M, the CIC-ZCP deploys an intelligent lighting management system comprising zone control, dimmable energy-efficient light fittings, pre-set scenes for multi-purpose rooms, time-clock and occupancy sensing, daylight harvest and responsive control, automatic shade for glare control, individual control and BMS integration. More than

[83] Hong Kong Green Building Council, What is Green Building?

2,500 sensors are installed to monitor the building performance and improve sustainability and building operation. Information from the BMS is displayed on a 3D model of the building in real-time in the Building Environmental Performance Assessment Dashboard (BEPAD), together with real-time energy and carbon emission performance."[84] In addition, the CIC-ZCP generates onsite renewable energy from photovoltaic panels and a tri-generation system using biofuel made of waste cooking oil, and is projected to achieve zero net carbon emissions on an annual basis. Surplus energy can even be exported to offset the facility's embodied carbon in its construction and use of major structural materials.[85]

7 action items are recommended to support the development of Smart AM/FM (DA6) as illustrated in Figure 9.33.

Figure 9.32: The CIC Zero Carbon Park

[84] Construction Industry Council, ZCP's Design Strategies.

[85] Construction Industry Council (2018), Formulation of Sustainable Trigeneration System Design for High-Rise Commercial Buildings in Hong Kong Research Summary.

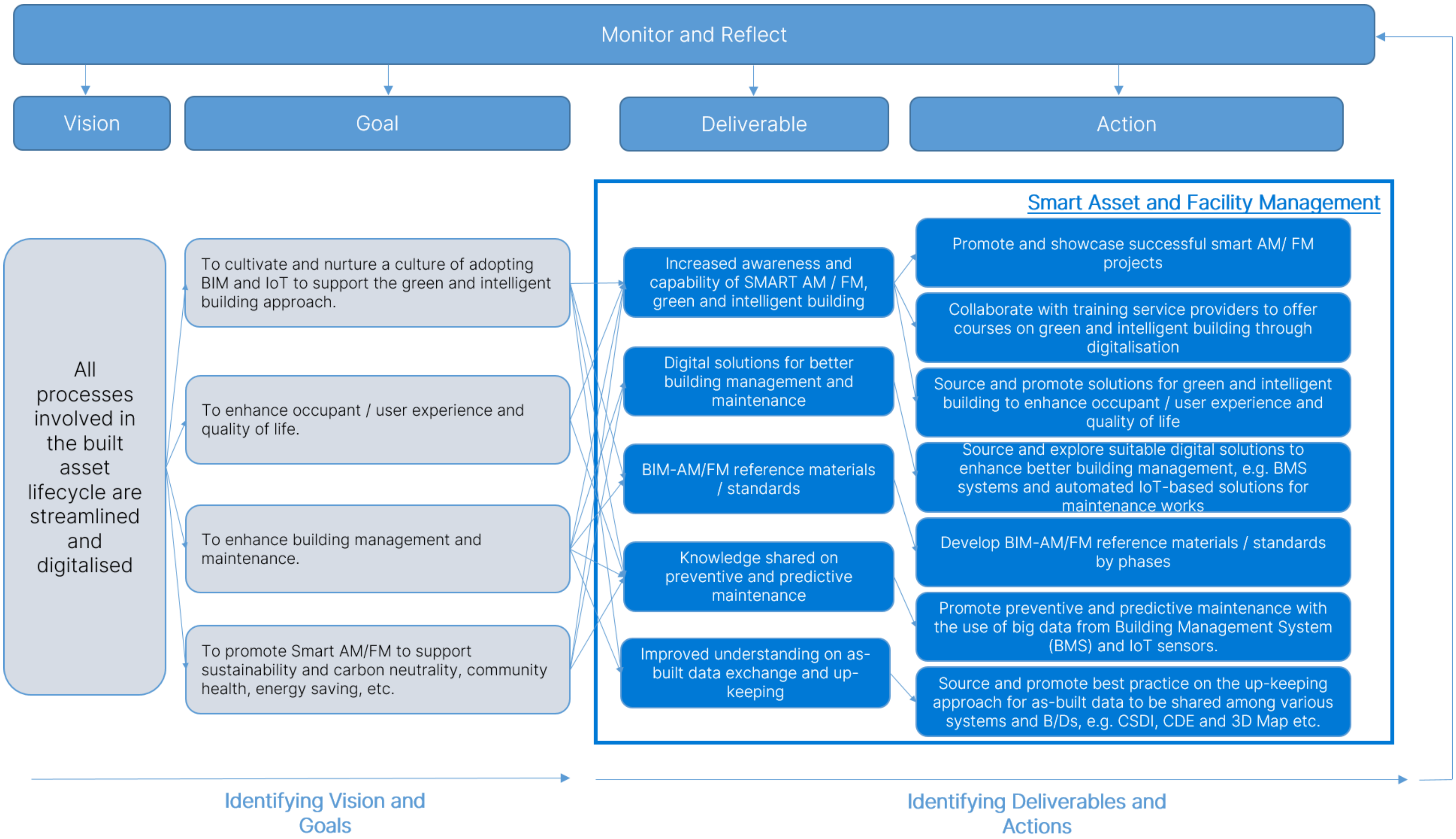


Figure 9.33: Impact diagram for DA6: Smart AM/FM

10. Strategies and Recommendations

The nine core strategies to support construction digitalisation are illustrated in Figures 10.1 and 10.2.

S1. POLICY

Policy is the most critical factor in driving technology adoption as well as motivating changes in established yet inefficient and ineffective practices. Establishing effective means of communication with the relevant Government bureaux / departments and regulators to drive the introduction of appropriate facilitating policies and identify pilot projects for showcase implementation is extremely important. Another focus would be to encourage clients to drive technology adoption by specifying such requirement in their projects.

S2. CHANGING MINDSET

Changing Mindset is often regarded as more important than the technology itself in the adoption of digital technology. In most cases, the technologies are there but the people involved are not ready to change. Some effective principles to impart a new mindset could be "providing positive examples", "use the bandwagon effect", "signal credibility" and "respect autonomy". Conducting workshops to "educate" project clients is among top priorities.

S3. STANDARDS & REFERENCE MATERIALS

Standards & Reference Materials are fundamental to the successful development of construction digitalisation. It provides good practice and information standards for industry to follow which could enhance communications and productivities. Promoting open standards, formulating survey standards/ specifications for public utilities, and publishing templates for MEP submissions are among the work required to facilitate digitalisation.

S4. CAPACITY & CAPABILITY BUILDING

Capacity & Capability Building should always be the focus prior to and in parallel with any initiatives on construction digitalisation. Promoting and developing training on CDE through project-based training, training on using digital tools for site safety and training for regulators, etc., are priority items. Introducing BIM to STEM/STEAM students is another important task to attract young talents to the construction industry.

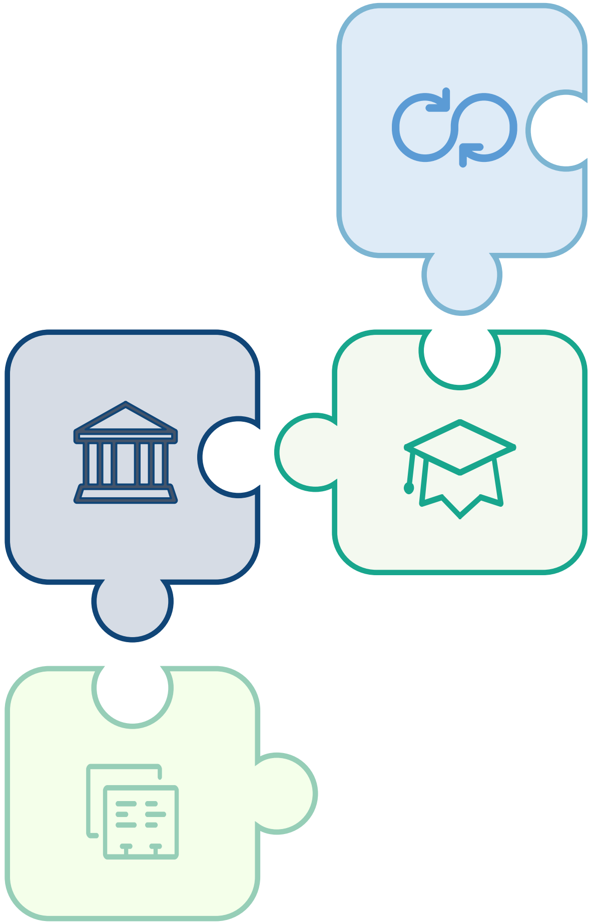
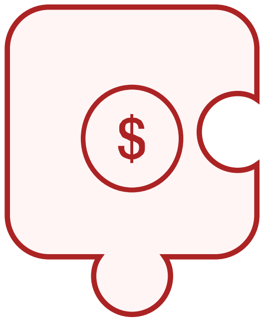
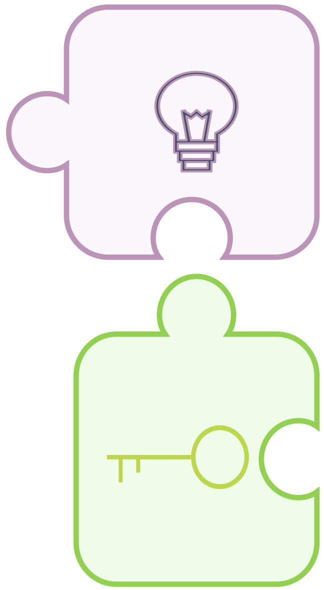


Figure 10.1: Core strategies to support construction digitalisation (Part 1)

S5. FUNDING SUPPORT

Funding Support cannot be over-emphasised in construction digitalisation as technology adoption inevitably requires capital investment and scepticism about Return on Investment (ROI) is understandable. Promoting the CITF, the CIC R&D fund, HKCA safety fund and other available funds for technology adoption, as well as providing feedback to enhance funding support, are all important.



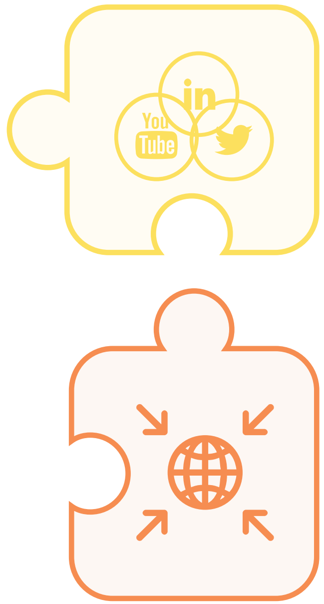


S6. RESEARCH & DEVELOPMENT

Research & Development will provide ideas and solutions for the continuous improvement of Hong Kong's construction industry. Developing a construction innovation platform to match solution providers to pain points of the industry is important to leverage the right resources on the right problems. Automating code compliance checking, and BEAM Plus, including the CIC Carbon Assessment Tool, and researching more on logistic planning are upcoming focus items. Exploring the use of Smart Contracts and Blockchain in construction among others will be next to enhance traceability and autonomy in contract execution. Technology transfer and adoption of R&D deliverables can make practical impact to the industry.

S7. DATA PROTECTION & CYBER SECURITY

Data Protection & Cyber Security are always priority concerns when implementing digitalisation. Protecting data and promoting best practices in cyber security are topics requiring further effort. As cloud storage, application and cloud computing are becoming more popular, reference materials and specification are needed to facilitate project stakeholders in procuring services on the basis of the reputation for confidentiality, integrity and resilience of, and the security services offered by, a provider.



S8. PROMOTION & SHOWCASING

Promotion & Showcasing are the means to spread beliefs, ideas, and best practices. Leveraging the CIC i-Club, sourcing and promoting the successful BIM-AM/FM systems, and promoting BIM auto-checking plugin and the CIC waste management plugin, etc., are some of the work planned within this strategy.

S9. GLOBAL COMPETITIVENESS

Global Competitiveness should not be overlooked. One of the reasons to carry out construction digitalisation in Hong Kong is to increase Hong Kong's competitive advantage in the region and in the world. Establishing a Construction Directory on a digital exchange platform for the GBA supply chain in DfMA/ MiC and collaborating with GBA's partners are important tasks to be accomplished.

Figure 10.2: Core strategies to support construction digitalisation (Part 2)

Taking forward the initiatives

There are six DAs to support the development of construction digitalisation in Hong Kong. The Relevant CIC board/committee will be identified to take forward each DA and formulates actions/tasks with specific measurable outcomes. To better monitor and achieve the vision, the responsible board/committee will review the objectives and recommended action items in this section and set KPIs and implementation plans to achieve them. Industry experts and practitioners would be invited to contribute to the various tasks.

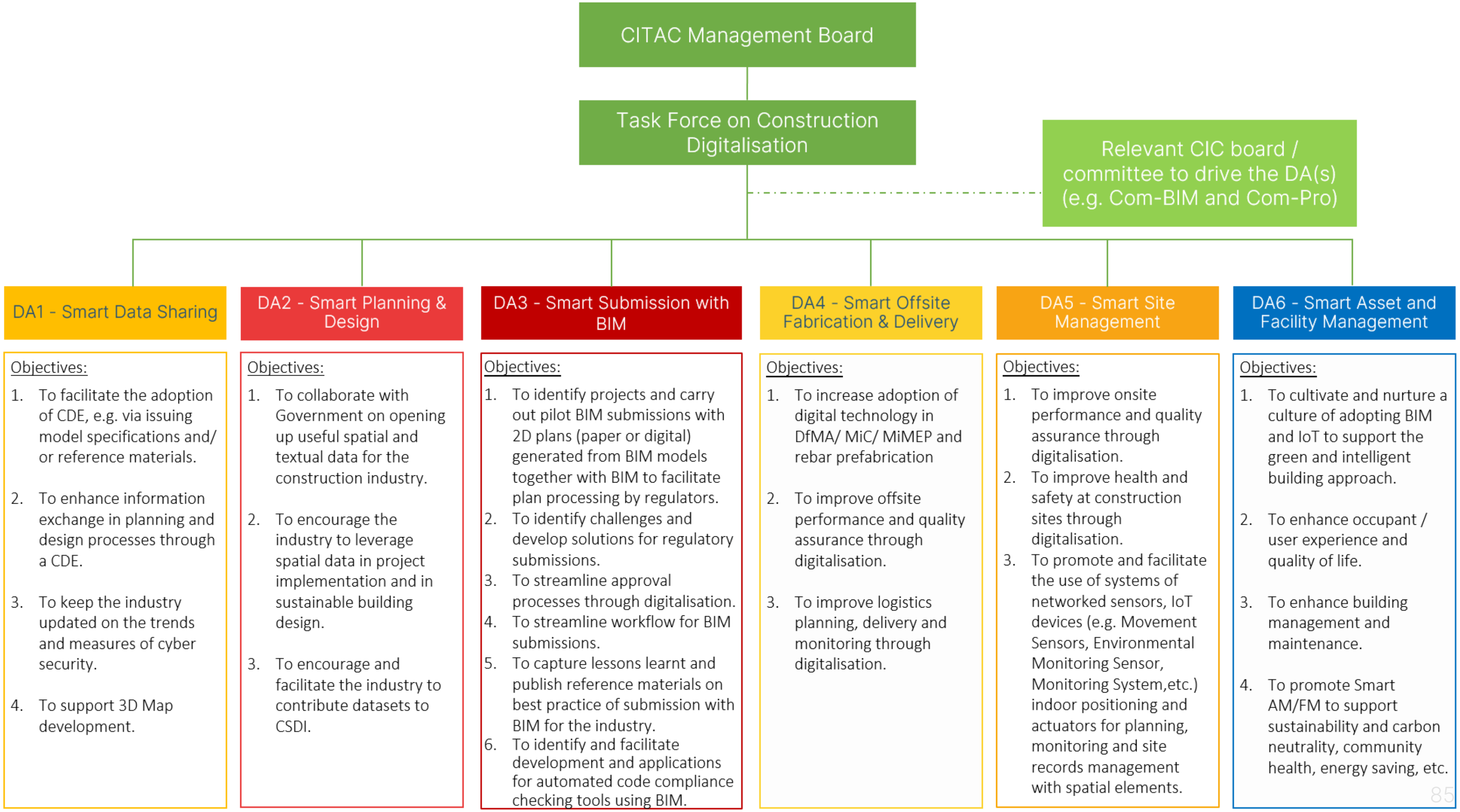


Figure 10.3: Taking forward the initiatives

<table>
<tr><th colspan="4">Digital Application Area 1 (DA1)</th></tr>
<tr><td>DA1</td><td colspan="3">Smart Data Sharing
Integrated with BIM and GIS, CSDI and CDE form the "core" of construction digitalisation.</td></tr>
<tr><td>Objectives</td><td colspan="3">1. To facilitate the adoption of CDE, e.g. via issuing sample specifications and/ or reference materials.
2. To enhance information exchange in planning and design processes through a CDE.
3. To keep the industry updated on the trends and measures of cyber security.
4. To support 3D Map development.</td></tr>
<tr><td rowspan="8">Recommended Action Items (Objectives/ Quick Wins (QW))</td><td>Collaborate with training service providers to develop and offer training courses on CDE using virtual/ real projects</td><td>1</td><td>QW</td></tr>
<tr><td>Provide more options on CDE to enhance project collaboration by sourcing and exploring more CDE solutions globally</td><td>1</td><td></td></tr>
<tr><td>Develop reference materials for specifying CDE implementation</td><td>1, 2, 3</td><td></td></tr>
<tr><td>Promote to project clients to specify CDE that suits their requirements, and use the CDE specified throughout various stages of a built asset (ongoing)</td><td>1, 2, 3</td><td>QW</td></tr>
<tr><td>Develop reference materials to guide the industry to select CDE and use open standards for information exchange at different stages of the built asset lifecycle</td><td>2. 4</td><td></td></tr>
<tr><td>Organise CPD events on cyber security issues for the construction industry</td><td>3</td><td>QW</td></tr>
<tr><td>Formulate good practices or specifications on data security for the construction industry and develop reference materials</td><td>3</td><td></td></tr>
<tr><td>Organise CPD events on 3D Map development</td><td>4</td><td></td></tr>
</table>

Digital Application Area 2 (DA2)			
DA2	**Smart Planning and Design** Open up Government spatial data to facilitate site planning, engineering and environmental analysis, and collect 3D Spatial and BIM data from the industry to build the 3D digital Map of Hong Kong.		
Objectives	1. To collaborate with Government on opening up useful spatial and textual data for the construction industry. 2. To encourage the industry to leverage spatial data in project implementation and in sustainable building design. 3. To encourage and facilitate the industry to contribute datasets to CSDI.		
Recommended Action Items (Objectives/ Quick Wins)	Collaborate with DEVB (WB and SDO) to form a liaison group to collect and release industry-requested spatial and textual data in an agreed and standardised format	1	QW
	Collect successful digital use cases of BIM-GIS Integration and promote smart planning and design	2	QW
	Develop and conduct CPD events to educate the industry in using 3D spatial data from Governments' open data platform	2, 3	QW

<table>
<tr><th colspan="4">Digital Application Area 3 (DA3)</th></tr>
<tr><td>DA3</td><td colspan="3">Smart Submission with BIM
Submission with 2D plans (paper or digital) generated from BIM model together with BIM to facilitate plan processing by the regulators.</td></tr>
<tr><td>Objectives</td><td colspan="3">1. To identify projects and carry out pilot submissions with 2D plans (paper or digital) generated from BIM models together with BIM to facilitate plan processing by regulators.
2. To identify challenges and develop solutions for regulatory submissions.
3. To streamline approval processes through digitalisation.
4. To streamline workflow for submissions with BIM.
5. To capture lessons learnt and publish reference materials on best practice of submission with BIM for the industry.
6. To identify and facilitate development and applications for automated code compliance checking tools using BIM.</td></tr>
<tr><td rowspan="4">Recommended Action Items (Objectives/ Quick Wins)</td><td>Identify projects and carry out pilot submissions with 2D drawings generated from BIM model, and identify challenges and develop solutions for regulatory submissions</td><td>1</td><td>QW</td></tr>
<tr><td>Develop reference materials on good practices in submissions with BIM to the regulators</td><td>2, 4, 5</td><td>QW</td></tr>
<tr><td>Facilitate early decision making by the regulators to accept digitalised submissions and introduce measures to streamline the approval process</td><td>3, 4</td><td></td></tr>
<tr><td>Encourage and facilitate development and adoption of automated code compliance checking tools (e.g. Automated GFA Calculation, Fire Safety and Prescribed Checking for GBP) to accelerate the checking and approval process</td><td>3, 4, 5, 6</td><td></td></tr>
</table>

Digital Application Area 4 (DA4)			
DA4	Smart Offsite Fabrication & Delivery Leverage digitalisation to shift onsite processes to a controlled offsite environment in the GBA, and just-in-time delivery.		
Objectives	1. To increase adoption of digital technology in DfMA/ MiC/ MiMEP and rebar prefabrication. 2. To improve offsite performance and quality assurance through digitalisation. 3. To improve logistics planning, delivery and monitoring through digitalisation.		
Recommended Action Items (Objectives/ Quick Wins)	Develop a Construction Business Directory on a digital exchange platform for the GBA's DfMA/ MiC/ MiMEP supply chain. (ongoing)	1	QW
	Establish a digital platform to facilitate adoption and implementation of DfMA/ MiC/ MiMEP/ etc.	1	
	Organise CPD events on "smart offsite fabrication and delivery". (ongoing)	1, 2, 3	
	Identify and promote useful digital applications for offsite inspection. (ongoing)	1, 2	QW
	Develop reference materials on digitalisation of offsite fabrication and delivery processes.	1, 3	QW
	Encourage development and adoption of digital tools for effective logistics planning, delivery and monitoring.	3	

Digital Application Area 5 (DA5)			
DA5	Smart Site Management System of seamlessly networked sensors, IoT devices and actuators for planning, monitoring and site records management.		
Objectives	1. To improve onsite performance and quality assurance through digitalisation. 2. To improve health and safety at construction sites through digitalisation. 3. To promote and facilitate the use of systems of networked sensors, IoT devices (e.g. movement sensors, environmental monitoring sensor, monitoring system, etc.) indoor positioning and actuators for planning, monitoring and site records management with spatial elements.		
Recommended Action Items (Objectives/ Quick Wins)	Identify site supervision and monitoring procedures for digitalisation to improve project management.	1	QW
	Enrich site safety training with digital technologies (e.g., VR Safety Training Platform to collect and disseminate safety training material).	1, 2, 3	QW
	Encourage development and adoption of digital tools to improve and monitor site environment (e.g. vibration, noise and air quality control).	2	
	Identify pilot projects for development of common digital platform for site supervision.	1, 3	QW
	Promote and facilitate wider adoption of smart site management technologies through funding support (e.g. CITF). Collaborate with clients, AP/ RSE/ RGE/ AS/ TCPs and contractors to adopt digital site supervision and monitoring tools in the private sector.	2, 3	QW
	Develop best practice guides and reference specifications for different trades in the industry.	1, 3	

Digital Application Area 6 (DA6)			
DA6	**Smart Asset and Facility Management** Use of digital technology and integration with Building Management Systems for better asset and facility management and to achieve sustainability.		
Objectives	1. To cultivate and nurture a culture of adopting BIM and IoT to support the green and intelligent building approach. 2. To enhance occupant/ user experience and quality of life. 3. To enhance building management and maintenance. 4. To promote Smart AM/ FM to support sustainability and carbon neutrality, community health, energy saving, etc.		
Recommended Action Items (Objectives/ Quick Wins)	Promote and showcase successful smart AM/ FM projects.	1, 2, 3, 4	QW
	Collaborate with training service providers to offer courses on green and intelligent building through digitalisation.	1, 2, 3, 4	
	Source and promote solutions for green and intelligent building to enhance occupant/ user experience and quality of life.	1, 2, 3, 4	
	Source and explore suitable digital solutions to enhance better building management, e.g. BMS systems and automated IoT-based solutions for maintenance works.	3, 4	QW
	Develop BIM-AM/ FM reference materials/ standards by phases.	1, 3	QW
	Promote preventive and predictive maintenance with the use of big data from Building Management System (BMS) and IoT sensors.	1, 2, 3, 4	
	Source and promote best practice on the upkeeping approach for as-built data to be shared among various systems and B/Ds, e.g. CSDI, CDE and 3D Map etc.	1, 3	

<table>
<tr><th colspan="4">Core strategies to support construction digitalisation</th></tr>
<tr><td>Strategic Areas</td><td colspan="3">The nine core strategies to support construction digitalisation are:

1. Policy
2. Standards & Reference Materials
3. Changing Mindset
4. Capacity & Capability Building
5. Funding Support
6. Research & Development
7. Data Protection & Cyber Security*
8. Promotion & Showcasing
9. Global Competitiveness</td></tr>
<tr><td rowspan="5">Recommended Action Items (Strategic Areas/ Quick Wins)</td><td>Promote CITF, CIC R&D Fund, ITF, HKCA's Construction Safety Fund and other suitable funds to speed up adoption of digital technologies and digitalisation. (ongoing)</td><td>5, 8</td><td>QW</td></tr>
<tr><td>Collaborate with DEVB to identify pilot projects of BIM use for tendering and share lessons learnt.</td><td>1, 8</td><td></td></tr>
<tr><td>Collaborate with professional bodies and trade associations to offer BIM training for their members. (ongoing)</td><td>4</td><td>QW</td></tr>
<tr><td>Introduce BIM and Digitalisation to STEM/ STEAM school students the trend of digital construction using BIM, the concept of BIM and how it benefits the whole lifecycle of a built asset through a fun and engaging hands-on workshop.</td><td>4, 8</td><td>QW</td></tr>
<tr><td>Encourage R&D and application on new emerging digital technologies in construction, e.g. smart contract, blockchain, etc.</td><td>6</td><td></td></tr>
</table>

Recommended Action Items (Strategic Areas/ Quick Wins)	Develop an interactive data platform for forecasting the demand and supply of workers and for accessing the forecast results.	6	
	Measure the adoption, outcome and KPI of digitalisation in Hong Kong construction industry.	6	
	Develop a Construction Innovation Platform for industry practitioners to share their pain points and solution providers to offer solutions using digital technologies.	8	
	Organise mindset changing workshops for project clients, consultants, contractors, subcontractors, suppliers and operators to facilitate digitalisation adoption.	3	QW
	Organise the CIC Construction Digitalisation Award 2021 and 2024. (ongoing)	8	QW
	Promote and facilitate clients to adopt Common Data Environment (CDE) in their projects throughout various stages of a built asset.	2, 8	
	Organise webinars to share development and progress of digitalisation in GBA.	8, 9	QW
	Facilitate the adoption of digitalisation of SMEs. Continue to subsidise training of practitioners and buying of digital tools for SMEs through CITF and develop Starter Kits to SMEs.	4, 8	

Remark*: For recommended action items related to "Data Protection & Cyber Security", please refer to "DA1 – Smart Data Sharing".

Strategy Map for Construction Digitalisation in Hong Kong 2021-2026

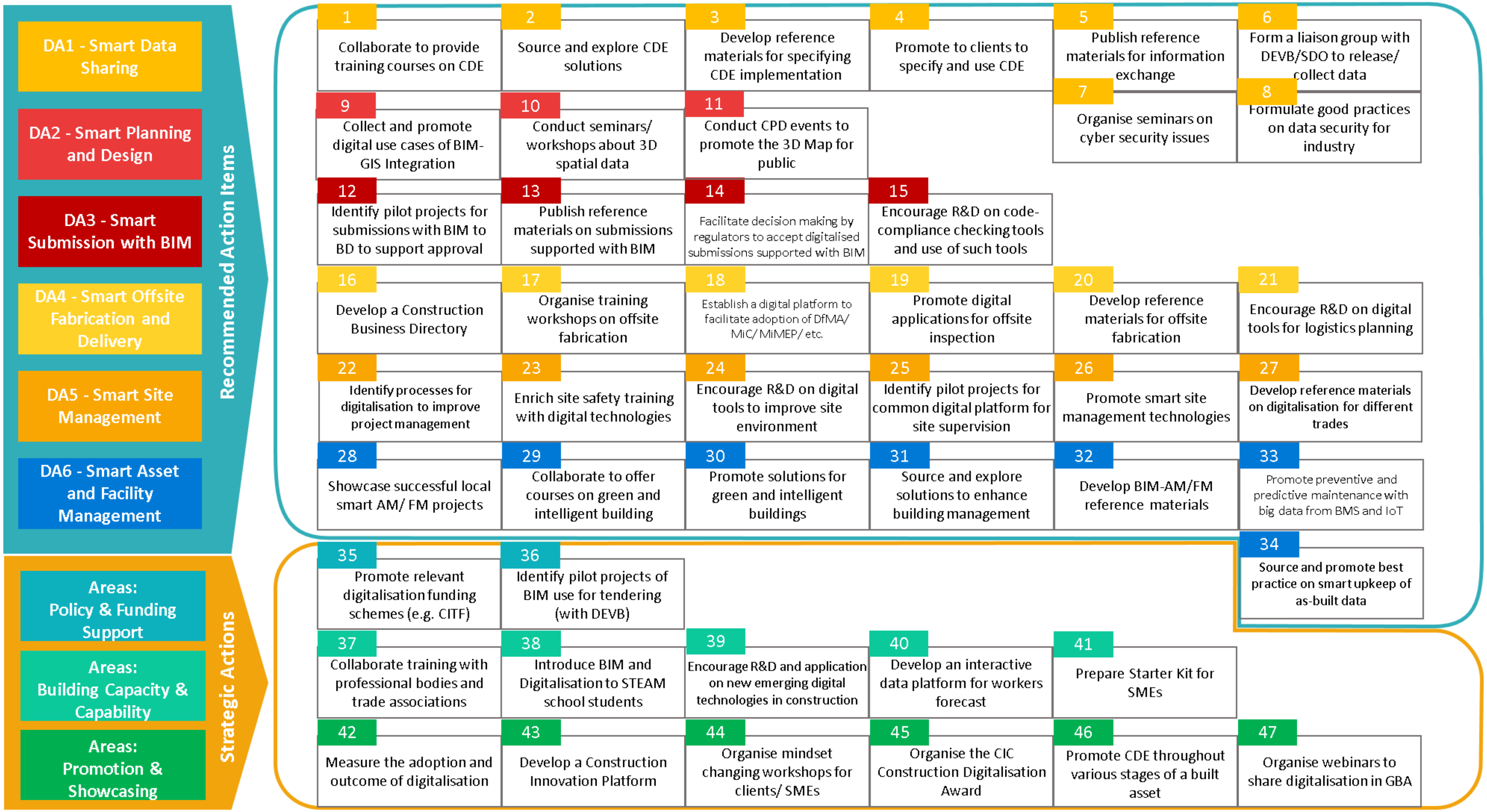


Figure 10.4: Summary of Strategic Actions and Recommended Action Items

11. Key Performance Indicators by 2026

The table below listed five important key performance indicators (KPIs) with specific and clear targets to be achieved by 2026. The KPIs provide quantifiable measures to ensure we are on the right path toward our vision - Smart Hong Kong empowered by construction digitalisation.

KPI[86]	Target by 2026
Adoption of Digitalisation by Projects[87]	100% for all $300M+ active projects
Adoption of Digital Tools in Site Supervision and Monitoring[88]	100% for all $300M+ active projects
Adoption of BIM by Projects[89]	100% for all $300M+ active projects
Adoption of CDE by Projects[90]	100% for all $300M+ active projects
Training of BIM Personnel[91]	100% for all BIM training targets

As illustrated throughout different sections of the Roadmap, digitalisation tools, in particular BIM, GIS, CDE and DWSS are integral to the built asset lifecycle and contribute to the Roadmap's vision of digital collaboration and streamlined workflow.

The CIC will provide support to the industry, in particular the SMEs, in the adoption of digitalisation. Starter Kits will be prepared to facilitate the adoption of digitalisation. The CITF will continue to subsidise training of practitioners and purchase of digital tools that are particularly useful.

The KPIs of the Roadmap will be continuously monitored. Individual KPIs may also be set by relevant boards/ committees to take forward the six DAs. A mid-term review will be carried out to document the status of adoption of digitalisation and its benefits and fine-tune the Roadmap for improvement if necessary.

[86] The first four targets exclude those projects for which adopt of BIM or digitalisation tools is not appropriate , see for example DEVB TC(W) No. 12/2020.

[87] According to the CIC "Survey on Adoption of Digitalisation in Construction Projects" ("Digitalisation Survey"), the overall digitalisation adoption rate in 2020 is 48% of all appropriate projects. (In the survey, a project with adoption of digitalisation is defined as" a project which had adopted or was planned to adopt at least one of the advanced construction-related digital tools").

[88] According to the Digitalisation Survey, 35% of all appropriate projects have adopted or planned to adopt DWSS (from those who answered they have adopted digitalisation in the projects surveyed).

[89] According to the Digitalisation Survey, 45% of all appropriate projects have adopted or planned to adopt BIM (from all projects surveyed).

[90] According to the Digitalisation Survey, 50% of all appropriate projects have adopted or planned to adopt CDE (from those who answered they have adopted digitalisation in the projects surveyed).

[91] The BIM training target refers to all BIM personnel mentioned in the holistic study of BIM training by the CIC and DEVB. The targets are: 850 CCBMs, 2,600 CCBC, 6,600 BIM Modellers and 17,000 BIM Viewers trained by end of 2025. For details, please refer to Construction Industry Council (2021), Launching Ceremony for the New Edition of CIC BIM Standards and Other BIM Initiatives [Webinar].

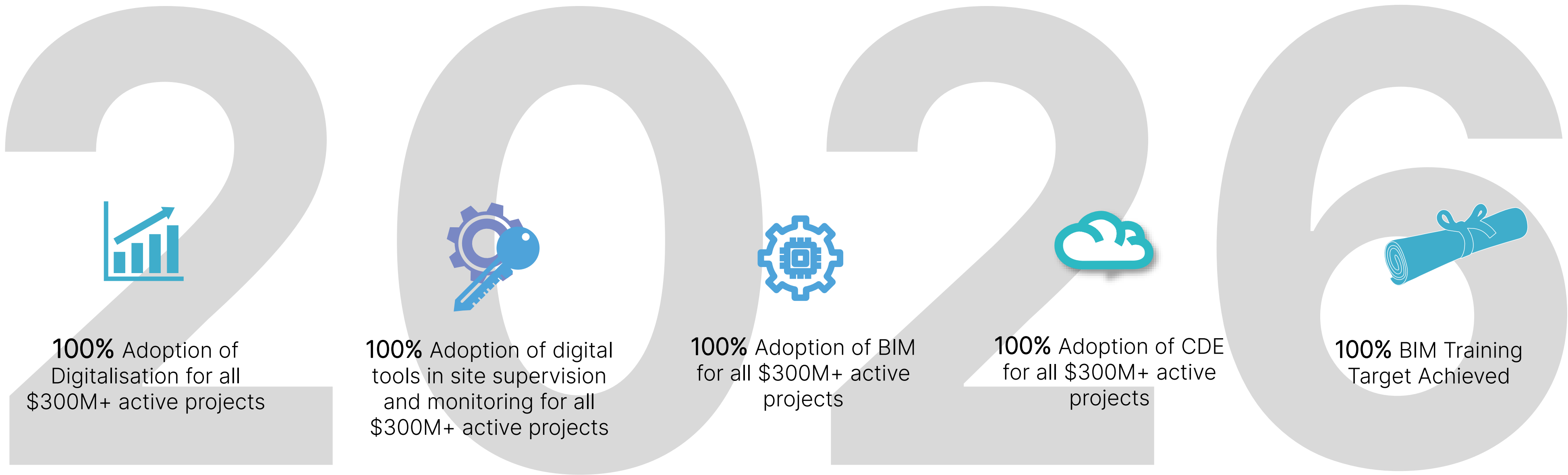


Figure 11.1: Key performance indicators by 2026

12. Going Forward

It is a long road to achieve the vision of "all processes involved in the built asset lifecycle are streamlined and digitalised to continuously improve productivity and safety during planning, design, construction and operation, and sustainability for better quality of life." With vigorous pursuit of the Roadmap, it is believed that stakeholders of the construction industry will steadily become more BIM-literate, be more eager to collaborate in common data environments throughout the project lifecycle, and more willing to share their data for a smarter Hong Kong.

The Government of the HKSAR will continue to be the driving force and strive for a world-class smart city, with construction digitalisation or Smart Construction playing a leading role in providing smart built assets for all the smart areas to thrive.

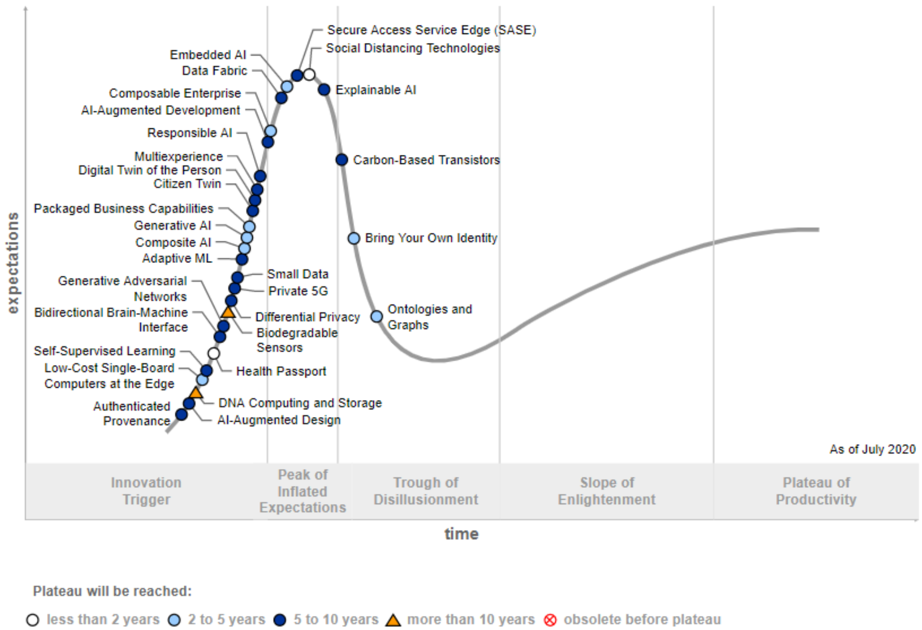


Figure 12.1: Hype cycle for emerging technologies 2020 (Source: Gartner)

Looking ahead to the coming decade, many technologies shown on the Gartner Hype Cycle 2020 will probably peak and become mature for successful application in the industry. On the other hand, many others on the Hype Cycle are also likely to disappear. Instead of speculating about this, what is needed along the journey of construction digitalisation are regular reviews to understand the changing circumstances, and to be sufficiently agile and dynamic to realise that changes will be essential to bring plans to pragmatic fruition. Nevertheless, one thing should remain unchanged - to keep dreaming of a Smart Hong Kong fully and seamlessly underpinned by construction digitalisation.

13. References

Burke, B. (2020). Top Strategic Technology Trends for 2021. Gartner.

Chan, P., Chan, H., Yuen P. (2016). Next-Generation Integrated Asset Management System with. Building Information Modelling.

Davis, F. D. (1985). A Technology Acceptance Model for Empirically Testing New End-User Information Systems.

Emani, P. (2020). Digital Feedback Loops - How to Track Integrated Engineering Change in AEC Projects Without the Heavy Lift. Bentley Systems.

Evans-Greenwood, P, Hillard, R, & Williams, P. (2019). Digitalizing the construction industry - A case study in complex disruption. Deloitte.

Fung, A. (2019). Disruptive Technologies For Built Asset and Environment.

Godsell, J., Kaya, L., Glass, J., Plante, D., Hanselmann, L., McGilvray, J. (2020). Creating Impact from Research. Transforming Construction Network Plus.

Greenough, T., Smith, M., and Mariash, A. (2019). Integrating Computational Design to Improve the Design Workflow of Modular Construction.

Schley, M. et al. (2016). BIM For Facility Management.

Shiu, W. (2020). Surveyor Times Vol 29.

Song, J. (2005). Tracking the Location of Materials on Construction Projects [PhD Thesis]. University of Texas.

Song, J., Haas, C. T., & Caldas, C. H. (2006). Tracking the Location of Materials on Construction Job Sites. Journal of Construction Engineering and Management [Thesis].

Tang, W. (2020). Are you Future Ready?.

Teicholz, E. (2012). Technology For Facility Managers. Wiley.

Teicholz, P. (2013). BIM For Facility Managers. Wiley.

Arup Group Limited. (2019). FM 2.0 Re-imagining Facility Management for the Digital Age.

Autodesk. (2020). Construction Connected - How Autodesk Construction Cloud combines advanced technology, a robust industry network, and powerful insights to help business thrive.

British Standards Institution. (2014). ISO 55000:2014.

British Standards Institution. (2017). ISO 41011:2017.

British Standards Institution. (2018). BS EN ISO 19650-1:2018.

Bryden Wood. (2017). Platform Design for Manufacture and Assembly (PDfMA): using lean construction to create a smarter.

Building and Construction Authority (BCA). (2017). Construction ITM Factsheet.

Building and Construction Authority (BCA). (2019). Guide to Smart FM - An initiative from FMIC (Facilities Management Implementation Committee) Smart FM Taskforce.

Building and Construction Authority (BCA). (n.d.). Design for Manufacturing and Assembly (DfMA).

Buildings Department. (2016). PNAP ADV-34 on Building Information Modelling.

Buildings Department. (2017). PNAP ADV-36 on Modular Integrated Construction.

Buildings Department. (2019). PNAP APP-161 on Exemption of Gross Floor Area for Buildings adopting Modular Integrated Construction.

buildingSMART International. (2020). Enabling an Ecosystem of Digital Twins.

Centre for Digital Built Britain. (2018). The Gemini Principles.

Centre for Digital Built Britain. (2019). Roadmap to the Information Management Framework for the Built Environment.

Centre for Digital Built Britain. (2020). The approach to delivering a National Digital Twin for the United Kingdom.

Centre for Digital Built Britain. (2020). The pathway towards an Information Management Framework - A 'Commons' for Digital Built Britain.

China Construction Technology Group. (2019). A report about localized development and application of "BIM Design and Management".

Civil Engineering and Development Department. (2020). BIM Horizontal Harmonization for BIM/ GIS Integration.

Civil Engineering and Development Department Geotechnical Engineering Office. (2021). GEO Data for Public Use.

Climate Ready@HK. (2017). Hong Kong's Climate Action Plan 2030+.

Committee for European Construction Equipment. (2019). Digitalising the Construction Sector - Unlocking the potential of data with a value chain approach.

Construction Industry Council. (2014). Roadmap for Building Information Modelling Strategic Implementation in Hong Kong's Construction Industry.

Construction Industry Council. (2018). Formulation of Sustainable Trigeneration System Design for High-Rise Commercial Buildings in Hong Kong Research Summary.

Construction Industry Council. (2019). CIC BIM Standards - General.

Construction Industry Council. (2020). Consultancy Services On The 3D And BIM Data User Case Requirements Of The Construction Industry For The Development Of Digital HK - Final Report.

Construction Industry Council. (2020). A Practical Systems Approach for Hong Kong to Re-invent itself as a Leader in Construction Productivity, Innovation and Expertise.

Construction Industry Council. (2020). Consultancy Study on the 3D Spatial and BIM Data Use Case Requirements of the Hong Kong Construction Industry.

Construction Industry Council. (2020). CIC BIM Standards - (General Version 2 - December 2020).

Construction Industry Council. (2020). CIC Webinar on BIM for Asset Management/ Facility Management: Experience Sharing and Way Forward from HKUST Digital Twin [Webinar].

Construction Industry Council. (2020). CIC BIM Adoption Survey 2019.

Construction Industry Council. (2020). CIC BIM Dictionary.

Construction Industry Council. (2021). CIC BIM Adoption Survey 2020.

Construction Industry Council. (2021). A Practical Systems Approach for Hong Kong to Re-invent itself as a Leader in Construction Productivity.

Construction Industry Council. (2021). ZCP's Design Strategies.

Construction Industry Council. (2021). Launching Ceremony for the New Edition of CIC BIM Standards and Other BIM Initiatives [Webinar].

Construction Industry Council. (2021). "Survey on Adoption of Digitalisation in Construction Projects".

Construction Innovation Hub. (2020). An Introduction to the value toolkit.

Development Bureau. (2016). Technical Circular (Works) No. 1/2016.

Development Bureau. (2017). Technical Circular (Works) No. 7/2017 .

Development Bureau. (2018). Construction 2.0 Time to change.

Development Bureau. (2018). Technical Circular (Works) No. 18/2018.

Development Bureau. (2020). Technical Circular (Works) No. 2/2020.

Development Bureau. (2020). Initiatives of Development Bureau in the Chief Executive's 2020 Policy Address and Policy Address Supplement.

Development Bureau, Construction Industry Council. (2020). VR Safety Training Software Download Platform and Virtual Reality Safety Training User Guide & Instructions.

Electrical and Mechanical Services Department. (2017). Building Information Modelling for Asset Management (BIM-AM) Standards and Guidelines Version 1.0.

Electrical and Mechanical Services Department. (2017). BIM-AM Standards and Guidelines Version 1.0.

Esri China (Hong Kong). (2020). Big Data and Smart City.

Esri China (Hong Kong). (2020). GIS and BIM Integration for Digital Uses.

European Network and Information Security Agency. (2012). Cloud Computing Benefits, risks and recommendations for information security.

FINALCLAD. (2020). A Digital Future for Global Construction.

Gammon. (2019). The Record - Smart and digital construction.

Gartner. (2020). 5 Trends Drive the Gartner Hype Cycle for Emerging Technologies.

Gartner. (n.d.). Gartner Glossary: Information Technology Glossary.

GeoPlatform.gov. (n.d.). Why GeoPlatform.gov?.

Highways England/ I3P. (2020). Connected and Autonomous Plant - Roadmap to 2035.

HKCERT. (2020). Hong Kong Security Watch Report Q2.

HKSAR Government. (2017). Hong Kong Smart City Blueprint.

HKSAR Government. (2017). Policy Address 2017.

HKSAR Government. (2018). Policy Address 2018.

HKSAR Government. (2020). Hong Kong Smart City Blueprint 2.0.

HKSAR Government. (2020). LCQ10: Common Spatial Data Infrastructure.

HM Government. (2013). Construction 2025 - Industrial Strategy: government and industry in partnership.

Hong Kong Green Building Council Limited. (2020). Hong Kong Report on the State of Sustainable Built Environment 2020.

Hong Kong Green Building Council Limited. (n.d.). What is Green Building?.

Innovate UK. (2019). Japan Transforming Construction 2019.

KPMG. (2020). Future Hong Kong 2030 - Public and private sector insights for smart city development.

Lands Department. (2020). The Establishment of A Territory-wide BIM Data Repository.

Lands Department. (2020). CIC Webinar on BIM Talks - The Establishment of A Territory-wide BIM Data Repository [Webinar].

Lands Department. (n.d.). BIM Data Management.

Legislative Council. (2017). Administration's paper on policy initiatives of the Innovation and Technology Bureau.

Legislative Council. (2018). Administration's paper on open data policy.

Legislative Council. (2018). Administration's paper on implementation of Electronic Submission Hub.

Legislative Council. (2018). Report Of The Public Accounts Committee On Report No. 70 Of The Director Of Audit On The Results Of Value For Money Audits.

Legislative Council. (2019). Administration's paper on development of Common Spatial Data Infrastructure and 3D Digital Map.

Legislative Council Panel on Development. (2019). Development of Common Spatial Data Infrastructure and 3D Digital Map.

McKinsey & Company. (2015). Digital America: A Tale Of The Haves And Have-Mores.

McKinsey & Company. (2016). Imagining construction's digital future.

McKinsey & Company. (2017). The new age of engineering and construction technology.

McKinsey & Company. (2019). Modular construction: From projects to products.

McKinsey & Company. (2019). Decoding digital transformation in construction.

McKinsey & Company. (2019). Modular construction: From projects to products.

McKinsey & Company. (2020). The next normal in construction.

McKinsey & Company. (2020). McKinsey Global Institute analysis.

Ministry of National Development. (2017). Construction Industry Transformation Map.

MTR Corporation. (2020). MTR Digital Journey.

Office of the Government Chief Information Officer. (2017). Report of Consultancy Study on Smart City Blueprint for Hong Kong.

Office of the Government Chief Information Officer. (2020). Smart Government Innovation LAB.

Planning Department. (2016). Hong Kong 2030+: A Smart, Green and Resilient City Strategy.

Plattform Industrie 4.0. (n.d.). What is Industrie 4.0?.

PricewaterhouseCoopers. (2018). PwC BIM Benefits Methodology and Report.

Smart City Consortium. (2020). Smart City Blueprint 2.0 Advisory Report.

SOPHOS Cybersecurity evolved . (2021). The Future of Cybersecurity in Asia Pacific and Japan 2nd Edition.

The Chartered Institute of Buildings. (2014). Code of Practice for Project Management for Construction and Development. Wiley.

住房城鄉建設部. (2011). 2011-2015 年建築業信息化發展綱要.

住房城鄉建設部. (2016). 2016-2020 年建築業信息化發展綱要.

住房城鄉建設部. (2020). 住房和城鄉建設部等部門關於推動智慧建造與建築工業化協同發展的指導意見.

住房城鄉建設部. (2020). 住房和城鄉建設部等部門關於加快新型建築工業化發展的若干意見.

14. Acknowledgement

Membership List of the Task Force on Construction Digitalisation
(in alphabetical order)

Members	Representative of
Ar. Donald CHOI (Chairperson)	Chairperson of CITAC Management Board
Ir Thomas CHAN	Development Bureau
Prof. Jack CHENG	Hong Kong University of Science and Technology
Dr. Eric CHONG	Business Environment Council
Ar. Rachel CHOW	The Hong Kong Institute of Architects
Mr. Ivan FU	Committee on Productivity
Ar. Ada FUNG	Committee on BIM
Mr. Simon KWOK	Hong Kong General Building Contractors Association
Sr Eric POON	Urban Renewal Authority
Sr Winnie SHIU	The Hong Kong Institute of Surveyors
Ir George SZE	The Hong Kong Institution of Engineers
Dr. Winnie TANG	Smart City Consortium
Ir Dr. Conrad WONG	Digital Solutions & MiC Expert
Mr. Rex WONG	Hong Kong Construction Association
Mr. Tony WONG	Innovation and Technology Bureau

Membership List of the Editorial Group
(in alphabetical order)

Members	Representative of
Ar. Ada FUNG (Editor-in-chief)	Committee on BIM
Dr. Winnie TANG (Deputy Editor-in-chief)	Smart City Consortium
Dr. Eric CHONG	Business Environment Council
Ir George SZE	The Hong Kong Institution of Engineers
Ir Dr. Conrad WONG	Digital Solutions & MiC Expert
Mr. Rex WONG	Hong Kong Construction Association

CONSTRUCTION INDUSTRY COUNCIL
建造業議會

Feedback Form

Thank you for reading this publication. To help us improve our future versions, we would appreciate your suggestions/feedback on the publication.

(Please put a " ✓ " in the appropriate box）

1. As a whole, I feel that this publication is:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Informative	❑	❑	❑	❑	❑
Comprehensive	❑	❑	❑	❑	❑
Useful	❑	❑	❑	❑	❑
Practical	❑	❑	❑	❑	❑

2. Does this publication enable you to understand more about construction digitalisation?	Yes	No	No Comment
	❑	❑	❑

3. Have you made reference to this publication in your work?	Quite Often	Sometimes	Never
	❑	❑	❑

4. To what extent have you incorporated the recommendations of this publication in your work?	Most	Some	None
	❑	❑	❑

5. Overall, how would you rate this publication?	Excellent	Very Good	Satisfactory	Fair	Poor
	❑	❑	❑	❑	❑

6. Other comments and suggestions (please specify and use separate sheets if necessary).

Personal Particulars (optional):*

Name: Mr. / Mrs./ Ms./ Dr./ Prof./ Ir / Sr ^ ____________________

Company: ____________________

Tel: ____________________

Address: ____________________

E-mail: ____________________

* The personal data collected will be used only for this survey. Your data will be kept confidential and dealt with only by the Construction Industry Council.

^ Circle the appropriate option.

Please send this feedback form to：

Construction Digitalisation Department, Industry Development Division, CIC

Email： bim@cic.hk

Address： 38/F, COS Centre, 56 Tsun Yip Street, Kwun Tong, Hong Kong

Fax： (852) 2100 9090

Enquiries

Enquiries on this Reference Material may be made to the CIC Secretariat:

CIC Headquarters
38/F, COS Centre,
56 Tsun Yip Street,
Kwun Tong, Kowloon

Tel : (852) 2100 9000
Fax : (852) 2100 9090
Email : enquiry@cic.hk
Website : www.cic.hk