CONSTRUCTION INDUSTRY COUNCIL
建造業議會

BIM

Report on 3D Spatial and BIM Data Use Case Requirements of the Hong Kong Construction Industry

2021

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Enquiries

Enquiries on the Reference Materials 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

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Abbreviation / Acronym	Definition
2D	Two Dimensional
3D	Three Dimensional
3DSD	3D Spatial Data
4D	Four Dimensional
A&A	Alterations and Additions
AAHK	Airport Authority Hong Kong
AAP	The Association of Architectural Practices
ACEHK	The Association of Consulting Engineers of Hong Kong
ACQS	Association of Consultant Quantity Surveyors of Hong Kong Limited
AECOM	AECOM Asia Company Limited
AI	Artificial Intelligence
AIIB	Asian Institute of Intelligent Buildings
AMO	Antiquities and Monuments Office
ArchSD	Architectural Services Department
ARUP	Ove Arup & Partners Hong Kong Limited
AVA	Air Ventilation Assessment
BD	Buildings Department
BEAM	BEAM Society
BGS	The British Geological Survey
BIM	Building Information Modelling
BRAVO	Building Records Access and Viewing Online
Build King	Build King Holdings Limited
CAD	Computer-aided Design / Drafting
CCTV	Closed-circuit Television
CD	Compact Disc
CEDD	Civil Engineering and Development Department
CE Library	Civil Engineering Library
CFD	Computational Fluid Dynamics
Chinachem	Chinachem Investment Company Limited
CIAT	Chartered Institute of Architectural Technologists Hong Kong
CIC	Construction Industry Council
CIOB	The Chartered Institute of Building
CityU	City University of Hong Kong
CLP	CLP Power Hong Kong Limited
Com-BIM	Committee on Building Information Modelling, CIC
Com-ENV	Committee on Environment, CIC
COVID-19	Coronavirus Disease 2019
CPS	Centralised Processing System
CSD	Census and Statistics Department
CSDI	Common Spatial Data Infrastructure

Abbreviation / Acronym	Definition
CSDSC	Common Spatial Data Steering Committee
CUHK	The Chinese University of Hong Kong
Cundall	Cundall Johnston and Partners
DEVB	Development Bureau
DEVB (PLB)	Development Bureau (Planning and Lands Branch)
DEVB (WB)	Development Bureau (Works Branch)
DEVB/EKEO	Energizing Kowloon East Office, Development Bureau
Disneyland	Hong Kong Disneyland
DSD	Drainage Services Department
DD	Detailed Design
EIA	Environmental Impact Assessment
EMSD	Electrical and Mechanical Services Department
EPD	Environmental Protection Department
Gammon	Gammon Construction Limited
GEO	Geotechnical Engineering Office, CEDD
GFA	Gross Floor Area
GI	Ground Investigation
GInfo	Geotechnical Information Infrastructure, CEDD
GIS	Geographic Information System
GML	Geography Markup Language
Henderson	Henderson Land Development
HGC	HGC Global Communications Limited
Hip Hing	Hip Hing Construction Company Limited
HK Electric	The Hongkong Electric Company
HKABAEMIA	Hong Kong Alliance of Built Asset & Environment Information Management Associations Company Limited
HKCA	Hong Kong Construction Association
HKFEMC	The Hong Kong Federation of Electrical and Mechanical Contractors Limited
HKGBCA	Hong Kong General Building Contractors Association
HKGISA	Hong Kong Geographic Information System Association
HKHS	Hong Kong Housing Society
HKIA	The Hong Kong Institute of Architects
HKIBIM	Hong Kong Institute of Building Information Modelling
HKICBIM	Hong Kong Institute of Civil and Building Information Management
HKIE	The Hong Kong Institution of Engineers
HKILA	Hong Kong Institute of Landscape Architects
HKIP	The Hong Kong Institute of Planners
HKIS	The Hong Kong Institute of Surveyors
HKIUD	Hong Kong Institute of Urban Design
HKIUS	Hong Kong Institute of Utility Specialists

Abbreviation / Acronym	Definition
HKJC	The Hong Kong Jockey Club
HKU	The University of Hong Kong
HKUST	The Hong Kong University of Science and Technology
HKSAR	Hong Kong Special Administrative Region
HOK	HOK International Limited
Hospital Authority	Hong Kong Hospital Authority
Housing Authority	Hong Kong Housing Authority
HyD	Highways Department
Hysan	Hysan Development Company Limited
ICES	Chartered Institution of Civil Engineering Surveyors
IFC	Industry Foundation Classes
IoT	Internet of Things
IRIS	Integrated Registration Information System Online Services
IVE	Hong Kong Institute of Vocational Education
JSON	JavaScript Object Notation
JUPG	Joint Utility Policy Group
LandsD	Lands Department
Leighton	Leighton Contractors Limited
LiDAR	Light Detection and Ranging
LingU	Lingnan University
LOD	Level of Development (for BIM) Level of Detail (for GIS)
LR	Land Registry
LWKP	LWK & Partners Limited
MEP	Mechanical, Electrical and Plumbing
MiC	Modular Integrated Construction
Mott MacDonald	Mott MacDonald Hong Kong Limited
MTRC	MTR Corporation
Nan Fung	Nan Fung Development Limited
NDAs	New Development Areas
New World	New World Development
NTHS	Natural Terrain Hazard Study
NWT	New World Telecommunications Ltd.
Ocean Park	Ocean Park Hong Kong
OCR	Optical Character Recognition
OGCIO	Office of the Government Chief Information Officer
O&M	Operations & Maintenance
OP	Occupation Permit
OZP	Outline Zoning Plan
PIO	Property Information Online

Abbreviation / Acronym	Definition
PlanD	Planning Department
PNAP	Practice Note for Authorised Persons, Registered Structural Engineers and Registered Geotechnical Engineers
PolyU	The Hong Kong Polytechnic University
PPD	Planning & Preliminary Design
PRN	Property Reference Number
PSG	Project Steering Group
PSI	Public Sector Information
PWG	Project Working Group
REDA	Real Estate Developers Association of Hong Kong
RICS	Royal Institution of Chartered Surveyors, Hong Kong Board
RRRs	Rights, Restrictions and Responsibilities
RVD	Rating and Valuation Department
SBDGs	Sustainable Building Design Guidelines
SDO of DEVB	Spatial Data Office, Development Bureau
SHKP	Sun Hung Kai Properties Limited
SRWR	Scottish Road Works Register
SPA	Swept Path Analysis
Swire	Swire Properties Limited
TD	Transport Department
TIA	Traffic Impact Assessment
THEi	Technological and Higher Education Institute of Hong Kong
Towngas	The Hong Kong and China Gas Company Limited
TXT	Text File (filename extension)
UAS	Unmanned Aircraft System
URA	Urban Renewal Authority
UU	Underground Utilities
UtiUs	Utility Undertakings
Vault	Community Apparatus Data Vault System
VDC	Virtual Design and Construction
VR	Virtual Reality
VTC	Vocational Training Council
XP	Excavation Permit
XPMS	Excavation Permit Management System
Wheelock	Wheelock Properties Limited
WKCD	West Kowloon Cultural District
WSD	Water Supplies Department
the Study	The Consultancy Services on the 3D and BIM Data Use Case Requirements of the Construction Industry for the Development of Digital Hong Kong to the HKSAR Government

Use Case	A popular type of study or assessment used in the construction industry. The Study grouped and prioritised 20 consolidated Use Cases, from which a final top 11 Use Cases were selected for the development of 3D and BIM data requirements
Raw Use Case	A type of study or assessment identified in the Study from analysis of questionnaire returns and interviews with stakeholders
Sub-Use Case	A specific aspect or type of study or assessment grouped under a broader Use Case heading

1. INTRODUCTION

The 'Consultancy Services on the 3D and BIM Data Use Case Requirements of the Construction Industry for the Development of Digital Hong Kong to the HKSAR Government' (known as "the Study" hereafter) was commissioned by the Construction Industry Council (CIC). It includes the development of solutions (the "Solutions") to facilitate 3D and BIM data sharing, BIM and Geographic Information System (GIS) integration and to support 3D Map, which represents the built environment for Digital Hong Kong.

This Report on 3D Spatial and BIM Data Use Case Requirements of the Hong Kong Construction Industry (known as "Final Report" hereafter) summarises the study approach, results of two stakeholder engagements, selected Use Cases and their solutions, and finishes with a proposed way forward regarding the overall 3D and BIM data situation in HK. "Use Cases" and associated terms "Raw Data Case" and "Sub-Use Case" are defined in the List of Abbreviations.

Section 2 provides summaries of the study approach and stakeholder engagements, which have been covered in detail in previous deliverables, namely the Inception Report, Desktop Review Summary, Summary Report of First Stakeholder Engagement, and Summary Report of Second Stakeholder Engagement.

Sections 3 and 4 present the process of selecting the final 11 Use Cases taken forward for the development of Solutions. Raw Use Cases collected during the stakeholder engagements were grouped and refined to ensure the selection of consistent, relevant Use Cases based on a number of criteria. The top selected Use Cases were then further studied before the development of Solutions.

Section 5 presents in-depth details of the selected 11 Use Cases by identifying their constraints and challenges at each project stage, data requirements and availability. The proposed Solutions are based on results of the stakeholder engagements, extensive desktop study, and consultation with relevant Government Departments. Suggestions are given for the workflow, processes and mechanisms needed to facilitate exchange/bi-directional data retrieval and deposition between relevant Government Departments and the industry. Potential benefits are also identified for each Use Case.

Finally Section 6 identifies ways to improve the current situation from a broader point of view and presents a high-level road map for future 3D and BIM Data developments in Hong Kong which align with the establishment of Common Spatial Data Infrastructure (CSDI) under the Smart City Initiatives.

The Solutions developed in the Study demonstrate the key benefits in the use of BIM and 3D data sharing, BIM and GIS Integration, and 3D Map for the construction industry. The overall aim of the Solutions is to deliver value to the industry and society in general, with clear guidelines for ownership, governance and regulation while still being adaptable to further technological development.

2. STUDY APPROACH

2.1. DESKTOP REVIEW

The current standards, documents, guidelines, and regulations, and all the latest developments relating to 3D data, BIM data, 3D Digital Map provided by the DEVB, CIC and its joint execution parties, were reviewed in-depth to ensure that all the latest BIM, GIS and smart city initiative-= related components were taken into account for the development of the Solutions. Overseas examples such as buildingSmart International, Open GIS Consortium and Centre for Digital Built Britain, were also studied to understand the current international standards, and to apply relevant overseas experience in the application of 3D and BIM data in the Hong Kong context.

The selected examples include many aspects of BIM-GIS development, from micromanagement to broad planning, and provide framework for understanding the rationale of BIM-GIS policies developed by different parties. For example, BIM is currently the "game-changer" to construction project lifecycle compared to the past. The overseas examples given introduce the idea of BIM maturity as a key concept in BIM development. This facilitates the strategic development of Solutions for the Use Cases as well as the future development of BIM-GIS in Hong Kong.

There has been recent rapid growth in the development of all kinds of 3D data by the HKSAR Government. As an important foundation for human-oriented city development, LandsD has developed the 3D Pedestrian Network to facilitate multiple applications, e.g. preference-based network analysis, navigation and routing in 3D, aid systems for the visually impaired and disabled users, etc. Meanwhile, 3D Indoor Data is also being developed to facilitate indoor related applications. Based on generation of massive 3D data as well as BIM data, there is an indispensable need to consider how to exchange and integrate these data in a consistent and well-coordinated manner. Development Bureau (DEVB) initiated the development of Common Spatial Data Infrastructure (CSDI) and 3D Digital Map in 2019, which is one of the key components underpinning Smart City development. PlanD has completed a feasibility study on “Development of a Common Spatial Data Infrastructure – Built Environment Application Platform (CSDI-BEAP)” which formulated the development framework for establishing BEAP and recommended prototype applications for its implementation to facilitate collaboration, co-creation and co-operation through application and data/information sharing among different parties. In addition, a study on the integration of BIM data and 3DSD has recently been completed by LandsD, which will lead to enhanced data exchange and integration between BIM and 3DSD, and develop and boost data exchange standards. In summary, both 3D data and BIM data have been enriched tremendously around the globe in the last few years, and this Study is timely and worthwhile to explore effective and consistent ways to exchange and integrate valuable information between the various parties involved in the Hong Kong construction industry.

2.2. STAKEHOLDER ENGAGEMENT

The stakeholder engagement consultations were aimed at collecting data requirements, concerns and use cases from an industry perspective. The stakeholders are categorised into two categories: Data Requester and Data Provider. Two rounds of stakeholder engagement consultation were conducted. The first-round engagement was for Data Requesters and the second round was for Data Providers. Stakeholders expressed their opinions via an online questionnaire or interviews after watching an introduction video about the Study. Interviews were conducted via web conferences due to the social distancing rules introduced under the COVID-19 pandemic.

Appendix A gives the list of invitations and summary of responses for the two rounds of stakeholder engagement.

2.2.1. Assumptions and Constraints

Due to tight schedule of the Study, as well as the social distancing rules under the COVID-19 pandemic, the stakeholder interviews were conducted through web conferences. Most of the invited organisations delegated their organisational BIM and/or GIS team lead or senior managers to attend the interview sessions, while some also responded by submitting questionnaires.

Two key assumptions were made in relation to the stakeholder engagements in the Study. First, it was assumed that interviewees would reflect the information needs of the entire organisation they represented. Second, the selected larger organisations' responses were assumed to reflect the overall view and information needs of the construction sector they represented.

However, such assumptions may result in certain limitations.

First, it was noticed that the most respondents belonged to the BIM and/or GIS team of the invited organisations. The respondents may be familiar with their organisation's BIM/GIS policies but they may not be fully aware of the information needs of other business lines of their organisation. As a result, the actual information needs of the daily operations of various business lines, by different construction professionals, may not have been properly collected in the first round of stakeholder engagement. Respondents often mentioned BIM/GIS related data, while the 2D data currently in use, which may contribute to potential benefits once the data is upgraded to 3D format in the future, could have been overlooked in the process.

Second, work practices of each organisation may differ and result in different information needs. Also, large companies were considered as the representatives to reflect the information needs of the relevant construction sector. The views of some smaller companies could have been overlooked, but the work practices and information needed by these small companies may be unique and different from the larger ones.

To fill in the possible gaps from the stakeholder engagements of this Study, the following measures were adopted. First, after the Use Cases were consolidated, the corresponding subject matter experts within AECOM were consulted to strengthen the Study team's understanding on the Use Case information requirements, as well as the responsible construction professionals' views on BIM and 3D data. Second, more than one representative company/organisation was engaged for each construction sector/ to ensure that the voice of a particular sector was not focused towards any one company/organisation. Professional bodies and industrial groups were also consulted as they consist of members across different companies and were considered as commercially independent.

2.2.2. Data Requester

The first round of stakeholder engagement took place from 19th March 2020 to 10th July 2020. It was targeted to collect information on the different use cases that stakeholders currently performed, potential use cases that stakeholders were interested in, what 3D, BIM and GIS data they were currently using, and any opinions they had on the data, in terms of availability, acquisition method and quality. The use cases mentioned by stakeholders formed an initial use case list for further development in the later stage of the Study.

A total of 69 organisations were invited from 7 categories, namely Government, Quasi-Government, Academic, Professional Association, Consultant, Contractor, and Developer. The response rate was 63.7% with 44 organisations responding.

Appendix B gives the complete list of Use Cases mentioned by stakeholders and Appendix C the list of data mentioned by Data Requesters.

2.2.3. Data Provider

The second round of stakeholder engagement took place from 28th May 2020 to 2nd September 2020. This round focused on understanding the datasets that stakeholders were willing to share with different sectors, and relevant data properties such as format, accuracy and update frequency. Suggestions about sharing mechanisms and concerns about data liability were shared and discussed in the interviews.

A list of Data Providers was identified from consultation with the Government, Quasi-Government, Academic, and Developer sectors. After further inviting underground utilities (UU) companies for consultation on use cases related to UU, a total of 52 organisations were invited. The response rate was 63.5% with 33 organisations responding.

Appendix D gives the list of available data mentioned by Data Providers.

3. DETAILS OF THE STAKEHOLDER ENGAGEMENT

3.1. REFINEMENT OF THE RAW USE CASES

The collected use cases cover a wide range of fields and expertise in the construction industry, namely, planning and design, geotechnical engineering, civil engineering, building engineering, environment, transportation, construction, and operations and maintenance. Several issues were identified in terms of the depth and scope of the use cases.

First, some use cases are subsets of another, broader use case, for instance, Noise Impact Analysis is one of various assessments commonly carried out under the broader heading of Environmental Impact Assessment. Second, the names given to some of the use cases provided by stakeholders are very broad and general, e.g. Schematic Design. Third, some use cases do not require data from another party, or 3D and spatial data are not needed at all. These use cases fall outside one of the Study's main objectives, which is to facilitate the sharing of 3D and BIM data.

Therefore, to facilitate the development of Solutions in the later stage, the collected use cases were reviewed with reference to the results of the interviews and questionnaire returns, in order to refine their scope and names and to ensure that the selected use cases can be demonstrated to fall clearly within the Study's objectives and project programme.

In the process, the use cases were either:

a. Merged;
    - When use case(s) were classified as a subset of another
    - For example: "Geotechnical Study" and "Prevention of geological disaster" are commonly part of a standard Natural Terrain Hazard Study and Man-made Slope Assessment, which, in broader terms can be combined as a Geotechnical Study in which landslide risk is estimated, followed by suggestions for a prevention and mitigation strategy.

b. Merged and renamed;
    - When use case(s) have a shared nature
    - For example: "underground utilities study" and "underground space planning" have a shared nature and the study of UU in a more general sense facilitates the planning and utilisation of underground space. Therefore, these two use cases were merged, and the merged Use Case is named as "Underground Utilities Study and Space Planning" so as to incorporate both concepts.

c. Renamed;
    - When use cases were considered to be not specific enough, or when an official existing term can be adopted, some renaming based on the records of the interviews and questionnaires were carried out

d. Deleted;

- When a use case was considered not relevant to this Study; or does not require data from another party; or where 3D and spatial data is not needed.

As shown in Table 3-1 a total of 47 Raw Use Cases were identified and refined by merging, renaming or deletion to create a consolidated list of 20 Use Cases. Table 3-12 gives a brief description of each of the consolidated 20 Use Cases.

Table 3-1 Rationale and details for refining Raw Use Cases into consolidated Use Cases

Raw Use Case	Merged with	Consolidated Use Case	Rationale
Merged Use Cases			
Air Ventilation Assessment/ Street Canyon Study	Wind Simulation and Analysis / Computational Fluid Dynamics Analysis	Air Ventilation Assessment	These various use cases are related to the interaction between wind and buildings, with a similar physical background, and are merged to create an AVA Use Case
	Micro-climate study		
Traffic Impact Assessment	Road Alteration, diversion	Traffic Impact Assessment	These various use cases are merged to create a TIA Use Case
	Flow Analysis		
	Traffic Forecast		
	Traffic road characteristics Analysis		
	Site Logistics Planning and Swept Path Analysis		
	Bus Route Study and Planning		
Visualisation of Construction Site	Building Demolition	Visualisation of Construction Lifecycle	"Lifecycle" is included in the consolidated Use Case name to cover site planning for construction activities as well as safety measurements and building demolition.
	Pre-Construction Site Planning		
Preliminary design and study	Site context, site constraint	Preliminary Design for a Building Project	These various use cases are merged as the Use Case for "Preliminary Design for a Building Project" so as to cover site selection and site analysis as well as conceptual design based on analytical results and recommendations.
	Conceptual Design for a Building Project		
	Redevelopment Site Selection		
Sewage System Upgrade	Drain Survey	Sewage System Upgrade	The purpose of a drain survey is to monitor changes in drainage conditions (e.g. by CCTV), the results of which can be used to upgrade the existing sewage

Raw Use Case	Merged with	Consolidated Use Case	Rationale
			system and are therefore considered to be included within the consolidated Use Case name.
Underground Utilities Study	Underground Space Planning	Underground Utilities Study and Space Management	This consolidated Use Case name includes both underground planning and space management aspects of a utilities study.
Architectural A&A design	Structural A&A design	A&A Design	In design works for A&A projects as-built drawings and models are commonly required to facilitate the design checking of existing structures. On the other hand, the original "A&A design" Raw Use Case was suggested by the HKIA. Combining the two use cases into the consolidated Use Case covers a broader time frame and includes more stakeholders in the life cycle of A&A projects.
Environmental Impact Assessment	Noise Impact Analysis Tree Survey 3D Environmental Impact Assessment Visibility and sustainability review	Environmental Impact Assessment	These various use cases are commonly included in a more general consolidated EIA Use Case.
Geotechnical Study	Prevention of geological disasters	Geotechnical Study	A Geotechnical Study often covers assessment of both natural terrain and man-made slopes, including an estimation of landslide risk and proposals for preventive measures.
Name Changed Cases			
Disease study	/	Community Disease/Health Study with respect to Urban Morphology	Questionnaire returns and interview records were reviewed again. The preferred consolidated Use Case name better reflects studies of the relationship between community disease and urban form.

Raw Use Case	Merged with	Consolidated Use Case	Rationale
Emergency Response Management/Safety Planning	/	Emergency Response Management for Construction Safety Planning	"Construction" is added to the consolidated Use Case name to specify that the safety planning is needed for the construction period.
Civil Schematic Design	/	Preliminary Design for Civil Engineering Project	After further review of the questionnaire and interview records, "schematic design" was found to be commonly applied to the civil engineering stage. The renamed consolidated Use Case is also intended to complement the similar style of another Use Case "Preliminary Design for Building Project".
Building Energy Analysis	/	Building Energy Monitoring and Facility Management	"Facility Management" is added to the consolidated Use Case name to include the O&M stage.
Cost Estimation	/	Premium Assessment and Property Valuation	Questionnaire returns and interview records were reviewed again. The renamed consolidated Use Case adopts a more commonly-used official term.
Pedestrian walkability and path finding on 3D map	/	3D Pedestrian Walkability and Navigation	/
Cases Not Relevant to this Study			
Urban Study / Planning / Layout Design Assessment	/	/	This Raw Use Case name is too broad as it can be considered to cover most of the other Use Cases on the list.
Backward study on the productivity data and benchmark for future project	/	/	The Raw Use Case is self-contained and may not necessarily need information from other parties. No 3D Data is involved.
Asset management	/	/	

Raw Use Case	Merged with	Consolidated Use Case	Rationale
3D GIS Research	/	/	This Raw Use Case is too broad. The stakeholder did not further explain what GIS research was intended.
Data Enrichment	/	/	No 3D Data from other stakeholders is involved.
Topography and Landscape Study	/	/	This Raw Use Case is considered to refer to a set of data needed instead of an application
No Change			
Foundation Design	/	Foundation Design	/
Excavation Permit Application	/	Excavation Permit Application	/
Embodied Carbon Calculation	/	Embodied Carbon Calculation	/
Virtual Site Supervision	/	Virtual Site Supervision	/
Flight planning	/	Flight Planning	/
Total: 47 Raw Use Cases		**Total: 20 Consolidated Use Cases**	

Table 3-2 Brief description of the consolidated 20 Use Cases*)*

Use Case	Brief Description
Underground Utilities Study and Space Management	Investigation of various underground utilities, such as gas and water. Investigation includes utility networks' depth and alignments and clash analysis.
Visualisation of Construction Lifecycle	4D visualisation and simulations that cover the entire lifecycle from preliminary design to construction, including demolition and safety measures. For example, to plan for demolition, the as-built design should be known, including RC details, E&M installations, as well as road and traffic condition of adjacent areas.

Use Case	Brief Description
Geotechnical Study	Investigation of slope geometry (e.g. slope gradient and height), and subsurface ground conditions (e.g. soil and rock composition, layering, etc.) to obtain physical properties of materials for design of ground engineering works, and to assess landslide risk from natural terrain and man-made slopes*)*
Traffic Impact Assessment	Assessment of the traffic generated by construction activities and to determine the manoeuvring activities and manoeuvrable space when transporting MiC materials. The suggested TIA framework provides a reference for construction planners and site managers in developing a traffic management and impact mitigation plan for construction projects.
Foundation Design	Design of the number of piles, or other types of foundations, and their layout, sizes, location and depth, using BIM and GIS technology.
Excavation Permit Application	Investigate and obtain the location of sub-structures (e.g. within the Mid-levels Scheduled Area, or MTR protection zones), to facilitate design and seek approval for excavation works and foundation works.
Environmental Impact Assessment	Modelling and simulation of environmental impacts due to development activities which are integrated with GIS data (e.g. water circulation models, noise impact analysis), for effective prediction, communication and public engagement.
Building Energy Monitoring and Facility Management	For assessment of building equipment at the DD stage, collection of building energy usage data, and analysis of performance characteristics and efficiency by monitoring programmes at the O&M stage.
Air Ventilation Assessment	Modelling and simulation at the planning stage of the effect of buildings on air flow/wind by visualising the air flow/wind in an area before and after its development (e.g. after construction of buildings and structures).
Premium Assessment and Property Valuation	Assessment of property valuation.
Preliminary Design for Building Project	Documents/drawings/3D models for concept design and to identify site constraints for a new building project, and for development of a simplified building model (i.e. using a massing model only).
Preliminary Design for Civil Engineering Project	Documents/drawings/3D models for concept design and to identify site constraints for a new civil engineering project, incorporating a topographic model for cut and fill volume calculation.
Embodied Carbon Calculation	Assessment of the carbon footprint of different materials used in the construction industry.

Use Case	Brief Description
A&A Design	Design of A&A works and the process of obtaining existing building and structural information, including as-built models/drawings, existing structural conditions, underground structures, soil and rock properties, and other potential site constraints.
Emergency Response Management for Construction Safety Planning	Planning emergency evacuation routes and safety management of a building or civil engineering project at the construction stage.
3D Pedestrian Walkability and Navigation	Analysis of outdoor and indoor pedestrian walkability and navigation in a 3D environment.
Sewage System Upgrade	Survey and monitoring of existing drainage systems (exposed and underground) to improve existing sewage design and capacity.
Virtual Site Supervision	Site supervision using VR at different construction phases of a building or civil engineering project.
Community Disease/Health Study with respect to Urban Morphology	Analysis of the relationships between demography, health and urban design, and prediction of health conditions and trends in the community.
Flight Planning	Flight schedule optimisation with respect to atmospheric wind and weather conditions, including analysis of flying height with respect to building height and restrictions using 3D data.

3.2. OBSERVATIONS OF STAKEHOLDER ENGAGEMENTS

Based on the two rounds of stakeholder engagements, several aspects regarding the existing data available from Data Providers and the data mentioned by Data Requesters are highlighted in the following sections.

3.2.1. Availability and Quality of Data

As of September 2020, there is a total of 133 available data items as mentioned by Data Providers and from desktop research in the Study. Together with 47 data items identified by Data Requesters, a mapping table has been prepared (Table 3-3) which shows that there is a gap between the data supply and demand. While the available data from Data Providers may be useful for other industries, the Study shows that the construction industry may not benefit much from these readily-shared data items. For construction projects which usually involve specific site or sites with unique aspects, it is understandable that some standardised datasets may not be sufficiently detailed and accurate. However, such data may still be highly relevant when they are in close proximity to the site location(s).

Datasets readily shared by data providers do not usually cover the entire territory of Hong Kong. Data Requesters often need to visit different Government Department websites to obtain or request similar types of data but more site-specific. Moreover, since some departments host than one web platform with different types of data available for download, stakeholders may overlook the availability of some data. Nonetheless, it is believed that with the launch of Common Spatial Data Infrastructure, more datasets can be uploaded to a single platform for more convenient access.

Data are available with different levels of access. Most of the data requested by stakeholders in this Study are not shared freely to the public. Instead, the data are obtained upon request to relevant Government Departments, or through web platforms hosted by them, and either needs to be purchased, or a registered account set up to view and download the data.

In terms of format, some data are not machine readable and lacks the spatial information required for data post-processing in a GIS environment. In addition, some data are not digitally available, e.g. General Building Plans are only available as scanned PDFs. Thus more time for interpretation and data translation is needed as compared with 2D CAD data. This also increases the risk of human errors.

Regarding data update frequency, it is noticed that there are very few shared IoT real-time or near-real-time data, shared except for HKO weather data and EPD Smart Lampposts Air Quality Data. There is increasing demand from Data Requesters in the industry to have real-time sensor data, for instance, traffic volumes for pedestrians, vehicles and vessels, instead of traditional manual counting in traffic surveys over fixed periods of limited duration.

3.2.2. Availability and Usage of 3D Data

The most commonly requested 3D and BIM data are building models, underground utilities models and terrain models. Some of these data, for instance, the LandsD 3D Spatial Data are readily available, but stakeholders commonly face a lack of information about provision of the data and are not familiar with handling the data format and the required software. Stakeholders with either a BIM or GIS background may not have sufficient knowledge for 3D data conversion and the integration between BIM and GIS data. The software they are familiar with may not be compatible with that shared by Data Providers, who may be unwilling to share the data in any case if they feel this would require taking extra steps to remove sensitive attributes and internal layouts. Provision of 2D data, on the other hand, involves more limited information, which Data Providers may think that it is enough for statutory submissions.

In general, the widespread adoption of 3D data in recent years is a major global industry trend. However, as use of such data is not yet mandatory for statutory submissions in private projects, together with inconsistent data standards and drawing practices for the data to be easily used across stakeholders and projects, the incentives to create and share 3D data are not yet sufficient to support an increasing number of stakeholders who are willing to switch from a 2D to 3D environment. Also, mechanisms for data sharing among the industry are still not clear. Current data sharing is mostly done through a top-down approach with data released by the Government departments to the industry/public, such as the datasets on the Public Sector Information (PSI) Portal, GeoInfo Map and Hong Kong GeoData Store. Only joint effort from Government and the industry will enhance the maturity of 3D data quality, usage and exchange between different data owners in Hong Kong.

Table 3-3 Mapping table for data mentioned by Data Requesters and Data Providers

Note 1: Data Availability

Type 1 : Data available from relevant government departments for public to purchase
Type 2 : Data available from relevant government departments on a request basis
Type 3 : Data available from relevant government departments for registered users
Type 4 : Data available from relevant government departments for public
Type 5 : Data available from relevant government departments but NOT known/familiar to most stakeholders
Type 6 : Data preparation by relevant government departments in progress
Type 7 : Partial data available from government departments/private sectors
Type 8 : Not available

Note 2: It should be noted that LandsD and CEDD has since published multiple datasets to the public free of charge. As of July 2021, freely accessible open data are marked with (*).

Data availability	Data mentioned by Data Requesters	Currently Available Data	Type	Provided by	Remarks
Type 1	Weather Data (Sun radiation, wind, temperature, humidity, precipitation)	Weather Data; *Rain gauge Data	2D Non-spatial Data	HKO; CEDD	Higher spatial and temporal resolution data can be purchased from HKO
Type 1	2D Topographic contour plan	*iB1000, *iB5000, *iB10000 and iB20000	2D Spatial Data	LandsD	Need to purchase
Type 1	Digital basemap (2D or 2.5D)	*iB1000, *iB5000, *iB10000 and iB20000	2D Spatial Data	LandsD	Need to purchase
Type 1	Aerial photos/orthophotos	DAP/*DOP5000, DOP1000-1963, DOPM50-LO	2D Spatial Data	LandsD	Need to purchase

Data availability	Data mentioned by Data Requesters	Currently Available Data	Type	Provided by	Remarks
Type 2	Satellite imagery	Satellite Image	2D Spatial Data	PlanD	These images not created and owned by the Government. PlanD may not have the right to redistribute satellite images to third parties.
Type 2	As-built UU record or UU model	Underground Utilities 2D Drawings, Drainage Records; Standard Drawings, Underground waterworks Assets, Waterworks BIM Models	2D Non-spatial Data	DSD; WSD CLP /HKE Towngas	Many private sector stakeholders are unwilling to share data in general, and prefer to provide it on a request or project basis. It is the data provider's discretion to provide the data or not. PDFS are sometimes provided but may contain CAD/GIS data; Stakeholders in telecommunications are generally willing to share data
Type 3/4	Geological Model /data with strata	*Geological maps	2D Non-spatial Data	CEDD	Data available in GInfo to registered users, GEO Open Data Portal.
Type 4	Health and Census data	Population by Census Data	2D Spatial Data	CSD	
Type 4	Wind speed/pressure and air movement data	Site Wind Availability Data	2D Non-spatial Data	PlanD	Site Wind Availability Data in CSV, GeoTiff and GeoJSON formats
Type 2	Scheduled and Protected Area information	Scheduled Area Railway Protection Area	2D Spatial Data	LandsD / MTRC	
Type 2	Existing E&M Installations	N/A		EMSD	

Data availability	Data mentioned by Data Requesters	Currently Available Data	Type	Provided by	Remarks
				CLP	
Type 2/3/4	Soil/water conditions, GI records	*GI Reports	Scanned Copy	CEDD	Data available in CEDD's Civil Engineering Library, and via GInfo for users working on public projects. Private projects need to request for more sensitive data.
Type 2	BD order	BD order	2D Non-spatial Data	BD	
Type 4	Occupation Permit (OP) Year, GFA	Monthly Digests with OP Year and GFA	CSV	BD	
Type 1	Rateable Value down to interest level	Rateable Value	2D Non-spatial Data	RVD	Need to purchase from RVD according to the statutory provision.
Type 2	Monuments Information	GIS of Hong Kong Heritage	2D Spatial Data	AMO	Not for download
Type 5	Existing Infrastructure model	As-built BIM Models; *3D Spatial Data (3DSD) Infrastructure	3D Spatial Data	HyD, CEDD; LandsD	Data from HyD is restricted and not available to the public
Type 1	Electronic record plans (Private Development Projects from BD)	Building Records Access and Viewing On-line (BRAVO) System; General building plan (GBP)		BD	Only scanned TIFF/PDF of GBP (PDF for minor works) are available
Type 2/7	Digital record plans (Private Development Projects from developers)	GBP		Swire, REDA, Wheelock, Ocean Park	

Data availability	Data mentioned by Data Requesters	Currently Available Data	Type	Provided by	Remarks
Type 5	Digital record plans (Public Development Projects from government)	GBP		ArchSD	ArchSD will share CAD drawings of approved statutory submission plans
Type 5	Simplified models for buildings	*3DSD	3D Spatial Data	LandsD	Stakeholders generally not familiar with 3DSD; not aware of its availability
Type 5	3D Topographical Data/Digital Terrain (Vector and Raster)	*3DSD; 3D Topographic Map	3D Spatial Data	LandsD, Swire, CityU	Stakeholders generally not familiar with 3DSD; not aware of its availability; Housing Authority can provide 2D CAD data
Type 5	Outline Zoning Plan (OZP)/ land use/Statutory Plans	Digital Planning Data of Statutory Plans	2D Spatial Data	PlanD	Stakeholders generally not aware that OZPs in SHP/GML/ GeoJSON format are available for download in PlanD's Digital Planning Data website. They usually use the Statutory Planning Portal 2.
Type 5	Plot ratio, height restriction	Boundaries of building height control area provided in the Digital Planning Data of Statutory Plans	2D Spatial Data	PlanD	Stakeholders generally not aware that SHP/GML/GeoJSON data are available for download in PlanD's Digital Planning Data website.
Type 2/4	Slope Information	Slope Information System	2D Spatial Data	CEDD	
Type 4	Environment Data	Environment Data	2D Non-spatial Data	EPD	
Type 4	Air Quality/pollution data	Air Quality/pollution data	2D Non-spatial Data	EPD	

Data availability	Data mentioned by Data Requesters	Currently Available Data	Type	Provided by	Remarks
Type 3/4	Landslide Statistics	*ENTLI	2D Spatial Data	CEDD	* Data may be downloaded from the CEDD GEO Open Data Portal
Type 1	Owners' Corporation data, Land Grant	Property owner information, Owners' corporations list	2D Non-spatial Data	LR	
Type 6	Pedestrian Network	N/A	3D Spatial Data	N/A	LandsD is currently producing 3D pedestrian network data; expected to be released in Dec 2020.
Type 6	Traffic Census and data (including vessels, vehicles and pedestrian)	Base District Traffic Model (2015)	2D Spatial Data	TD	TD will commence sharing Annual Traffic Census survey data updated daily with hourly traffic volumes of selected routes only in April 2021. Pedestrian data are not available.
Type 7	As-built /Design BIM model for buildings	As-built BIM Models; As-fit BIM Models (Massing Only)	3D Spatial Data	ArchSD, CEDD, URA, Swire	
Type 7	Groundwater table	Field Survey		N/A	
Type 7	3D laser scanned data	*LiDAR data; Point Cloud of watermains	3D Spatial Data	CEDD; WSD	* LiDAR data captured by CEDD may be obtained from the CEDD GEO Open Data Portal
Type 7	Parking data	Parking vacancy data	2D Spatial Data	TD	
Type 8	Surface water and foul drain survey data (videos taken by CCTV)				Project specific data

Data availability	Data mentioned by Data Requesters	Currently Available Data	Type	Provided by	Remarks
Type 8	Noise Data	Field Survey			Project specific data
Type 8	Street Furniture Inventory GIS Data				Government internal data
Type 8	Tree Record	Field Survey			
Type 8	Water flow/discharge rate	Field Survey			
Type 8	Road Limitations	Field Survey			
Type 8	Existing catchment information	Field Survey			
Type 8	Road size and alignment	Interpret from Road network from TD or *LandsD iB1000 (Topographic Map)			
Type 8	360° photos	Related data: *3D Photo-realistic Mesh Models; *3DSD	3D Spatial Data		Data can be freely downloaded from the PlanD and LandsD websites, but does not cover the whole Territory of Hong Kong; Need to purchase Level 3 3DSD data from LandsD
Type 8	3D laser scanned data (building)	Field Survey	3D Spatial Data		
Type 8	Vehicle Specifications (dimensions and handling)	From manufacturer			
Type 8	Property data (contract)	From manufacturer			
Type 8	Material Data (specifications, performance and cost)	From manufacturer			

Data availability	Data mentioned by Data Requesters	Currently Available Data	Type	Provided by	Remarks
Type 8	Energy and water consumption data	Field Survey			
Type 8	Pedestrian Traffic Count Data (Telecom/ IoT)	Field Survey			
Type 8	Site surrounding building data	Field Survey			

4. DEVELOPMENT OF THE SOLUTIONS

4.1. SELECTION OF THE 10 USE CASES

The Assignment Brief for the Study required ten Use Cases to be selected among the 20 consolidated use cases and Solutions to be developed respectively.

The consolidated use cases were categorised into one or more of the 4 stages of construction lifecycle, namely Planning & Preliminary Design (PPD), Detailed Design (DD), Construction (C), and Operations & Maintenance (O&M). Those use cases with the highest score under each of the 4 stages were selected as the top 10 Use Cases. As agreed with the PWG and PSG members, the distribution of the top 10 Use Cases is shown in Table 4-1, as follows:

Table 4-1 Distribution of the top 10 Use Cases across the construction lifecycle

Construction Lifecycle Stage	PPD	DD	C	O&M
No. of selected Use Cases	3	3	2	2

4.1.1. Scoring Mechanism

All the consolidated use cases were scored according to 3 scoring criteria:

i. Demand

The Demand score takes into account the number of votes for a particular use case by Data Requesters during the first stakeholder engagement. A higher score was given to those use cases mentioned by multiple more than one interviewee.

ii. Social/Industry Value

The Social/Industry Value score concerns the s potential value of a particular use case to society and the industry once it is realised in the future.

iii. Data Average Score

The Data Average Score of a particular use case is calculated by averaging all scores among its constituent data categories. The example shown in Table 4-2 illustrates the calculation of a Data Average Score for AVA:

Table 4-2 Example of the calculation of data average score

Use Case: Air Ventilation Assessment		
Data Required	**Data Score**	**Data Average Score**
3D Topographical Data/ Digital Terrain	71.7	$\frac{71.7 + 50.8 + 76.1 + 44.7}{4}$ $= 60.8$
Digital Base Map	50.8	
Simplified Models for Buildings	76.1	
Wind Speed/ Pressure and Air Movement Data	44.7	

Each type of item of data was scored under 6 areas, namely data availability, data quality, data format, time required for acquiring data/ information, interoperability, and software capability. Details of the data scores are given in the Summary Report of First Stakeholder Engagement.

4.1.2. Weighting Matrix

Each consolidated use case was scored with the 3 criteria listed in Section 4.1.1 with weightings applied to each criterion. The final score of the use cases was calculated by averaging the score of the 3 criteria with weightings applied according to the formula below:

$$Final\ Score = \sum Criterion\ Score \times W_i$$

where W_i = agreed weighting of the scoring criterion

Table 4-3 and Table 4-4 below show the weighting matrix and scores of the 20 consolidated use cases.

Table 4-3 Weighting matrix for calculating Use Case scores

Criterion	Sub-category	Score	Weighting	Definition
Demand from Stakeholders	Use Case demand	0 - 100	**32%**	$\frac{\text{No. of votes}}{\text{Data with the highest votes}}$
Society/Industry Value	Collected data have ***short term*** effect with little value to society ***or*** the industry	25	**32%**	The benefits of the Use Case to the industry and/or society; and short/long term effect. Highest score given if it can cover both groups of people and have a long-term effect.
	Collected data have ***short term*** effect with significant value to society ***or*** the industry	50		
	Collected data have ***long term*** effect with significant value to society ***or*** the industry	75		
	Collected data have ***long term*** effect with significant value to society ***and*** the industry	100		
Data availability	Available Data	0/25/50/75/100 (most favourable)	**10%**	Whether or not the data/information is currently available without further field testing or research. Lower score given for complicated processes or high cost in acquiring the data/information.
	Field Data Reduction	0.5		Currently unavailable data but can be obtained by field testing or research. Availability of field data = 50% of Data Availability score
	Visionary use	Bonus mark		Low availability but with visionary use. Availability score plus visionary bonus capped at 100
Data Quality	Very positive	100	**5%**	Data quality including cleanliness, integrity, precision, resolution and updateness etc.
	Positive	75		
	Neutral	50		

Criterion	Sub-category	Score	Weighting	Definition
	Negative	25		
	Very negative	0		
Data Format	3D	100	**6%**	Format weight to encourage the use of 3D data: - open format and 3D enabled: highest weight - proprietary format and textual: less weight/no score
	2D GIS	50		
	No	0		
Time required for acquiring data/ information	Years/currently unavailable	0	**5%**	Time required for acquiring the data/information
	Months	20		
	Month	40		
	Week	60		
	Days	80		
	Immediately	100		
Interoperability	Related Use Cases		**5%**	No. of Use Cases that require the data: - can be used for many Use Casse: highest weight - can only be used in single/special Use Case: lowest mark or no score
	1 - 4	0		
	5 - 8	25		
	9 - 12	50		
	13 - 16	75		
	17 - 20	100		
Software Capability	NA	0/25/50/75/100 (most favourable)	**5%**	Software capability to process the data. Scored as 100 if fully capable and no obstacles.
		Total	**100%**	

Table 4-4 Final scores of the 20 consolidated Use Cases

Use Case	Stage	Demand	Society/ Industry Value	Data Average Score	Use Case Score	Stage (for calculation)				Ranking							
		32%	32%	36%	100%					PPD	Rank	DD	Rank	C	Rank	O&M	Rank
Underground Utilities Study and Space Management	PPD	100.0	75	19.1	62.9	PPD	DD		O&M	62.9	1	62.9	1			62.9	1
Visualisation of Construction Lifecycle	C	48.1	50	21.5	39.1	PPD	DD	C		39.1	6	39.1	7	39.1	2		
Geotechnical Study	DD	51.9	100	22.5	56.7	PPD	DD	C		56.7	2	56.7	2	56.7	1		
Traffic Impact Assessment	PPD	59.3	75	18.7	49.7	PPD	DD			49.7	3	49.7	3				
Foundation Design	DD	14.8	75	20.5	36.1	PPD	DD			36.1	7	36.1	8				
Excavation Permit Application	C	7.4	50	22.0	26.3	PPD	DD	C		26.3	12	26.3	14	26.3	3		
Environmental Impact Assessment	DD	48.1	75	18.5	46.1	PPD	DD			46.1	4	46.1	5				
Building Energy Monitoring and Facility Management	O&M	22.2	100	20.1	46.4		DD		O&M			46.4	4			46.4	2
Air Ventilation Assessment	PPD	33.3	75	21.9	42.6	PPD				42.6	5						
Premium Assessment and Property Valuation	O&M	3.7	100	25.8	42.5		DD		O&M			42.5	6			42.5	3
Preliminary Design for Building Project		29.6	50	19.7	32.6	PPD	DD			32.6	8	32.6	9				
Preliminary Design for Civil Engineering Project		11.1	50	23.2	27.9	PPD	DD			27.9	11	27.9	13				
Embodied Carbon Calculation		3.7	75	16.7	31.2		DD		O&M			31.2	11			31.2	5
A&A Design		18.5	50	17.4	28.2		DD		O&M			28.2	12			28.2	6
Emergency Response Management for Construction Safety Planning		3.7	50	20.0	24.4		DD	C				24.4	15	24.4	4		
3D Pedestrian walkability and navigation		7.4	75	16.5	32.3	PPD	DD		O&M	32.3	9	32.3	10			32.3	4
Sewage System Upgrade		7.4	50	15.0	23.8			C	O&M					23.8	5	23.8	7
Virtual Site Supervision		3.7	50	16.3	23.0			C						23.0	6		
Community disease/health study with respect to urban morphology		7.4	75	14.8	31.7	PPD				31.7	10						
Flight planning		3.7	25	19.4	16.2				O&M							16.2	8

4.1.3. 10 Use Cases for Development of Solutions

Table 4-5 shows the finalised 10 Use Cases with the highest scores across the 4 stages of the construction lifecycle.

Table 4-5 The top 10 Use Cases

Number	Use Case
1	Underground Utilities Study and Space Management
2	Visualisation of Construction Project Lifecycle
3	Geotechnical Study
4	Traffic Impact Assessment (TIA)
5	Foundation Design
6	Excavation Permit (XP) Application
7	Environmental Impact Assessment (EIA)
8	Building Energy Monitoring and Facility Management
9	Air Ventilation Assessment (AVA)
10	Premium Assessment and Property Valuation

4.2. DEVELOPMENT AND REFINEMENT OF THE SOLUTIONS

The Solutions were developed, verified and adjusted based on further consultation with relevant stakeholders and professionals related to the different Use Cases. Table 4-6 below shows the consultation for each Use Case. These discussions enabled the Study Team to better formulate the way forward for respective Use Cases, for instance, for those Solutions involving enhancement of the web service platform provided by government departments, the Study Team understood more about limitations on data sharing, in terms of both existing data quality and technical issues.

Table 4-6 Parties consulted for the development of Use Case Solutions

Use Case Number	Professionals/Data Providers/Concerned Departments
	OGCIO
1	Concerned Government Departments: WSD, DSD, HyD, LandsD UU companies: CLP, HK Electric, HGC, Towngas, HKT, New World Telecomm Association: JUPG
2	VDC Team (AECOM)
3	Geotechnical Team (AECOM), CEDD GEO
4	Traffic Team (AECOM), TD
5	Structure and Geotechnical Team, AECOM, CEDD GEO
6	HyD, LandsD

Use Case Number	Professionals/Data Providers/Concerned Departments
7	Environmental Team (AECOM)
8	URA, Cundall, EMSD
9	Environmental Team (AECOM), PlanD
10	Private Property Valuers, Estate Surveyors in LandsD

4.2.1. Small Group Discussion

A full-day Small Group Discussion was organised on 16th September 2020, in the form of a Virtual Meeting. The 10 Use Cases and their respective Solutions were presented and demonstrated in different sessions. Organisations that participated in the first and second round stakeholder engagements were invited to review the draft Use Case Solutions, together with PWG, PSG and COM-BIM members. It was a great opportunity for Data Requesters and Data Providers to share their expectations and available data/information during the discussion. An average of 45 participants and more than 32 organisations attended the discussion, with more than 60 participants joining simultaneously during the peak time.

That said, since not all the stakeholders were invited but only those originally contributing to the idea of the Use Cases, this discussion implicitly assumed that the selected Use Cases accurately represented general demand from the industry and was focused more on ensuring the selected Use Case matched the interests of the industry, and to refine and supplement the proposed Use Case Solutions.

General support and appreciation were received. A few stakeholders from both developers and associations supported the way forward of having a centralised data platform to store and exchange 3D data, and emphasised the importance of having a common data standard and drawing practice. However, to facilitate such data sharing, it was recognised that liability and copyright issues, and the host for the centralised data platform, would first need to be addressed and determined. There were voices to suggest forming a neutral data agent that jointly comprised related government departments and associations to collect data from the industry.

In addition, developers generally expressed willingness to share building layouts in CAD and BIM format after the issue of an Occupation Permit (OP) from BD, while BD responded that paragraphs 19 and 20 of the Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers (PNAP) ADM-19 and ADV-34 stipulates that submission of BIM models to BD as supplementary information to general building plans will be taken as granting permissions for the use of the BIM models by LandsD and PlanD for their updating. Any amendments to the PNAP normally require consultation with building stakeholders through the established mechanism.
For particular Use Cases, for instance, Building Energy Monitoring and Facility Management, developers stated that they are not willing to share building energy and IoT data; while for Geotechnical Study and Foundation Design, geotechnical

engineers suggested AECOM should further consult with relevant associations and CEDD GEO for collecting more solid opinions about the best way forward. Comments that are within the scope of the Study have been incorporated into development of the Use Case Solutions in this report.

4.2.2. Presentation to Common Spatial Data Steering Committee (CSDSC)

On 28th October 2020, CIC's representative and AECOM's Project Manager presented the Study findings and observations to the Common Spatial Data Steering Committee (CSDSC) organised by the DEVB, with a view to contributing 3D and BIM data requirements of the local construction industry to CSDI. After the presentation, members of the CSDSC showed strong interest in the Study findings, and AECOM agreed to prepare a half-day webinar to present details of the Use Cases to government bureaux and departments. It was intended that the comments and opinions collected from the half-day webinar would be used to refine the Use Cases and the respective Solutions.

4.2.3. Webinar for Government Bureaux and Department

On 12th November 2020, AECOM conducted the half-day webinar to present the details of the Study to government bureaux and departments. The webinar consisted of four sessions which included each Use Case's description, relevant solutions and Q&A sessions. Over 14 bureaux and departments joined the event with over 90 participants. Several bureaux and departments provided valuable comments and opinions to the Study team, and such details have been documented in this report.

4.3. ADDITIONAL USE CASE 11

4.3.1. Background

The Study of the top 10 Use Cases was completed in January 2021. With the positive feedback from the CIC, PWG, PSG members and industry stakeholders, an advanced request was issued by CIC on 14th April 2021 to follow up and reconsider other consolidated use cases outside the top 10, as identified in Section 4.1.2.

4.3.2. Additional Use Case Selection

Among the remaining consolidated use cases, it was decided to combine and merge "Preliminary Design for Building Project", "Preliminary Design for Civil Engineering Project" and "Alteration &Addition (A&A) Design" as "Preliminary Design for Building (including A&A works) & Civil Engineering Project" as an eleventh Use Case.

This Use Case was selected by realising that the HKSAR Government has initiated two main development activities in the whole Territory for the next few decades, namely revitalisation of old districts, e.g. Kowloon East, Kowloon West and Hong Kong West; and development of New Development Areas (NDAs), such as Kwu Tung North, Fanling North, Ping Che/Ta Kwu Ling (NENT NDAs) and Hung Shui Kiu (HSK NDA). Preliminary design for building projects, such as revitalisation/development of existing buildings/historical buildings in old districts, and for civil engineering projects such as the NENT NDAs, are of utmost importance prior to full implementation. The selected extra merged Use Case will be able to demonstrate how the use of BIM, GIS and 3D data facilitates various stakeholders in conducting preliminary design and A&A works for the above-mentioned areas.

4.3.3. Stakeholder Engagement

To identify the constraints faced by the industry and the data required for this additional Use Case, another round of stakeholder engagement was conducted with virtual interviews in May 2021.

Engineers from the AECOM Civil Engineering and Building Engineering (Structural) team were first interviewed by the Study Team to understand the background and basic workflow of preliminary design and A&A works for building and civil engineering projects. These sessions helped in developing a questionnaire and interview questions for a number of/variety of stakeholders related to the additional Use Case, e.g. Government, Quasi-Government and Professional Associations, as shown in Table 4-7. The URA and Housing Authority were also interviewed for their extensive experience in A&A works, including revitalising historical buildings, and refurbishing housing estates and shopping malls that were established decades ago.

Details of the invitation and response list and the interview sessions have been included in Appendix A.

Table 4-7 Consulted parties for the development of Use Case 11

#	Professionals / Data Providers / Concerned Departments
11	Government: BD, Housing Authority Quasi-Government: URA Professional Association: HKIA, HKIE, HKABAEIMA, HKGISA, HKIBIM

In summary, the common difficulties/problems expressed by stakeholders that carry out the preliminary design and A&A works are in searching for as-built drawings/records for existing buildings; the tedious procedure to acquire these data; inconsistency of the records against real-life conditions; and thus the amount of time and cost required for survey and validating the data.

All stakeholders generally supported the idea that 3D data such as BIM models and advanced data capture could help in visualising the project site and for conducting clash analysis, calculating GFA, preparing sections and elevation plans, etc. They acknowledged that currently only large-scale or government projects require the use of BIM and other innovative solutions, but the overall trend for adopting digital technology is promising in the construction industry. These insights align with the findings from stakeholder engagement for the first 10 Use Cases, and have helped formulate more holistic recommendations for improving data availability and quality for the development of digital Hong Kong.

Details of the constraints and way forward for the additional Use Case is documented in Section 5.11. It should be noted that some data that were unavailable to the public in the first phase of the Study, became available in May 2021, for instance, digital topographic maps and 3DSD from LandsD, terrain LiDAR data from CEDD, etc.

5. USE CASE DETAILS AND SOLUTIONS

5.1. Underground Utilities Study and Space Management

The amount of UU in Hong Kong has increased rapidly in the past decade, resulting in an increasingly congested underground space. However, reliable UU records are not readily available. Because of this, engineers and contractors often conduct extensive UU surveys to collect information on actual underground conditions prior to the commencement of design and construction works. In addition, according to Para. 3.13 of Audit Report No. 70 Section 4 by the Audit Commission Hong Kong 2018 (‘the Audit Report’), both master plans submitted upon land licence application and road-opening plans submitted upon XP application often/commonly do not show detailed records of the UU installations. As a result, HyD does not possess sufficient underground utility information to assess whether sufficient underground space is available and to determine whether excavation works should be allowed. The Audit Report also identified that ineffective underground space management might cause improper use of space, damage to existing utilities, and delays in emergency repairs and excavation works.

<u>Clash Analysis</u>

During the first stakeholder engagement, it was identified that reliable UU records, if available in 3D format, will enable designers to conduct clash analysis in which the 3D geometry of as-built UU can be compared with new design installations using various commercial software. Spatial coordination can also be performed to ensure an optimal design that maximises space efficiency, design performance, and avoids damaging existing UU. Therefore, it is acknowledged that the availability of 3D UU data will be beneficial to the construction industry, particularly for the design and construction stages. However, achievement of these benefits depends on the availability and accuracy of UU records. It is noted that currently records of most UU generally are not kept in 3D format, in particular their depth. Converting existing UU records to 3D format will likely involve various assumptions, including but not limited to a “depth” value. Therefore, limitations on the accuracy of a 3D geometrical database built up from deficient existing records should be borne in mind.

5.1.1. Solution Deliverable Format, Selected Sub-Use Case and Location

A graphical illustration using Microsoft PowerPoint was produced to demonstrate the constraints and way forward for this Use Case. Current practices of UU data sharing among utility undertakings (UtiUs) and other construction practitioners were reviewed. Overseas experiences were also taken into account to reinforce the way forward made in the Solution. Screen captures and videos were included to illustrate useful overseas experiences referred to in the Solution.

5.1.2. Data Required and Availability

A majority of the currently available UU records in HK are in 2D format. UtiUs may have their own drawing records either in CAD or PDF formats. According to the two rounds of stakeholder engagements, it was noted that 3D UU data are uncommon in HK. The limitations of traditional 2D drawings were also identified. Interviewees mentioned that the depths and sizes of UU were sometimes absent in existing records, resulting in larger errors and unknowns when designing new UU installations or excavation works.

In addition, 3D data are required to perform clash analysis. Therefore, 3D format is preferred in the future. Table 5-1 below shows the data commonly required for this Use Case.

Data	File Format	Obtained from
iB1000 (Topographic Map)	CAD/GDB	Purchase from LandsD
UU Record Plans	DWG/PDF	UtiUs
3D/2.5D UU Data (long term)	DWG/DXF/JSON PTS/SHP/RVT/RFA/DWG Various BIM/GIS formats	DSD WSD Other UtiUs

5.1.3. Current Constraints

i. <u>Poorly organised data</u>

According to Para. 3.2 in Section 4 of the Audit Report N. 70, as of December 2017, there were 18 major UtiUs installing their services beneath public roads to providing different utilities in Hong Kong. It was noted during the first stakeholder engagement that engineers and contractors in general would first contact each UtiUseparately to acquire as-built UU records under the area of concern as a desktop study, followed by detailed UU surveys to verify the actual UU locations if necessary. New designs would then be formulated after understanding the actual locations of the as-built UU. However, it was also well noted that actual on-site UU conditions may also deviate from UU survey results. The current workflow was considered by interviewees as tedious and time-consuming, often resulting in unsatisfactory accuracy.

During the second stakeholder engagement (attended by Data Providers) it was noted that a system called the Electronic Mark Plant Circulation (EMPC) system had been jointly developed by major UtiUs and government departments to facilitate the speedy transfer of UU information. However, the result of stakeholder engagements suggested that this system is not being used by some construction practitioners. In fact, the EMPC system was not mentioned by Data Requesters during the first stakeholder engagement.

ii. Data not properly recorded

A frequent comment received during the first stakeholder engagement suggested that the quality of existing UU records in HK was unsatisfactory. Detailed UU surveys were needed to verify the actual UU locations due to the fact that discrepancies were often found between the two.

During the second stakeholder engagement, it was suggested that the poor quality of data records was often a result of data outdatedness, where actual locations of a UU may have been shifted years after it was first installed. In addition, it was found that as-built surveying qualities and methodologies vary amongst surveyors and the as-built surveying requirements also vary amongst UtiUs. Therefore, it was concluded that data outdatedness and inaccuracy were the two main reasons for unsatisfactory data quality amongst data receivers.

It was also mentioned by some Data Requesters that inaccurate UU records contributed to difficulties when identifying particular underground installations on-site, due to the on-site situation being ‘completely different’ from the existing records.

iii. Data format incompatible

It was noted during the first stakeholder engagement that the record drawings of different UtiUs had different styles, legends, and scales. Because of this, the process of preparing a holistic overview of as-built UU was often found inconvenient by Data Requesters. Also, some drawings were presented as line-drawings where the actual geometry of utilities required further review or verification. Combined with constraint (ii), huge errors were sometimes found between actual UU locations and as-built records. Designers also reflected that such 2D line-drawing records had resulted in difficulties in performing clash analysis for the design of new utility installations. Data Providers in the second stakeholder engagement acknowledged that the as-built records of their own utilities were usually 2D drawings and such drawings were often shared in PDF format, which is not readily computer decipherable. The absence of a universal drawing standard resulted in difficulties when designers attempted to understand the as-built underground condition.

5.1.4. Way Forward

With reference to the Audit Commission’s findings, as well as overseas case studies from Belgium and the UK, potential ways forward have been identified for the three current constraints identified in Section 5.1.3. In the long run acentralised data sharing platform system could be explored for adoption in HK, with appropriate supporting policies and standards to facilitate sharing and access of UU data while ensuring acceptable data quality.

However, it is acknowledged that UtiUs are concerned about the recipients of their shared data, especially due to the strong competitive nature of telecommunication services providers. It was well noted during the second stakeholder engagement that telecommunication providers preferred not to share detailed information about their UUs. In view of this concern, an open platform that stores all UU records within a data hub for users' instant review may not be an appropriate approach for establishing a common data platform in HK. Instead, it is suggested/recommended that the proposed data platform could consider using an approach similar to that adopted for the KLIP system in Flanders, Belgium, as shown in Figure 5-1. The KLIP system receives data requests and passes on the requests to data providers. UU records of different UtiUs, using a specified digital format, will then be separately transferred to and merged into the system to produce an integrated as-built UU map within areas specified by requesters. It should be stressed that the data requester can only view the UU records within the specified area with a controlled amount of detail. In this way, data ownership remains with the original data owners. The owners also have full control of the level of data details released, and to whom the data is being shared.

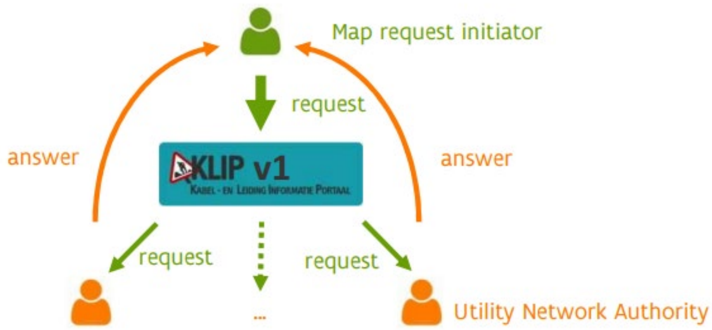

Figure 5-1 KLIP (First Phase) Data Sharing Mechanism

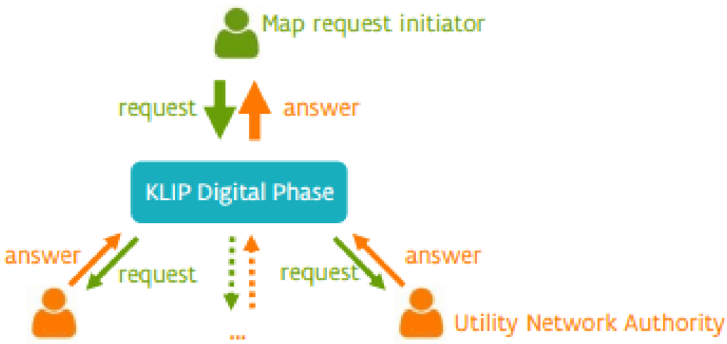

Figure 5-2 KLIP (Second Phase) Data Sharing Mechanism
(Source: Location Powers: Underground, London)

In fact, the first phase of KLIP system is very similar to the existing EMPC system in HK. Referring to Figure 5-1 above, both the early version of the KLIP system and the current EMPC system merely act as a medium for transferring data requests from a data requester. Upon receiving data requests, the data providers would respond to the requests separately by sending 2D drawings often in scanned PDF formats. The drawings from different data providers may have different drawing standards, scale, format, and may not be computer decipherable. Data requesters would then have to integrate the UU records of different sources themselves. Like the HKSAR Government, the Flanders government acknowledged the limitations of such a data sharing mechanism and upgraded the KLIP system to its second phase (digital phase), as shown in Figure 5-2. Currently, the KLIP system produces integrated maps for data requesters. The benefits of the upgrade were also identified by the Flanders government and are discussed in Section 5.1.5below. The KLIP upgrading experience is therefore considered a possible way forward for UU data sharing in HK.

According to HyD, a study called the Consolidated Utility Installation Modelling System (CUIMS) for building a 3D model for UU records was conducted in selected trial areas from 2016 to 2018, with an objective to identify an effective means of tightening control over excavation works on public roads with congested underground utilities. In the Final Report of the consultant's study, it was suggested that in the long run, it would be necessary for the existing 2D record systems adopted by most UtiUs to be upgraded to 3D digital records so as to meet the rising expectation and demand for more accurate UU utility records by the public. In order to facilitate efficient building up of a 3D database/model, the standard and form of records kept by UtiUs would need to be aligned. A common platform for storing and viewing of all the 3D as-built UU records was recommended to be built in the long term, with UtiUs held responsible for uploading, updating and maintaining their own utility records within the platform.

In view of this, other overseas experiences were studied under this Assignment, and it is suggested that the UK's National Underground Asset Register (NUAR) system could also be considered for use in HK. Using an underground asset data model based on an initial conceptual model called Model for Underground Data Definition and Integration (MUDDI), the NUAR prototype platform is able to incorporate UU data from multiple sources in various GIS/BIM formats and visualise the data on a single map over the web. The Open Spatial Consortium has commissioned a working group to undertake further research on use of the MUDDI model. This serves as an important insight that, as technology advances and open formats mature over the years, data compatibility issues could be improved in the future. The NUAR prototype has also demonstrated the possibility and feasibility of developing a multi-source, user-friendly UU data platform.

Acknowledging the benefits of 3D UU data as suggested in the stakeholder engagements, it is also recommended that a future HK UU common data platform should support 3D as-built data which is expected to become increasing popular in HK. In the short term, pilot areas such as the New Development Areas could be early sources of 3D as-built UU model data in order to build up a library of 3D UU data in HK. Existing UU records, should their accuracy be deemed acceptable, could then also be shared across the platform after appropriate digitisation. Similar to the Flanders and the UK experience, existing records could also be digitised into 2D or 2.5D (2D layouts with a z-value attribute added to identify the depth of UU) and shared across the platform. The attributes of UU records on such a platform would also enable workers to easily identify utilities on site by linking to the platform and accessing the attributes on the system provided that UU tagging (e.g. QR code, RFID chip, etc) is available.

In the long term, 3D UU models of the entire Territory of HK could be shared amongst UtiUs and other industry stakeholders. While international standards (PAS128) and local standards (CIC Building Information Modelling Standards for Underground Utilities, August 2019) have been published in recent years, it is also desirable for a standardised surveying methodology to be adopted in HK to pave the way to upgrade the quality of UU data, provided that suitable policy support is available. Data up-to-date-ness is also essential to maintain the accuracy of such UU data. Furthermore, the party responsible for record upkeeping, liability of such a party, and the corresponding statutory and legal requirements, are still subject to further political study and discussion, as this Study has found that the industry and the government has not yet been able to reach any consensus on these issues.

5.1.5. Benefits

It is anticipated that, if a UU sharing platform is available in the future, the data could be useful before conducting excavations. The data collected in this Use Case could also be useful as one of the data sources for Use Case 6 – Excavation Permit (XP) Application (see Section 5.6 for more details).

After the Belgian KLIP system was introduced, surveys were conducted to collect feedback and assess performance of the system. Survey results showed that the UU data automatic exchange platform had successfully led to reductions of 60% of the data interpretation time and cost, 80% of the administrative cost by automating the process, and 50% of the delivery time in responding to the data request. Intangible benefits were also identified in that having more accurate and comprehensive knowledge of UU resulted in “significant reduction” in utilities damage, thus avoiding potential accidents and providing a safer environment for the general public.

5.2. VISUALISATION OF CONSTRUCTION PROJECT LIFECYCLE

5.2.1. Brief Description of Use Case and Sub-Use Case(s)

As shown in Figure 5-3, visualisation of the construction project lifecycle covers simulation of the entire process from preliminary design to construction, operation, and management, including demolition and safety measures as well.

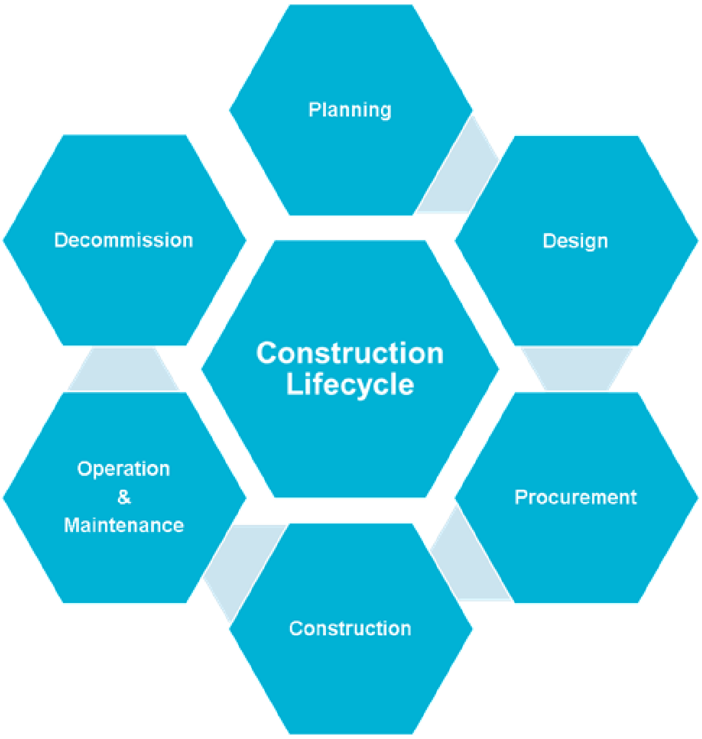

Figure 5-3 Six stages of Construction Lifecycle

5.2.2. Solution Deliverable Format, Selected Sub-Use Case and Location

An animation illustrating the whole construction lifecycle from geotechnical investigation, to design, construction, facility management and the demolition of building, with consideration of the surrounding site conditions and environment was produced as a Microsoft PowerPoint with embedded video to demonstrate the current constraints and the way forward for this Use Case. Some screenshot captures from the video are provided in Section 5.2.3 below to show the data required and has also been uploaded to YouTube at this link: https://www.youtube.com/watch?v=W6VE4zgp1hU. The animation includes the safety measures and practices used in the construction stage. Also the incorporation of data on traffic conditions, and road alignment and width surrounding the project site, means that the logistics for delivery of construction materials and MiC modules can be well planned during construction or demolition.

5.2.3. Data Required and Availability

Tables below list the commonly-required and project-specific data needed for visualisation across the whole project lifecycle.

Commonly Required Data

Data	File Format	Obtained from
3DSD (Terrain & Building)	3DS/FBX/VRML	Purchase from LandsD
Road Alignments / Interpret from LandsD iB1000 or TD Road Network	SHP/GDB; FGDB/KML/GML	Purchase from LandsD; Download from PSI (DATA.GOV.HK)
3D Construction BIM Model	RVT	Custom data
Time Schedule of construction	XLS	Custom data

Project Specific Data

Data	File Format	Obtained from
Logistic routes & transport coordination plan	XLS/PDF	Custom data
Foundation model	RVT	Custom data
Construction Machinery Models	RVT	Custom data

i. <u>Design Stage (Figure 5-4)</u>

An animation of the detailed design of further expansion of the Shek Wu Hui Effluent polishing plant was prepared to demonstrate the use of laser scanned and point cloud data to generate the existing terrain data and ground features.

Detailed design models of the sewage and sludge treatment facilities were then attached to the terrain data to check if the design is viable and workable. The visualisation facilitated making impact assessments of the design on the surrounding environment, and existing drainage, waterworks and geotechnical works.

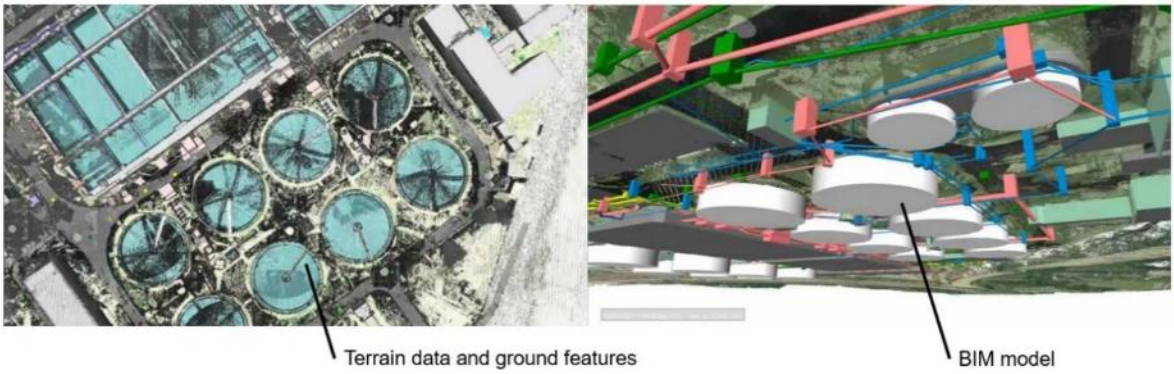

Figure 5-4 Example of data required for visualisation of design stage

ii. Construction Stage (Roadworks) (Figure 5-5)

An animation of the construction process for the Tai Po Road Widening project was made to demonstrate widening of the 1.1km Tai Po Road from a dual two-lane to dual-three lane carriageway, along with provision of noise barriers, and a traffic control and surveillance system and associated works.

In order to visualise the construction stage of this project, 3D spatial terrain and building data from LandsD were required to illustrate buildings and terrain, as well as road alignment and traffic data from HyD to present roads and bridges as well as traffic conditions. A construction programme was also essential in order to express the construction schedule and time required.

In this case the visualisation technique helps to simulate the construction processes for the Tai Po Road widening, including traffic coordination over time to cope with different phases of construction. It also shows how the construction mitigate the impact it has to the traffic on the road.

Figure 5-5 Example of data required for visualisation of construction stage (Roadworks)

iii. Construction Stage (Building works) (Figures 5-6 and 5-7)

In order to visualise the installation of MiC modules on-site, road alignment data from HyD and 3D spatial terrain data from LandsD were used to demonstrate the site boundary, site formation and roads around the site for the ABC project. A customised 3D MiC model as shown in Figure 5-7 and a foundation model were required to show the installation process. 3D construction machinery models were also included to show the transportation of MiC modules within the site and the installation sequence, as shown in Figure 5-6.

This visualisation of MiC installation allowed the clients to experience the construction process virtually. Logistic routing for trucks and spacing analysis was also carried out to ensure there is enough space for the storage and installation of the MiC modules.

Figure 5-6 Example of data required for visualisation of construction stafe (Building works)

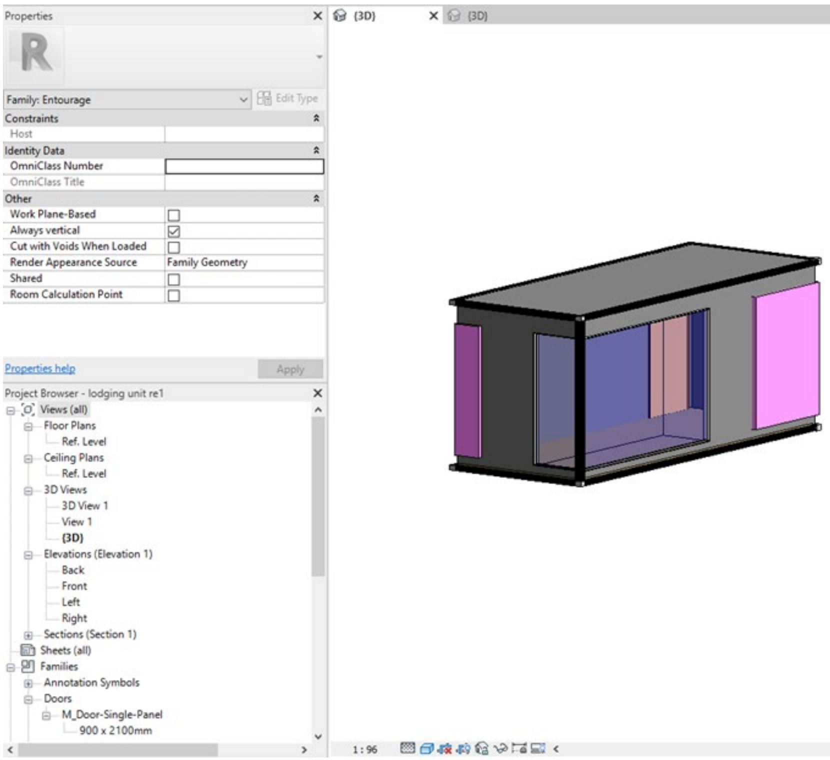

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Figure 5-7 MiC BIM model

5.2.4. Current Constraints

Despite the construction industry's success in playing a key role in Hong Kong's development, the industry faces a number of key challenges. The following challenges are extracted from the Construction 2.0 document released by DEVB in 2018.

i. Significant future construction volumes

Pressure and risk on the industry's workforce would increase significantly due to the increased volume of construction activities. Also the risk of project failures would potentially rise.

ii. High costs

According to Turner & Townsend's International Construction Market Survey in 2018, Hong Kong had the third highest construction costs globally at that time. As the construction volume would increase in the future, it was predicted that Hong Kong will become the city with the highest construction costs worldwide. This will probably lead to a generally higher cost of housing and lower residential affordability.

iii. Unsatisfactory mega-project performance

High levels of procurement, design and construction are required for mega-projects. This may result in consequential/ high-level delays, cost overruns, and quality failures to some participants.

iv. Unsatisfactory safety performance on site

The total number of industrial accidents continues to rise every year. Hong Kong has relatively underperformed in terms of safety on construction sites for many years. There is for much further improvement in safety on construction sites.

v. Stagnant productivity

The productivity of the construction industry has been declining due to the decline in the skilled construction workforce of between 5,000 to 10,000 people between 2018 and 2022. As construction projects are becoming more complex, stagnant productivity could lead to a greater risk of project failure.

vi. A lack of creativity and innovation

The construction industry has been relatively lacking in the integration of new technologies and construction methods. Adaptation to new technologies will have a positive impact on the industry's productivity levels, and help to reduce the pressure on future costs and risk of project failures.

5.2.5. Way Forward

i. <u>Visualisation of Construction Project Lifecycle</u>

Visualisation of the construction project lifecycle allows stakeholders to step into the project site and visualise it virtually at any point in the project cycle as if they were there in person. Various analyses can be carried out for different purposes by having an information model with all the data required through visualisation to avoid any clashes and issues.

Time-based analysis can also be carried out if the construction programme is available. The construction sequence can then be simulated virtually before building it in real life. Process tracking and construction monitoring as well as visual validation can be enabled with the collaboration and coordination of different parties in real time. This enhances communication and collaboration between stakeholders to minimise the possibility of design variations and amendments.

With the inclusion of logistic routing data as well as transportation coordination plans, simulations could be carried out to check for clashes, as well as the possibility of road congestion. In this way design changes can be efficiently managed, and plans could be checked before construction to reduce the chances of project delay.

With the visualisation of the construction lifecycle, high-level health and safety risks analysis could also be conducted to identify such risks at the design stage of a project. This would assist engineers in developing accurate safety plans to reduce accidents on site.

ii. Common Data Exchange Platform

A common data exchange platform would allow the data exchange of BIM models between different stakeholders. However, the data would need to have different levels of accessibility assigned relating to its sensitivity and ownership restrictions. Disclaimers and terms of use of the platform would need to be set up to inform users about responsibilities in using data obtained from the platform. Ownership of the data would also need to be clarified to avoid the concerns of other stakeholders.

There is still a lack of clarity on the standard data format for data exchange. The format of the data would need to be standardised to allow seamless data exchange and to reduce the time required to convert data to a useable format.

5.2.6. Benefits

Construction processes and methodologies can be rehearsed virtually with the visualisation technique. Stakeholders could interact through the visualisation in real time, which enhances communication, collaboration and coordination between different stakeholders. Clients could experience the construction virtually before it is built, which should help them make confident decisions about the design. This potentially reduces the chance of design amendments and project overruns. As design changes are efficiently managed, more projects could be kept on schedule and within budget.

With the visualisation of the construction lifecycle, site logistics and safety coordination can be simulated before construction to reduce the risks of delays as much as possible. Also, accurate planning of construction orders leads to increased safety on site.

Visualisation is also a powerful marketing tool for enhancing public engagement, and allowing members of the public with no technical knowledge to understand the construction processes and impacts on society and the surrounding environment.

5.3. GEOTECHNICAL STUDY

5.3.1. Brief Description of Use Case and Sub-Use Case(s)

Geotechnical study is often conducted to assess geotechnical risk associated with existing and proposed developments. When necessary, stabilisation and mitigation strategies to manage landslide hazards will be recommended as a result of a geotechnical study. The consequences of landslide hazards cannot be overlooked as Hong Kong is a highly populated city and undergoing urban encroachment onto steep natural slopes. 'Geotechnical Study' as used in this Study covers Natural Terrain Hazard Study (NTHS) and Man-made Slope Assessment.

<u>NTHS</u>
An NTHS covers both existing and new development. It normally includes desk study, detailed aerial photograph interpretation, field mapping and determines the hazard types, scale and mobility of possible landslides and potential impact to nearby developments, roads and infrastructure, etc. For new development, optimisation of the site layout could be used to minimise the landslide risk, for instance, adjustments to the facility layout or providing buffer zones may be preferred to carrying out large scale stabilisation or mitigation works, which may be environmentally damaging.

<u>Man-made Slope Assessment</u>
For man-made slopes, the geotechnical study should include assessments of stability of those slopes that could pose potential landslide risks affecting the development. Slope upgrading works may be recommended in the assessment.

5.3.2. Solution Deliverable Format, Selected Sub-Use Case and Location

A Microsoft PowerPoint presentation was produced to demonstrate the constraints and way forward for this Use Case. As an example, project data on natural terrain along the Tsing Long Highway were collected and reviewed, such as point cloud, slope models and the BIM model for stabilisation and mitigation techniques such as retaining wall and soil nail. Ground Investigation reports and data on past landslides in the area were obtained from the CEDD Geotechnical Information Infrastructure (GInfo). No actual landslide risk and impact assessment was performed in this Use Case.

5.3.3. Data Required and Availability

Three types of data listed in Tables 5-4, 5-5 and 5-6 below were compiled from the stakeholder engagement sessions.

i. Commonly Required Data for a Geotechnical Study*)*

NTHS	MSA	Data	File Format	Obtained From (Govt Project)	Obtained From (Private Project)
✓	✓	iB1000 (Topographic Map)	CAD/GDB	LandsD	Purchase from LandsD
✓	✓	iC1000 (Land status plan)	CAD/GDB	LandsD	Purchase from LandsD
✓	✓	Contour map	SHP/CAD	LandsD	Purchase from LandsD
✓	✓	Systematic Identification of Maintenance Responsibility of Slopes (SIMAR)	PDF	LandsD Slope Maintenance Responsibility Information System (SMRIS)	
✓		Aerial Photo	Hardcopy/TIFF	Purchase from LandsD	
✓	✓		Hardcopy	Borrow from CEDD GEO	N/A
✓	✓	LiDAR Data*	LAS	CEDD / LandsD / GEO Open Data Portal	Site survey
✓	✓	Slope Information Data*	PDF / XLSX Hardcopy	CEDD Slope Information System (SIS) / GEO Open Data Portal	
✓		Enhanced Natural Terrain Landslide Inventory (ENTLI)*	SHP / GDB	CEDD GInfo / GEO Open Data Portal	Site survey / Research
✓	✓	Ground Investigation (GI) / Site Investigation (SI) report with Borehole Information*	Scanned PDF, Some with AGS	CEDD Ginfo / GEO Open Data Portal	CEDD Ginfo; Site Survey
✓		Old research and study reports	Hardcopy	CEDD CEL	Cannot be scanned / borrowed, Desktop research
✓	✓		Softcopy	CEDD website under “GEO Publications” Ginfo	many old reports accessible from the CEDD website
✓	✓	Rainfall Data*	Textual	CEDD Rain Gauge & HKO / GEO Open Data Portal	HKO
✓		Country park boundary	SHP	AFCD	Estimated based on the relevant zoning of statutory plans as shown in PlanD Statutory Planning Portal 2

NTHS	MSA	Data	File Format	Obtained From (Govt Project)	Obtained From (Private Project)
✓		Outline Zoning Plan (OZP)	SHP/GeoJSON/ GML	PlanD's Digital Planning Data website	PlanD's Digital Planning Data website

MSA = Man-made Slope Assessment

CEDD copies of GEO publications: https://www.cedd.gov.hk/eng/publications/geo/index.html
Ginfo: https://www.ginfo.cedd.gov.hk/GINFOINT
PlanD Digital Planning Data: https://www.pland.gov.hk/pland_en/info_serv/digital_planning_data/download.htm

Remarks:
* A new open platform "GEO Data for Public Use" (GEO Open Data Portal) was launched in Sep 2020 via https://www.geomap.cedd.gov.hk/GEOOpenData/eng/Default.aspx.

ii. Project Specific Data for a Geotechnical Study

Data	File Format	Obtained from
Topography Survey	Table	Site Survey (for both Government and Private projects)
GI Survey	Table	
Population Estimation	Table	
Traffic Survey (Pedestrian and vehicle flow)	Table	

iii. Data Available but Not Used for a Geotechnical Study

Data	File Format	Obtained from	Constraints/Reason not used
Traffic Volume (for reference)	Table	Request from TD	Only vehicle flow available, no pedestrian count. Prefer site survey
Census Data (for reference)	GML/ XLSX / CSV	Download from CSD or Geodata Store	Prefer site survey
3DSD Building & Terrain & Infrastructure Model (for reference)	3DS/FBX/ VRML	Purchase from LandsD	Unfamiliar

Commonly required data, listed as table (i) above, refers to datasets in standardised format published by certain departments. There are a few common procedures for obtaining some of the data, for instance Digital Planning Data of Statutory Plans from PlanD's website that are open for both public and private projects and no request is required. However, it is observed that for Government projects, most of the data can be obtained on request from LandsD, or from the online systems e.g. Ginfo, while for private projects, consultants/contractors can still purchase LandsD's topographic data, land status plan and aerial photos directly.

A new open platform "GEO Data for Public Use" (GEO Open Data Portal) was launched in Sep 2020 by CEDD GEO. It contains digital data such as GDB and CSV for public download, e.g. GI and Laboratory Test (LT) Records, ENTLI, GEO rain gauge data, registered man-made slopes and Location of Landslide Incidents. LiDAR data can also be obtained but only on request due to the large file size. Geological data such as 1:20,000- and 1:100,000-scale geological maps in shape file format are also available for public download on the portal.

Project-specific data in table (ii) refers to data that required site-specific Survey and which are more accurate than reference data in terms of the spatial and temporal resolution. Stakeholders are able to collect raw data about the site which may be accompanied by an interpretation or have parameter settings that are more suitable to their project scope and objectives.

When asked if data requesters are aware of other existing data such as census data for population estimation, and traffic volumes from TD, stakeholders preferred Site-specific survey for more timely and accurate data; while for 3D Spatial Data from LandsD with information on buildings, terrain and infrastructure, they are not familiar with its format and compatible software.

5.3.4. Current Constraints

i. <u>Incomplete Database</u>

Site survey data, and the results or reports produced from different parties in a construction project are usually scattered between various companies and government departments, such as private companies, BD, CEDD and LandsD. The records might be duplicated or be inconsistent for the same site or nearby construction sites.

In addition, consultants/contractors usually search for borehole information from GI reports for previous projects that are adjacent or close to their current project site for reference. From records available in the CEDD CE Library (CEL), there are currently more than 370,000 GI stations in total, of which private projects account for about 18%. Nonetheless, if the relevant ground investigation was conducted for a private project, the Ginfo would refer the users to obtain the GI records from BD's BRAVO system. Users can also visit the CEL and BD's Building Information Centre during slightly restricted normal working hours. Extensive time is needed for searching reference data from various sources. From the stakeholder interviews, it often takes about 2-3 weeks to collect data for government projects which cover a larger extent, e.g. a study with around 200 slopes, while a similar duration is typically needed/ for a private project that contains 20-30 slopes.

ii. <u>Non-machine-readable data</u>

Data in Ginfo like GI reports are in scanned PDF format. For government projects, AGS files (an open geological data format) have been submitted to GEO as part of the GI records. The AGS files can be read and interpreted by specialised programs, e.g. Leapfrog, gINT, etc, and presented as geological information in a 3D environment, as shown as Figure 5-8. This format is stated as one of the deliverables for GI conducted under government projects. However, when using borehole information from old sites for reference, manual digitisation of GI reports is still required.

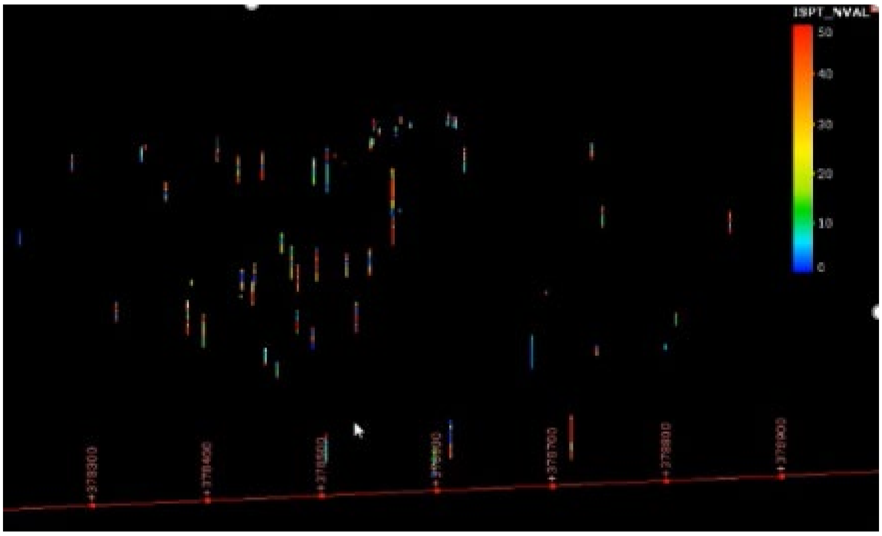

Figure 5-8 GI Data in AGS format viewed in 3D Environment (Source: Leapfrog 3D)

iii. <u>Unutilised 3D data</u>

3D slope models, 3D Geological models and BIM models may be produced as part of a Geotechnical Study but only 2D screen captures are needed in the report. For certain major public works in recent years, models such as as-built site formation and slope models were also collected upon project completion, but they were not put in other platforms for other parties to access and take reference. LandsD is currently preparing a standard for the project offices to provide as-built BIM models to them. It is understood that these data are interpreted data which may not give the most accurate information. However, these models when joined together would form a database and facilitate the visualisation and monitoring of the terrain and geological landscape of Hong Kong. Figure 5-9 below shows point cloud data on a slope model and an overlay used with a BIM model for design of landslide mitigation measures.

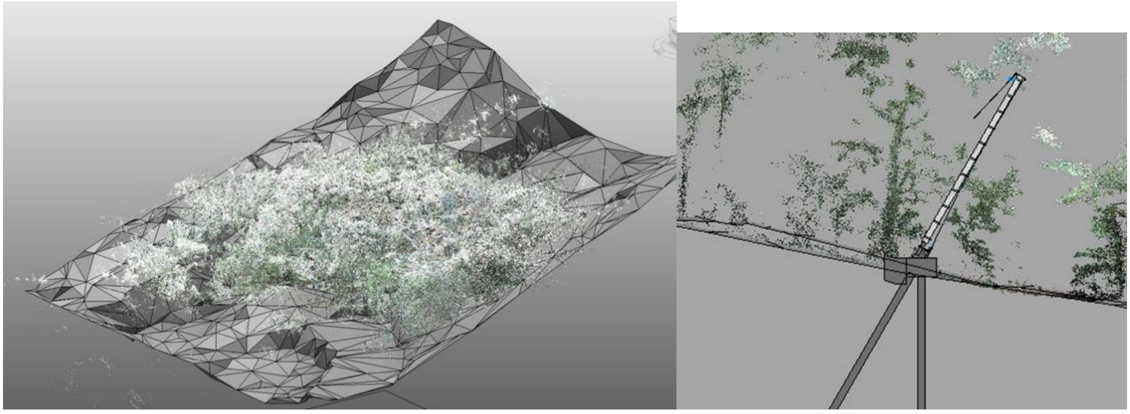

Figure 5-9 Screen capture of slope model with point cloud and with BIM flexible barrier design

5.3.5. Way Forward

i. Development of a 3D Mapping System

For the historic borehole information, it would be ideal to convert more borehole data into AGS format with attributes input. Depending on the quality of the old GI reports, for instance, dealing with any missing information and non-standardised coding could require much effort and, the time cost varies a lot[1]. If Microsoft Excel spreadsheets were attached to such reports, the data conversion would be fast. However, if manual digitisation is needed for a huge amount of reports, various alternatives should be considered with regard to time and cost, for example, entering the whole borehole log, or entering only the basic geology (e.g. rock and soil types) and standard penetration test (SPT) data, or entering the metadata only. To facilitate creation of a searchable database, data indexing and linkage between metadata and scanned reports with OCR is also crucial[2]. Having more digitised data increases data requesters' efficiency for extracting useful information by minimising manual work for data entry and digitisation.

For better visualisation, a 3D mapping system should be developed to support 3D viewing of borehole information retrieved from AGS files, capable of being overlain with BIM models, LiDAR terrain or LandsD 3D Spatial Data, similar to Figure 5-10. This facilitates spatial understanding and inter-relationships of geological strata. CEDD GEO also plan to make GInfo 3D available and have been developing a pilot 3D platform prototype for a few testing areas.

[1] Entwisle, D C. & Self, S. (n.d.). Using AGS Digital Data Transfer Format (Presentation material). British Geological Survey, Natural Environment Research Council.

[2] Chandler, R. (2011). Geotechnical Data Transfer and Management for Large Construction Projects and National Archives. International Symposium on Advances in Ground Technology and Geo-Information (IS-AGTG).

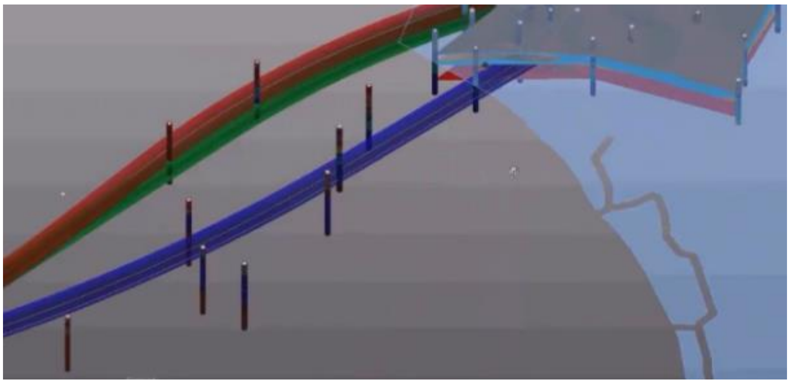

Figure 5-10 3D viewing with borehole data, BIM models combined (Source: Keynetix Ltd.)

In Singapore, a 3D geological modelling and management system (GeM2S) has been under development in recent years by the Nanyang Technological University and the Building Control Authority. The objective of this project is to transform 60,000 borehole data and geotechnical test data to 3D geological and geotechnical models and present it in the form of a web-based design tool for future underground projects. It is planned to be BIM-ready and will form part of the Digital City program in Singapore. Figure 5-11 shows an example of borehole data collected from different government departments and the private sector in both AGS and PDF format can contribute to the system. Figure 5-12 illustrates the milestones for this project[3].

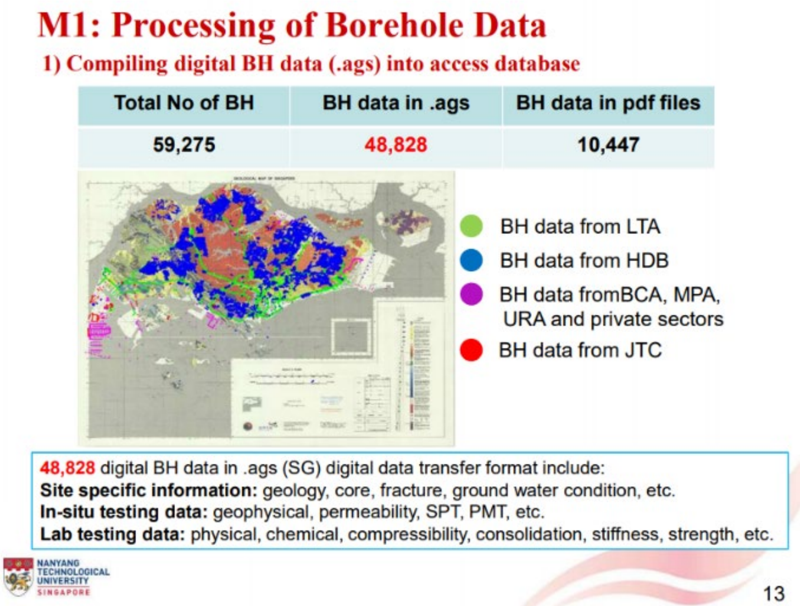

Figure 5-11 Borehole data types and sources for the GeM2S

[3] Chu, J., Pan, X., Chiam, K., & Wu, D. (2018). 3D geological modeling and management system (GeM2S) for Singapore. (Proceedings) from the DMT'18 Meeting in University of Kentucky, Lexington, KY. Retrieved from https://ngmdb.usgs.gov/Info/dmt/docs/DMT18_Chu.pdf

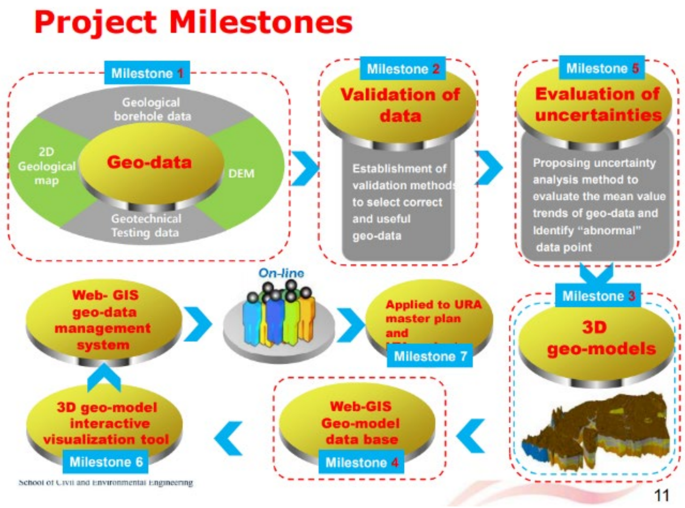

Figure 5-12 Project milestone for setting up a web-3D geological modelling and management system (GeM2S) for Singapore.

On the other hand, as mentioned in the previous section, GInfo also contains GI reports that were conducted for private projects, for which the copyright is not owned by the government. The difficulty for publishing both the existing and old project data is understood, as some joint venture companies established for a specific project could be difficult or impossible to identify. Therefore, for upcoming projects only, it is suggested that relevant Departments should review the preliminary design of their electronic submission requirement with BD to first collect digital project data including the GI reports, boreholes in AGS format and even as-built BIM models and slope models, together with data owners' consent during statutory submission, so that data can be readily disseminated to the industry. In that way, data requesters would not need to visit the CE Library and BD's BRAVO system. However, suitable disclaimers would need to be added to avoid legal liability, and deal with data accuracy issue and data misuse, stating that the data in the platform are not necessarily endorsed by the host organisation, and thus should only be used for reference only.

ii. Opening up of Data for Private Projects, and Public

From the interview results, current search methods used to obtain data on nearby geological and landslide information is not efficient for private projects. The industry suggests opening up these data to the public as well. CEDD have released spatial GI data on CSDI and also on their "GEO Data for Public Use" platform (GEO Open Data Portal). GInfo provides access to the public for data overlay and viewing. Several access levels for GInfo have been established for different users and purposes, for instance, at the public level, sensitive data attributes are purged.

iii. Centralised 3D Data Platform

3D data including geological models, slope models, BIM models for design of slope stabilisation and landslide mitigation measures, etc, have been under-utilised up to now but they would form a comprehensive database for understanding the geology and assisting in the design of geotechnical works in Hong Kong.

A centralised 3D data platform is recommended for the industry to share data among various stakeholders and with the government. It would be a good bottom-up initiative from the industry to have control of data to be shared, as for the time being, CSDI is a top-down data sharing infrastructure set up by the HKSAR Government and to be launched by 2022. After this system is maturely developed and data are aligned with industrial standard, potentially it can then be integrated via web API with other geospatial systems, e.g. GInfo that supports 3D models and 3D viewing, to maintain a single source of truth, while some of the unclassified data can be shared to the public via CSDI.

A neutral data host should be established and made responsible for the platform. For Hong Kong, one of the stakeholders mentioned that a group of geotechnical professionals from HKIE, CEDD GEO and ACEHK, etc. could form a joint committee to collect data from the industry and make it widely accessible.

An alternative to setting up a data exchange platform would be to encourage the industry to voluntarily upload and share project data with CSDI upon completion. Nonetheless, incentives may be needed to ensure the availability of effective and substantial shared data.

That said, the risk of compiling data from different projects into a single database should not be overlooked, for instance, drawing a cross-section which contains data generated from multiple projects and where the accuracy highly depends on the completeness and standardisation of data in the area. In addition, the industry needs to be aware that some data like geological models consist of interpreted data derived from raw data. In such cases different parameter settings could lead to different model outputs. Therefore, metadata should be included when sharing these data, and users advised to use the data for reference only even for factual data, e.g. LiDAR data. The original file in an open format could also be attached.

It takes time to promote and educate data sharing to stakeholders and also create suitable incentives for the industry, e.g. when a company provides data, they will be permitted gain access to the centralised 3D platform to view and download similar data from other projects as well. Statutory submission requirements of project data to BD could also be updated. On the other hand, a data standard and guidelines for each data set would need to be established, for BIM models, GIS data, borehole data, etc. Encouragement should be given to share data in an open format e.g. IFC, CityGML, AGS etc., which would allow the potential and extent of data loss to be studied, and metadata should also be provided to understand the parameters for any interpolation applied, e.g. for geological models. The data standard should also be aligned with CSDI. Data quality checks and update should be performed by the data host upon receiving new data.

5.3.6. Benefits

For the industry, opening up more data from the Government and uploading data from private projects will effectively narrow the workflow and data gap between government and private projects. It will also provide more easy reference for nearby project sites, thus helping to minimise rework and data inconsistency and hence facilitating better decision making for drawing up an effective mitigation strategy and designing suitable geotechnical works.

Efficiency in project delivery can be enhanced if stakeholders are able to obtain regularly updated and readily-available data for Reference. In turn will facilitate better assessment of mitigation approaches and strategy.

For the Government, collecting data from the industry can increase the degree of collaboration and engagement with related stakeholders. The Government can also monitor and manage the data standard for the industry. When data in the centralised platform is integrated into government systems, such as GInfo and CSDI Portal, it can ensure a single source of truth, minimising data redundancy and rework.

5.4. TRAFFIC IMPACT ASSESSMENT AND SWEPT PATH ANALYSIS

5.4.1. Brief Description of Use Case and Sub-Use Case(s)

Traffic impact assessment (TIA)

TIA is a technical analysis of traffic problems and safety issues relating to a specific development. The main objective of the TIA report is to identify whether a particular development project will have an impact on the safety and efficiency of adjacent roads. Moreover, the report paves the way to investigate and develop traffic management plans that help minimise traffic congestion. The TIA considers not only traffic impacts such as road network efficiency and safety, but also the impacts on all road users, including public transport users, pedestrians and cyclists. The TIA considers both impacts on operations and physical impacts on transport infrastructure.

The TIA report covers many aspects, such as pedestrian, access, and public transport arrangements, etc. However, as the proposed development and traffic characteristic of the study area would be different each time a TIA is performed, the traffic consultants need to identify the project-specific issues and recommend practicable mitigation measures to address the possible traffic impacts. The content of a TIA is "site-specific", which means the TIA report has to address the project-specific issues.

Conventional TIA deliverables include descriptive reports, tables, site plans and so on. Some projects require a 3D animation to simulate the traffic or/and pedestrian flow. Some existing software packages designed for automated 3D traffic simulation allow the consultant to generate animation by inputting traffic flow data. However, consultants not only conduct traffic surveys to record the arrival of various vehicle class and pedestrian groups at the project site, but also the surrounding buildings and environment as the 'background' of the animation. If the 3D building and street view can be provided, resources and time can be allocated more efficiently on calculating the traffic demand and interaction, and changes within the project timelines within the study area.

In the study of Use Case 4, as many stakeholders have mentioned the access arrangements for modular integrated construction (MiC) in Hong Kong, instead of reviewing all aspects a focused Swept Path Analysis (SPA) has been used as an example to demonstrate the application of TIA for temporary traffic arrangement and the improvement made by switching from 2D to 3D data.

SPA

SPA is a simulation of a vehicle in motion. The purpose is to create designed spaces, such as roads, driveways, or parking facilities that can accommodate vehicle needs during operation, or ensure that specific vehicles can manoeuvre through specific routes. In Hong Kong, SPA is required if a load width exceeding 3 m applies to an application for a Wide Load Permit.

The development of MiC

MiC is an innovative modular construction method. With the advantages of short construction time and high construction quality, the method is being widely promoted by CIC, and several construction projects being built by the MiC method have been launched. MiC assuredly will become one of the main construction methods in the future. However, transporting large pre-fabricated modules is a great issue in project scheduling. Thus SPAs or even full TIAs are likely to be conducted more frequently for the foreseeable future.

With the increasing amount of 3D data, the conventional approach to preparing temporary traffic arrangements can be improved in terms of reality and visual communication by using 3D data. SPA is a good example of how to demonstrate the improvement in switching from 2D to 3D data. The temporary traffic arrangements can be easily identified in a 3D simulation. SPA also provides a useful reference for transitioning from 2D to 3D in other aspects of TIA.

5.4.2. Solution Deliverable Format

SPA is chosen as an example in this Use Case as suggested by many stakeholders during the interviews. Two SPAs were performed, in Lok Ma Chau and Mong Kok, to simulate the case of a MiC truck passing along major highways, as well as through narrow streets in dense urban areas.

A Microsoft PowerPoint presentation was produced to demonstrate the constraints and way forward for this use case. 3DSD data, including building, infrastructure and terrain data, were adopted to demonstrate a 3D SPA.

5.4.3. Data Required and Availability

The lists in Tables 5-7 and 5-8 below are non-exclusive and only includes data commonly used by traffic consultants. For example, road data from LandsD and HyD can also be used as a substitute for Traffic Department's road network data, where applicable.

Data required for traditional TIA

Data	File Format	Obtained from
Road size and Alignment / Interpreted from LandsD iB1000 or TD Road Network	SHP/GDB; FGDB/KML/GML	Purchase from LandsD; Download from PSI (DATA.GOV.HK)
Traffic aids and traffic signs	GDB/KML/ GML/CSV	TD - download from PSI (DATA.GOV.HK)
Base District Traffic Model (BDTM)	DAT	Purchase from TD
Annual traffic census	GDB/GML/KML	TD - download from PSI (DATA.GOV.HK)

Data	File Format	Obtained from
Outline Zoning Plan (OZP)	SHP/GeoJSON/ GML	PlanD's Digital Planning Data website
Census Data	CSV/GML/XLS	Download from CSD or Geodata Store
Traffic count survey	Table	Custom made by traffic consultant
Aerial Photo	TIFF	Purchase from LandsD; Custom made by traffic consultant
LiDAR Data	LAS	Custom made by traffic consultant

Data on the road network, traffic aids and traffic signs are used by traffic consultants to enter into the traffic model. The annual traffic census is often used as a reference on a macro scale. Land use zoning data are required if there is an impending development that involves a change of land use, such as new town development or local rezoning exercises. Census data, especially population and employment data, are used for traffic forecasting.

Traffic count surveys, including data on traffic flow, turning movement (turn right/ left), traffic queuing and journey time, are obtained by traffic consultants. Traditionally these data are measured by traffic surveyors on site. The purpose of a traffic count survey is to acquire traffic data for the peak period. The scope and duration will be project- and site-specific, and could range from studying traffic at a single road intersection, to an entire study area.

In recent years video-analytical solutions based on AI have emerged, which are capable of conducting traffic count surveys in any time interval. These systems are capable of classifying all categories of vehicles, as well as pedestrians, using only a camera. However, the use of such technology has not prevailed in Hong Kong due to major concerns about data privacy, safety of installation of CCTV on site, and the cost implications. To sum up, there is an enormous opportunity for innovation in traffic count surveys in Hong Kong, if the data privacy issue can be resolved.

Aerial photographs and LiDAR data are adopted more frequently by traffic consultants. There is also potential for greater use of Unmanned Aircraft Systems (UAS), or drones, but traffic consultants have reflected that the process of applying for a UAS flight permit takes up to 28 working days, which has led to prolonged waiting times and short post-processing times within a fixed project schedule.

Data required for the SPA Use Case **Data**	**File Format**	**Obtained from**
3D Spatial Data (3DSD)	3Ds/FBX/VRML	Purchase from LandsD
iB1000 (Topographic Map)	CAD/GDB	Purchase from LandsD

MiC module design	CAD/RVT/etc.	Custom made by contractor

5.4.4. Current Situation

Currently, SPA is performed in 2D since it is an effective means of communication between a traffic consultant and TD. However, as more MiC projects are implemented in future, 3D visualisation of the SPA should be appropriate and accurate as it transforms the technical numbers (e.g. height restrictions, road widths, etc.) into symbology and animation, and can demonstrate the results of the analysis to the public or local stakeholders in a more efficient way.

5.4.5. Demonstration of SPA in 3D

In Use Case 4, a simple version of SPA in 3D was conducted. Some road alignment data in Lok Ma Chau and Mong Kok were selected for the demonstration since these areas both contain viaducts and footbridges in the road datasets.

Lok Ma Chau

As shown in Figures 5-13 and 5-14, 3D Spatial Building Data, 3D Spatial Terrain Data and 3D Spatial Terrain Data from LandsD were used to present the buildings, terrain and infrastructure of the district tile. MiC truck data were customised in the CAD software, using the dimensions of the MiC module provided by the contractor.

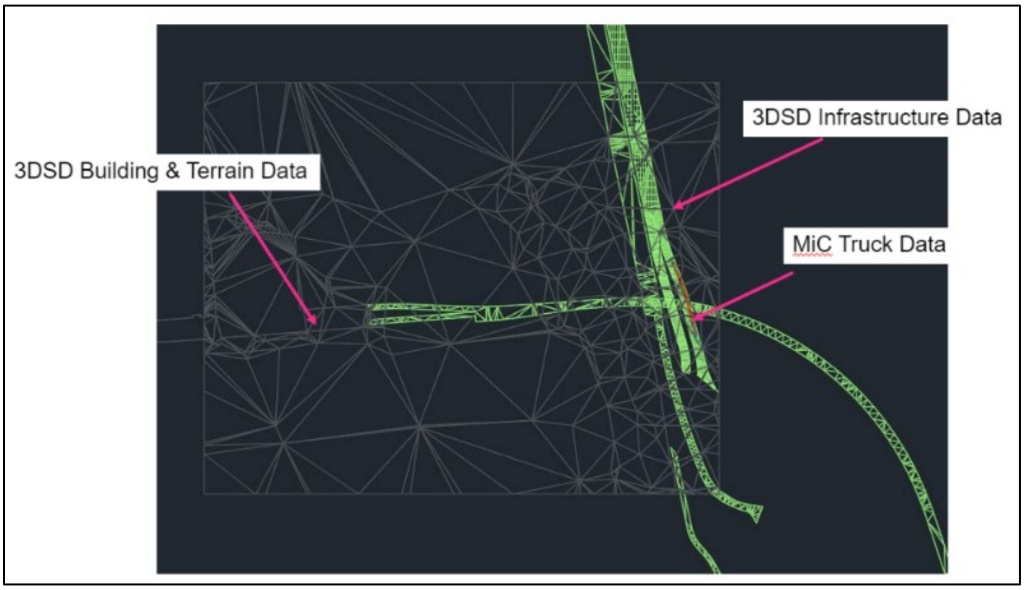

Figure 5-13 Data required for demonstration – Lok Ma Chau

With the 3D simulation, it is easy to identify that the height of the MiC truck is lower than the height limit at the Lok Ma Chau railway viaduct.

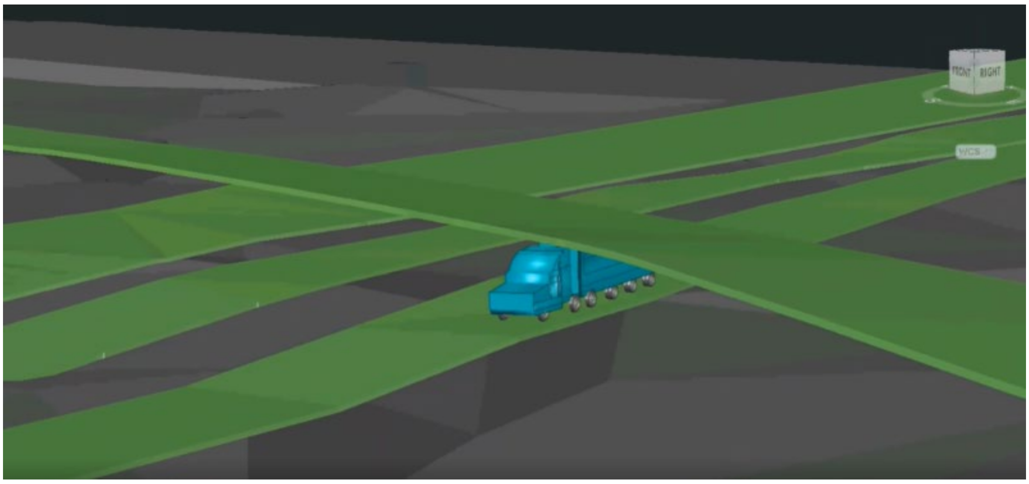

Figure 5-14 Screenshot from Demo video – Lok Ma Chau

Mong Kok

As shown in Figures 5-15 and 5-16, 3D Spatial Building Data, 3D Spatial Terrain Data and 3D Spatial Terrain Data from LandsD were used to present the buildings, terrain and infrastructure of the district tile. As before, MiC truck data were customised in the CAD software, using the dimensions of the MiC module provided by the contractor.

Figure 5-15 Data required for demonstration – Mong Kok

With the 3D simulation, it is easy to identify that the height of the MiC truck is lower than the height limit at the Mong Kok footbridge and can pass through a road junction.

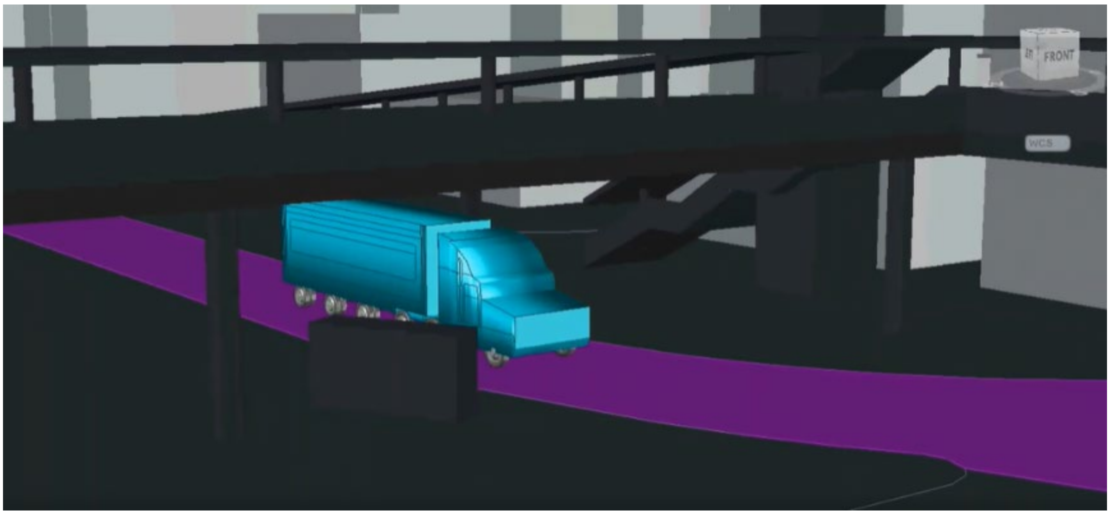

Figure 5-16 Screenshot from Demo video – Mong Kok

The Advantages of 3D visualisation in SPA

Since z values (height value) are introduced in 3D simulations, they can accurately represent the traffic problems, and identify potential problems before they become actual issues. Also, time and costs can be saved due to the maximisation of the load within the limits for each ride. Most importantly, 3D simulation is beneficial for stakeholder engagement as it is more realistic than 2D simulation. Effective communication can be facilitated not only among engineering professionals, but also with other decision makers and the general public. Last but not least, duplicated effort by traffic consultants is avoided, as the 3D animation can be generated from 2D SPA with the press of a button.

Therefore, it is a suitable time to promote the use of 3D data for SPA in the construction industry.

5.4.6. Way forward

i. A centralised database of previous SPA
As SPA has to be carried out for all vehicles with a load width exceeding 3 m, there are already roads in Hong Kong with repetitive completed SPA. It is recommended that relevant government departments should open a centralised database of previous SPA, so that traffic consultants can refer to it and be capable of carrying out future SPA in a more efficient way.

ii. Smart Mobility, Smart City
According to the Smart City Blueprint for Hong Kong, Smart Mobility is one of the six key focus areas. TD has developed a 'HKeMobility' mobile application and has developed a routing system comprising useful information on potential problems and delays, such as road works, vehicle restrictions and real-time traffic conditions. Relevant government departments may consider incorporating the database of previous SPA to 'HKeMobility', or to establish a similar platform specifically for use within the industry.

5.4.7. Benefits

For the construction industry, the existing manual data collection and assessment or modelling approach to TIA can be greatly enhanced, and cost-savings can be achieved, through saving repetitive effort on data collection by adopting pre-existing 3D data, using 3DSD. 3D simulation of SPA can help to optimise the design and planning in the transportation of MiC modules, which will minimise impacts on the local environment and people living in the area. Finally, by promoting usage of 3D data similar techniques can be applied in other aspects of TIA as the 3D data becomes more common, such as 3DSD street level data from LandsD in this example. Since 3DSD has a different level of granularity of the street view, using 3D street view data for TIA is more powerful in simulation and analysis than traditional 2D data.

For society in general, timely traffic condition data, e.g. on traffic flows, traffic conditions, vehicles types, etc., can be collected and shared with concerned stakeholders and the public. It is easier for the public to understand traffic impacts by visualisation and simulation. Thus, public engagement can be facilitated.

5.5. FOUNDATION DESIGN

5.5.1. Brief Description of Use Case

Currently, obtaining GI data for foundation design reference for private projects is rather indirect and time-consuming. More readily accessible GI data would allow foundation design engineers to make good reference about ground conditions at the site, thus the foundation design process can be done more easily and accurately. In this Study an automatic foundation design process was also demonstrated.

5.5.2. Solution Deliverable Format

i. Automatic Design of Bored Pile
Automatic foundation elements were created by BIM scripting from integration of 2D layout plan and GIS data.

ii. Mock up of Data Platform
A mock-up data platform was prepared, showing how private sector and government can upload their data on piled foundations online, including as-built BIM models of the piles, GI records etc.

5.5.3. Data Required and Availability

To design a 3D bored pile schedule for end-bearing piles, the levels of the top and bottom of each pile are required. Reliable estimates of the top level can be obtained by interpolation of topographic contour data from LandsD, and the bottom level by obtaining rockhead data fromGI records. Traditionally foundation engineers have collected different reference data such as rockhead data and GI reports of the surrounding sites before carrying out GI on their own site.

CEDD’s GInfo platform stores a wide range of geological and related data. Public and private developers can register to view and download the data, but they have different access levels. GInfo contains GI data that were conducted for private projects but the copyright of these data is not owned by the Government. Hence, private developers could only access the GI data of private projects by making visits to the CE Library and BD’s Building Information Centre, and not via the GInfo platform.

Currently GEO has stored data from 370,000 GI stations across Hong Kong, among which are 23,000 in AGS format. 82% of these data were collected from government projects and 18% from private projects.

Designing a pile layout is project- and site-specific and is usually created in a CAD format by engineers, based on the data listed in Table below.

Data	File Format	Obtained from	Remarks
Rockhead data (for reference)	Scanned PDF	CEDD GInfo	

Data	File Format	Obtained from	Remarks
GI Reports	Scanned PDF; some with AGS	CEDD GInfo / GEO Open Data Portal	Require digitisation
Contour data (from iB1000 Topographic Map)	SHP / GDB	Purchase from LandsD	
Pile Layout	CAD	Custom made	
Rockhead data (detailed)	AGS	Custom made	

Remarks:
* A new open platform "GEO Data for Public Use" (GEO Open Data Portal) was launched in Sep 2020 via https://www.geomap.cedd.gov.hk/GEOOpenData/eng/Default.aspx.

5.5.4. Current Constraints

i. Inefficient Method of GI Data Storage

The traditional practice of storing GI data is now inefficient. Most GI data and reports are in textual format like scanned PDF, which is not machine readable and requires manual input of the textual data into software for design purposes. Extra time and resources are needed to digitise data manually from textual content before it can be used for design.

Other than GInfo, foundation engineers can also check BD's BRAVO system, or request the data from the landowner, but such requests are usually rejected due to liability issues, or because landowners do not have an organised database for their earth and foundation/ works.

A visit to the CE Library is another option, but requires consultants/contractors to go to the library and to print out relevant scanned GI reports in the library. While they are able to access all geological data gained from both government and private projects, the disadvantage is that such visits and data searching is time consuming.

ii. Copyright Issue of GI records from private projects

Although GI data from private construction projects are often submitted to relevant government departments on project completion, and also to CEDD GEO for record purposes, these data are not shareable due to the copyright issue. Thus private practitioners cannot access existing data from other completed projects near the site. This may lead to an incomplete study of the site.

5.5.5. Way Forward

i. Short term: Develop a Data Collection Deliverables Standard and Consent to Data Sharing

A standardised format of the deliverables should be adopted in order to facilitate data storage and future data usage. For private submissions, it is suggested that provision of GI data in AGS format should be a compulsory deliverable for project completion. A consent form should also be devised, for signature by the developer to agree to the project data being shared on a centralised data platform.

From interviews with geotechnical engineers, it is clear that they would like to acquire GI data from adjacent private sites. However, they perceived the copyright issue as an obstacle that could not be solved easily. For instance, as many joint venture companies are shut down after construction of a project, it may be impossible to seek consent from these data owners. Therefore, obtaining consent from owners for data owners should begin soon in order to collect shareable data as early as possible.

ii. Medium term: Digitisation of GI Data

It is recommended to store and record GI data in AGS format so that the information can be easily extracted and processed for further analysis. The AGS data format was set up in 1991 as a digital format for geotechnical and geo-environmental digital data exchange. The other great advantage of the AGS format is that it is compatible with BIM software.

It is proposed that all existing stored GI data should be subject to an initial review and a decision made on which data are reasonably reliable and capable of being converted where necessary into AGS format. It is not recommended to convert all the existing GI data, as a vast amount of digitisation would be required for all 370,000 existing GI stations. Besides, the older historical GI data from a few decades ago may not be so reliable in terms of precision and modern logging standards. Instead, it is suggested that provision of a more machine-readable data format, OCR for scanned PDF, should be considered for the more reliable data.

iii. Long term: Centralised Data Platform with 3D

A centralised data platform with 3D should be developed in the long run. This will serve as a one-stop platform for all geological and related data collected from both public and private sector investigations, including site topographical surveys, GI reports, LiDAR data, 3D slope and geological models, BIM models, etc.

GEO has recently launched a GEO Data for Public Use website (GEO Open Data Portal) in September 2020, which incorporates GI data, geological maps, boundaries of Scheduled and Designated Areas, etc. The data are freely accessible by the public for commercial and non-commercial purposes. In the future, different kinds of BIM and 3D GIS data can be added to the GEO Data and incorporated into a centralised platform, such as 3D ground objects, 3D photo-realistic mesh models, BIM data, etc.

There will need to be suitable incentives to encourage private practitioners to deposit their own data, as the benefits of data sharing are enormous. The ownership of the information itself and that of the copyright and other intellectual property rights will need to be clearly established before any collected data is deposited on the platform.

There will also need to be guidelines developed for data interpretation: for instance factual data, such as that included in GI reports, serve as a reliable source of information, while models that involve human interpretation of the raw data, should be used for reference only.

It should be noted that, in view of future technological improvement, and issues such as misinterpretation, data loss, etc. making shareable data available in a portal is not a substitute for a professional technical interpretation. The British Geology Survey (BGS) has stated that, '*The data, information and related records supplied by BGS should not be taken as a substitute for specialist interpretations, professional advice and/or detailed site investigations. You must seek professional advice before making technical interpretations on the basis of the materials provided.'* Therefore, some on-site GI will still be essential for many site developments at the detailed planning stage. However, if the GI data from adjacent sites are made available in a convenient format, it will still be worthwhile to develop such a platform as far as costs and time saved in avoiding repetitive GI are concerned.

<u>Overseas reference – UK</u>

Many geotechnical standards and practices in Hong Kong are legacies from the UK. The UK's BGS, a partly publicly funded body, has a close connection with the industry, government, regulators and other academic institutes, and has developed a Centralised Data Platform storing geological data, including borehole data. This is useful as an example for constructing a similar platform in Hong Kong.

BGS produces a wide range of data products on a national scale, such as energy, environmental chemistry, geology, etc. It collects and preserves geoscientific data and information, making them available to a wide range of users and communities.

The web platform "Geology of Britain" currently stores >1 million items of borehole data across Britain. According to the Public Records Act 1958, BGS has statutory rights of access to boreholes drilled to >30m for mineral exploration, and to >15m for water supply assessment. However, the majority of data held are from voluntary deposition. A small percentage of the borehole data BGS hold are confidential and may only be acquired upon written release from the data owner. Under the *Open Government License version 3*, the vast majority of data has no such restrictions and individuals are encouraged to use and reuse the data freely and flexibly.

Figure 5-17 A screen capture of Geology of Britain 3D
(Source: http://mapapps.bgs.ac.uk/geologyofbritain3d/)

In the example shown in Figure 5-17, the locations of all bored holes are stored in GIS format with added depth data, all of which is readily available for users to download for further study purposes.

Once the Centralised Data Platform is constructed in Hong Kong, digitised GI data can made available in a similar way for further usage, such as for foundation design. All the data that can normally be found in a scanned GI report, such as SPT 'N values and type of material, are available in an AGS file. In the following case study, rockhead levels, one of the data items extracted from GI data, is used to illustrate an automated workflow for bored pile design.

Case Study – Integration of BIM and GIS for automated bored pile design
Steps to perform in automated bored pile design:
1. Obtain digitised rockhead level data (CAD format) from ground investigation
2. Integrate piling layout design and rockhead level data in GIS software
3. GIS manipulation to obtain elevations of piles founded on rockhead to create a pile schedule
4. Import pile schedule to BIM software
5. Use scripting plug-in in the BIM software to generate an automatic pile schedule

Caution should be taken when using rockhead level data downloaded from the platform. Such data should be used for reference only and GI will need to be carried out at the detailed design stage to confirm the rockhead levels.

5.5.6. Benefits

The above demonstration highlights the usefulness of digitised GI data in the foundation design process. There is potential to develop more advantages in future.

i. Data platform facilitates data sharing and exchange
A Centralised Data Platform can facilitate users to obtain GI data from different sectors. If there are completed projects at adjacent sites, developers can easily acquire the GI data shared on the platform. Currently it can take up to 1 month for developers to search relevant GI data, but with online data available, time and cost can be saved.

ii. Automatic Design
The use of digitised GI data will allow the foundation design process at the preliminary stage to be carried in an automated way through BIM and GIS. By visualising the pile design in 3D, the number of trial and error exercises can be greatly reduced and the accuracy can be improved.

iii. Contribute 3D design and visualisation to industry
As illustrated in Figures 5-18 and 5-19, a completed BIM model for a piled foundation does not only facilitate 3D design and visualisation by the project owner. It can also be uploaded back to the Centralised Data Platform and increase the completeness of the platform.

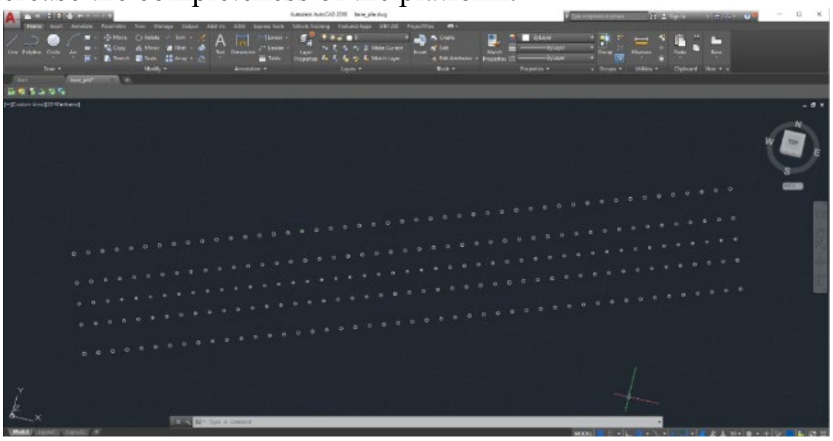

Figure 5-18 Traditional pile design in 2D CAD

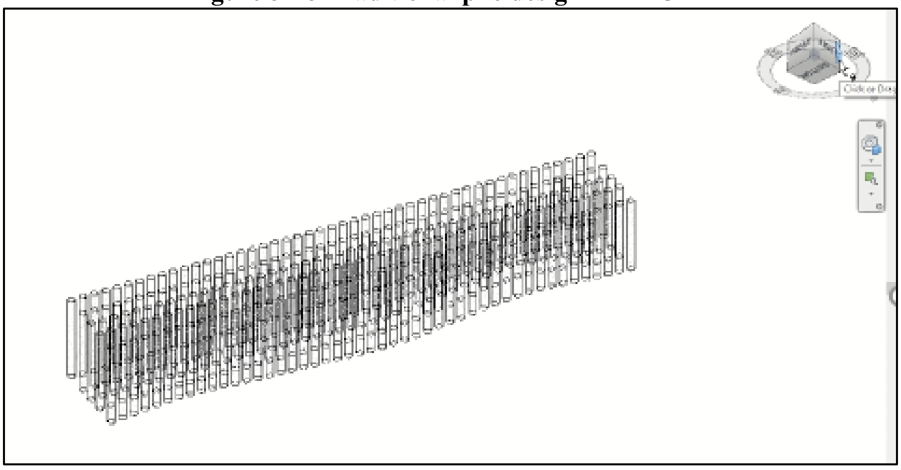

Figure 5-19 Automatic pile design with BIM

5.6. EXCAVATION PERMIT (XP) APPLICATION

5.6.1. Brief Description of XP Application Process

Apart from carrying vehicular and pedestrian traffic, most of the public roads in Hong Kong are used by UtiUs to accommodate their utility services underneath. Road openings are therefore necessary from time to time for the installation, maintenance, repair and improvement of the public utilities underneath.

When the government works departments and other utility undertakings need to excavate unleased land for installation, maintenance, repair and improvement of underground utilities, they are required to obtain the Excavation Permit (XP), either from LandsD or HyD, as the case may be, before commencement of the concerned road excavation works. Prior to obtaining an XP from HyD for making or maintaining an excavation in unleased land which is a street maintained by HyD, in general it is also necessary to obtain a master plan and a land licence from the LandsD for installing utility facilities.

Before submitting an application for excavation works under public roads, the applicant should register the excavation works with HyD, normally through the Excavation Permit Management System (XPMS). XPMS is a web-based system for HyD to administer and control road excavation works electronically. The applicant is required to provide the details of the excavation works for the registration, for example, start date, end date, location, contractor’s contact, etc. Also, the excavation boundary will be incorporated on a 2D map, showing attributes of width, length, depth and area.

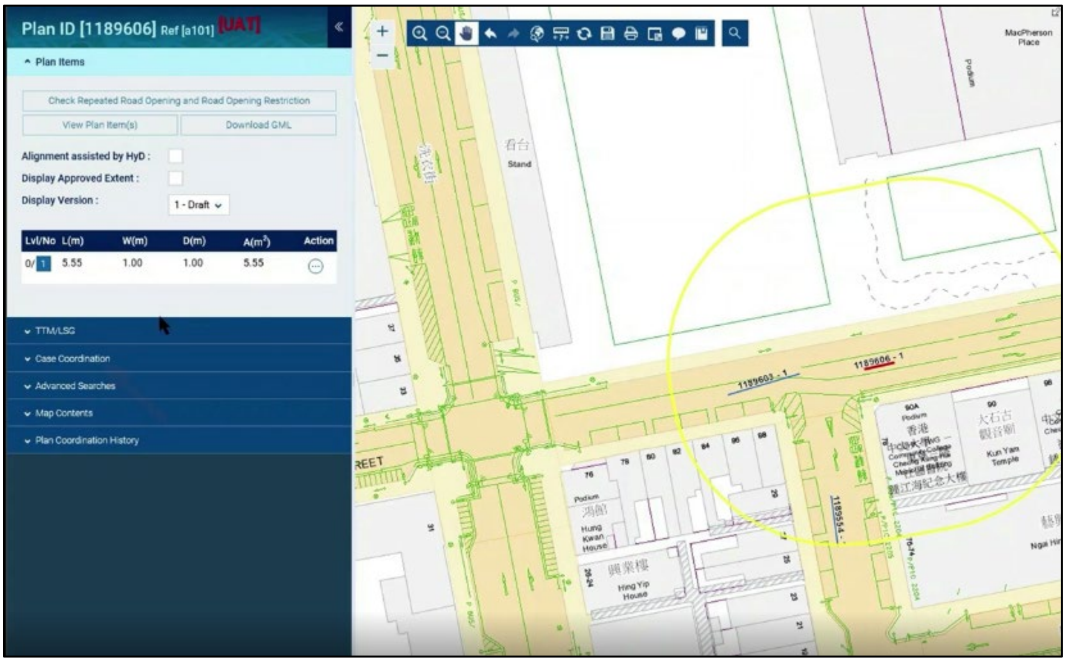

Figure 5-20 The interfaces of XPMS
(Source: https://xpms.hyd.gov.hk/XPMS/xpms/login?locale=en_US)

Figure 5-20 above shows one of the XPMS interfaces, which is for the applicant to register the excavation boundary.

5.6.2. Data Required and Availability

Beyond the available data for underground utilities (refer to Section 5.1.2), the following data as listed in Tables 5-9 and 5-10 are also required for this Use Case.

i. Commonly Required Data

Data	File Format	Obtained from
Excavation Boundary	CAD	HyD
Excavation Depth	TXT	HyD
Excavation Works Start/End Date	TXT	HyD

ii. Available Data that can be used

Data	File Format	Obtained from	Source from
Excavation permit issued (Feature Classes: Polygon)	GML	Download from PSI (Data.gov.hk)	XPMS of HyD
Issued Excavation Permit (Feature Classes: Line)	GML	Download from PSI (Data.gov.hk)	XPMS of HyD
Issued Excavation Permit (Feature Classes: Point)	GML	Download from PSI (Data.gov.hk)	XPMS of HyD
Issued Excavation Permit (respectively for Standard, Emergency Opening, Small Scale Work, Capital Work, and Extension) including Plan ID, Permit Start/End Date, Permit Duration, Location, Length, Width and Depth of Excavation, and Propose of Excavation	JSON	Download from PSI (Data.gov.hk)	XPMS of HyD

5.6.3. Current Constraints

According to Para. 2.3 in Chapter 4 of the Audit Commission Report No. 70 “Government’s Efforts in Managing Excavation Works on Public Roads” (2018) (Audit Report), while the total number of XPs decreased from 13,297 in 2010 to 8,921 in 2016, the number of XPs with extensions increased by 78% from 727 in 2010 to 1,293 in 2016. As a result, the number of XPs with extension as a percentage of authorised XPs increased from 5% to 14%, as shown in Table below and illustrated in Figure 5-21. The average extension period also increased by 90% from 48 days to 91 days during this period

Excavation Type	2010	2016	Remarks
XPs	13297	8921	
Extension	727	1293	78% Increase
Average extension period(days)	48	91	90% Increase
% of XPs with extension	5%	14%	

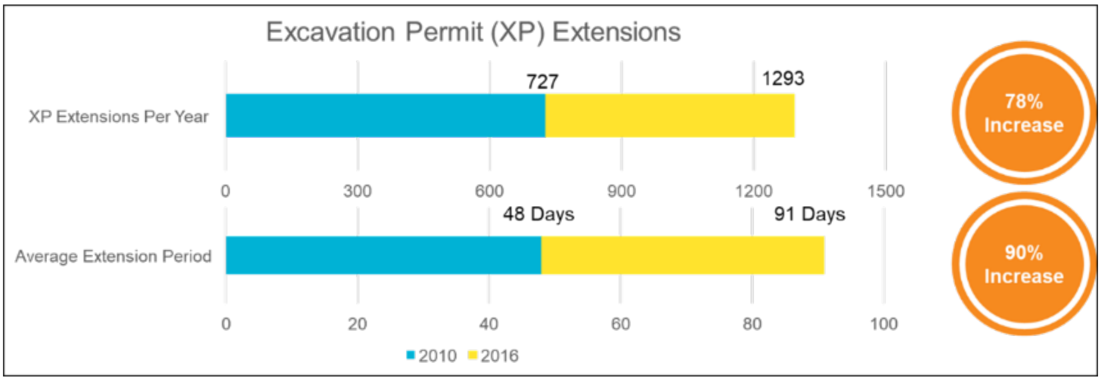

Figure 5-21 XP Extension Status of 2010 and 2016
(Source: Report No.70 of Director of Audit)

According to Para. 2.4 in Section 4 of the Audit Report, the increase in the number/percentage of XPs extended in these 6 years might be attributed to a number of factors, including uncharted underground utilities, unanticipated obstructions, unforeseen rectification works, change in construction methods, delay in material delivery, new site constraints identified, accidents causing works suspension and/or adverse weather conditions. Submissions of a completed and an accurate set of underground utility records by UtiUs, and also carrying out desk study and on-site verification by utility proponents to ascertain the underground conditions for placing the proposed utilities, are crucial to minimise the number of XP extensions.

Figure 5-22 illustrates the statutory control framework in place for utility services. According to HyD, as mentioned in Para. 3.11 in Section 4 of the Audit Report, under the existing control mechanism, there is no documented standard on checking of the detailed alignment and disposition of the system, and it does not require the XP applicants to ascertain and confirm whether the related alignment and disposition of the proposed installations will be in conflict with other existing installations or proposed installations. Para. 3.11 in Section 4 of the Audit Report also stated that the statutory authorities bestowed upon the Director of Highways under the LMPO are to issue an XP which mainly controls conducting or maintaining road excavations to ensure that permittees comply with the XP conditions, such as the minimum depth requirement. While the UtiUs prepare the XP application materials containing the schematic layout, as shown in the master plan drawings and land licence issued by LandsD, HyD will issue the XP for public roads requiring applicants to ascertain the underground conditions before commencement of excavation, with due consideration of unforeseen underground conditions and the accuracy of existing as-built utility records submitted by UtiUs.

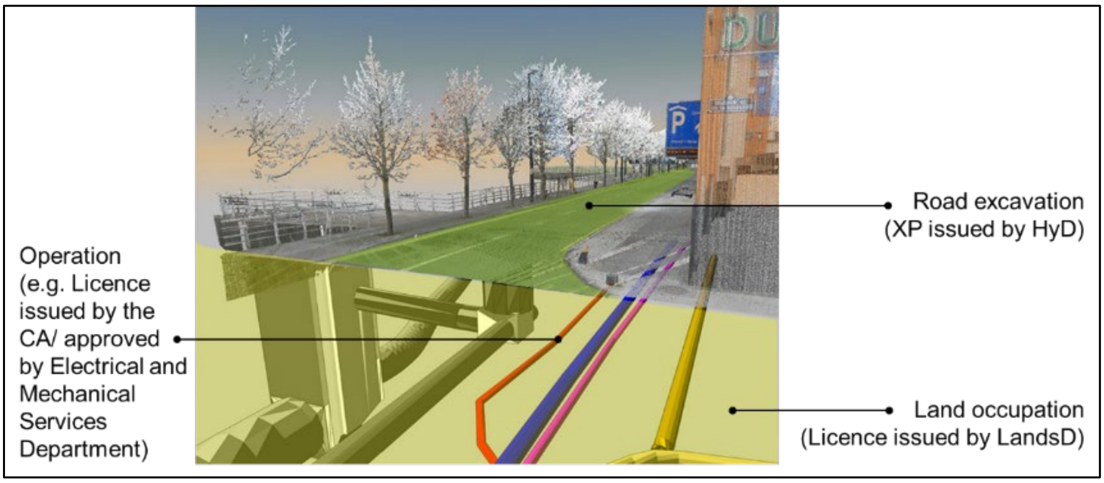

Figure 5-22 Statutory Control Framework for Utility Services

(Remarks: "Licence issued by the CA" is only applicable for some fixed telecommunications services licensed by the Communications Authority (CA). Referring to Figure 4 of the Audit Report, according to theEMSD, only gas pipes operating at high pressures as defined in the Gas Safety Ordinance or liquefied petroleum gas pipes under public roads require its approval.)

However, unforeseen ground conditions and inaccuracy of existing utility records might cause problems for the utility coordination works after road excavation, which may lead to excavation extensions.

5.6.4. Case Study (Figure 5-23)

In order to oversee improvements to the planning, coordination and quality of road works in Scotland, the office of the Scottish Road Works Commissioner was created. The founding legislation envisages that this control will be done by monitoring road works across Scotland, promoting compliance with the legislation, and promoting good practice.

The Scottish Road Works Commissioner is an independent public official who is tasked to improve the planning, coordination and quality of road works throughout Scotland.

The Commissioner monitors performance, promotes and encourages good practice across both utility companies and roads authorities. The Commissioner also has powers to impose financial penalties on roads authorities who systematically fail in their duty to coordinate, and upon utility companies who systematically fail to co-operate when undertaking road works.

It is noted that the responsibility for the day-to-day management and coordination of works undertaken on roads remains unchanged.

Two systems are implemented for the Scottish Road Works Commissioner to monitor the road works. One system is the Scottish Road Works Register (SRWR). It is a central tool for Scottish roads authorities and utilities to assist with planning/ coordination of road works. It stores the sources of data for indicators to determine performance of the undertaking of road works, and also stores accurate sources of information for the public and organisations interested in future, ongoing and past road works. The other system is the Community Apparatus Data Vault System (Vault). Vault is a GIS platform which storres information on UUs. It is a supplement to the SRWR. Historically, Plant Information Requests had been provided, using a combination of proprietary systems such as maps sent by email, access to websites, distributed on CDs containing the data, or on printed paper plans. Vault is intended to centralise this information on the SRWR, adding UU information alongside details of where works are taking place.

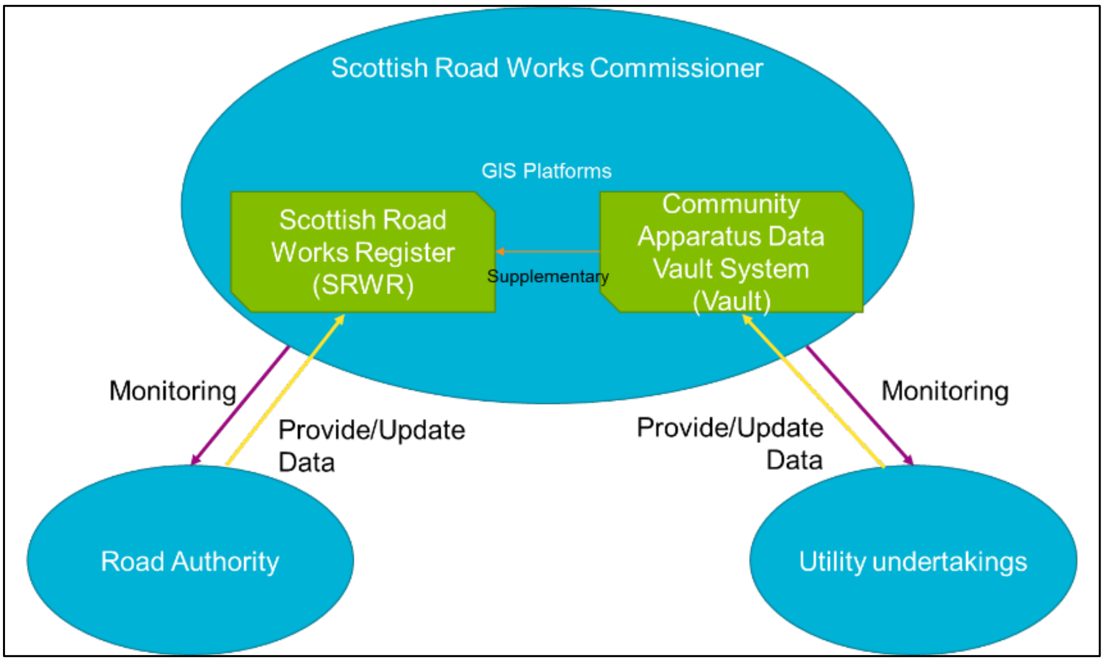

Figure 5-23 The Relationship between Scottish Road Works Commissioner, Road Authority, Utility Undertakings and the two systems

5.6.5. Way Forward

Taking the implementation of the centralised data platform for underground utilities (refer to Section 5.1) as a premise, proposed underground utilities can be overlaid on the 3D underground utilities data from the centralised data platform (mentioned in Section 5.1) to clarify the space occupation underneath. With the adoption of the SRWR and the Vault system, only concerned or related utilities data are accessible and readable alongside where the excavation works are taking place. Thus data privacy and security can be ensured to a certain extent. Ideally, clash analysis as mentioned in Section 5.1 could be performed between the proposed or need-to-be-updated utilities and the existing utilities within the excavated area. Whilst there is limitation on the accuracy of the existing utility records to reflect the actual underground conditions, the use of analysed clash results as a reference for facilitating XP approval is expected to be realised in the long term.

5.6.6. Benefits

For the industry, if the existing underground condition can be referenced through a centralised data platform with accurate UU data in the long term (see Section 5.1 for more details), the potential issues related to utility coordination can be identified in advance, which results in better estimation of road excavation works. As the difficult underground utility condition can be foreseen before excavation works, the UtiUs and contractors can estimate and control the time and budget more easily. Moreover, the number of excavation extensions and the extension period can be controlled or even reduced compared to the present.

For the government, if the road excavation location data could be shared with industry stakeholders via a common data platform, it will be easy-accessible and convenient to monitor the status of road excavation works. It will also help coordination between government works departments and other UtiUs for better management of the underground space.

For society in general, if the possibility of road excavation extensions caused by difficult UU conditions could be foreseen, controlled and even reduced, the road occupation would be released earlier to ease the traffic congestion. As the excavation works are executed on public roads, this would mean less time for road openings and improved safety for the public. Besides, well pre-planned excavation works can reduce the risk of utility damage, especially for gas and electric utility services, which have the potential to cause catastrophic accidents and multiple injuries.

However, achievement of these benefits depends on the availability and accuracy of UU records. It is noted that currently most UU records generally are not kept in 3D format, in particular the depth of the UU. Converting existing UU records to 3D format in a centralised data platform will likely involve various assumptions, including but not limited to the “depth” value. Therefore, the limitations on the accuracy of the centralised data platform built up from deficient records should be borne in mind. The suggested addition of UU records to a centralised data platform should be explored as a long-term goal.

5.7. ENVIRONMENTAL IMPACT ASSESSMENT

5.7.1. Brief Description of Use Case and Sub-Use Case(s)

An Environmental Impact Assessment (EIA) provides information at the planning stage of a project, prior to decision making, on the nature and extent of the impacts of new construction and operation to the surrounding environment.
Where necessary mitigations are planned to minimise and control the adverse impact to the environment. Analysis of alternative designs and selection of improved technology should be taken into account to minimise risks and impacts on the environment and the public.

There are various aspects involved in an Environmental Impact Assessment, for instance, air quality, water quality, noise impact, and landscape and visual impact assessment, etc.

5.7.2. Solution Deliverable Format, Selected Sub-Use Case and Location

<u>Noise Impact Assessment</u>

Noise Impact Assessment was selected as the Sub-Use Case. The Central - Wan Chai Bypass project, along with residential buildings around the area o City Garden, was selected as the location for the study and demonstration. A Microsoft PowerPoint presentation was produced to demonstrate the 3D data required for visualisation of the different elements in the EIA, current constraints, and way forward.

<u>Solution Deliverable Format</u>

An animation was produced to demonstrate visualisation of the noise impact assessment by using 3D data as an example for the Sub-Use Case. Noise sensitive receivers and operational noise pollution sources in the local environment are identified. Block 11 of City Gardenwas selected as the noise sensitive receiver for this demonstration because it is next to the Central - Wan Chai Bypass, as shown in Figure 5-24.

Noise data for the study area was obtained from the Wan Chai Development Phase II EIA report in 2008. Referring to Figure 5-25, the noise data are expressed in decibels (dB) and related to the mPD level.

Noise data were illustrated and modified to a new version to elaborate the current situation and condition. The noise data could be collected from the actual site or from the existing EIA report from EPD.

A Microsoft PowerPoint presentation was used to present the current challenges the traditional EIA is facing, while the way forward for this Use Case was addressed with the utilisation of 3D data. An animation was prepared to demonstrate the impact of different design options for noise barriers to control the respective noise levels at the surrounding buildings.

Figure 5-24 Noise Sensitive Receiver N18A – City Garden, Block 11

mPD Level	Operation Traffic Noise						
	Prevailing Traffic Noise Levels in Year 2008	Predicted Unmitigated Noise Level in Year 2031			Predicted Mitigated Noise Level in Year 2031		
		New Road	Existing Road	Overall	New Road	Existing Road	Overall
13.7	72	73.0	49.5	73.0	54.5	45.2	55.0
24.3	81	78.4	54.2	78.4	55.9	46.7	56.4
37.6	81	77.8	55.9	77.8	57.7	49.6	58.4
50.8	80	77.0	56.1	77.0	59.7	52.9	60.5
64.1	79	76.4	56.0	76.4	61.7	54.2	62.4
77.3	78	75.8	55.9	75.9	64.1	54.4	64.6
82.6	78	75.6	55.8	75.6	64.5	54.4	64.9
Noise Criteria	70	70					

Figure 5-25 Operational Traffic Noise of the City garden, Block 11 from EPD's Wan Chai Development Phase II EIA at 2008

5.7.3. Data Required and Availability

The data required are listed in Tables 5-13 and 5-14 below.

Commonly Required Data

i.

Data	File Format	Obtained from
3DSD (Terrain)	3Ds/FBX/VRML	Purchase from LandsD
3DSD (Building)	3Ds/FBX/VRML	Purchase from LandsD

Project Specific Data
ii.

Data	File Format	Obtained from
Air quality statistics	Statistics	EPD - Download from PSI (DATA.GOV.HK)
Traffic estimates	Statistics	TD
Vehicle Emission data (CO_2 & NO_2)	Statistics	EPD
Human Population data	CSV/GML/XLS	Download from CSD or Geodata Store
Habitat Survey data	Statistics	EPD
Marine Ecology data	Statistics	EPD - Download from PSI (DATA.GOV.HK)
Vegetation map	Statistics	EPD
Hong Kong birds reports	Statistics	EPD
Water Quality data	Statistics	WSD
Sample pollution data	Statistics	WSD

5.7.4. Current Challenges

i. <u>Increasing need of precise future environment forecast</u>

With the increasing pressure on natural assets due to various factors such as climate change, invasive species and cumulative human activities, the demand for precise forecasting of environmental changes is growing. Besides, public awareness of environmental issues and sustainability has been significantly raised in recent years.

ii. <u>Lack of 3D data and environment</u>

Currently there is a lack of 3D data for visualisation due to data usually being recorded in 2D and then locked in a PDF format. Also, there are legal barriers to prevent data exchange between organisations. The absence of data standards and legal requirements for collecting, storing and presenting data also contributes to legal barriers for data exchange between organisations.

Due to ownership and data trust issues, stakeholders are concerned that the data from other organisations has not been validated and could lead to Misinterpretation. This may cause stakeholders to be nervous about using such data. Data from private companies is privately owned and therefore is usually inaccessible for other organisations due to its commercial earning potential. For these reasons organisations may need extra time to gather the primary data required for an EIA.

Moreover, there is currently no centralised data exchange platform for data storage and sharing between organisations. Data from different organisations are widely dispersed between different domains accordingly. As a result, it is difficult to visualise an EIA in 3D without having the specific 3D data required for graphic designers and engineers to proceed. This adds more time and cost to gather information for preparing a 3D EIA and visualisation.

iii. Audience interpretation

EIA reports are currently delivered in 2D paper-based format, which is usually voluminous and written in technical language. The inclusion of much non-essential information in these documents means that it is often difficult to locate the key findings on environmental impacts and recommendations. This can result in the client being unable to process and make decisions based on the report. It is challenging for a non-technical audience (e.g. the public) to understand the technical information and the real environmental impact of a development. Trust between the public and government may suffer accordingly.

iv. Lack of post-construction evaluation and monitoring

Post-construction environmental impacts are traditionally not monitored and data are rarely collected to check whether the predicted effects and mitigations are successful. In such cases *(continue directly)*new EIAs will not be able to improve the performance on prediction and mitigation based on the experience from previous applications. New assessments will then have to start from scratch, which consequently will increase the time taken for the process.

5.7.5. Demonstration of Visualisation with 3D data

3D spatial terrain and building data from LandsD were used to present the terrain and buildings (City Garden) surrounding the Central - Wan Chai Bypass in the demonstration. Road alignments and traffic data for the Wanchai Bypass project were obtained from HyD to demonstrate the traffic situation at the bypass. Noise data were obtained from EPD

According to EPD’s Noise Criteria, noise levels lower than 70dB can be toleraed to humans. The Noise Pollution Index shown in Figure 5-26 was produced to aid in visualising the impact of noise pollution to the building. Figure 5-27 shows the data required for the visualisation in a screen capture of the video.

Noise Pollution Index (db)
0 to 20
20 to 40
40 to 60
60 to 80
80 to 100
100 to 120
120 to 140

Figure 5-26 Noise pollution index

Figure 5-28, Figure 5-29 and Figure 5-30 below demonstrate the three mitigation options developed to reduce the noise impact to the surrounding residential buildings. Coloured contours were utlised to present the noise data in 3D. Options were compared at the end of the video in order to select the most efficient mitigation.

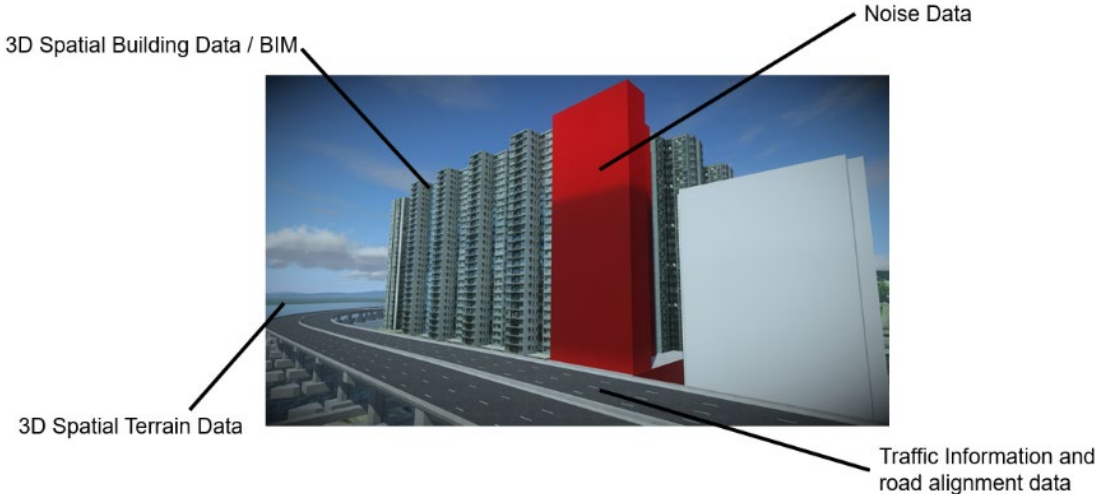

Figure 5-27 Data required for the demonstration

Figure 5-28 Option 0 Unmitigated option

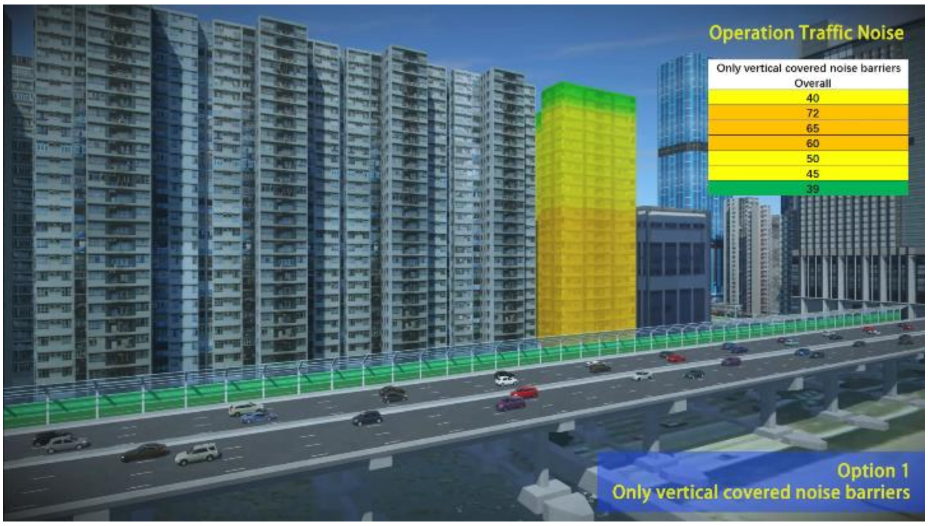

Figure 5-29 Option 1 Only vertically covered noise barriers

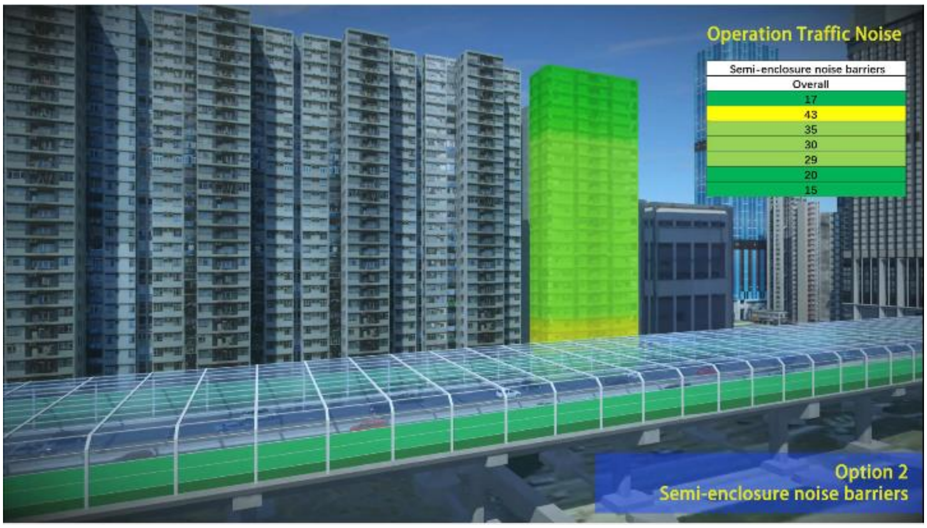

Figure 5-30 Option 2 Semi-enclosure noise barriers

5.7.6. Way Forward

i. <u>Visualisation of EIA</u>

Instead of having traditional paper reports as the final output for the submission, visualisation of EIA aspects can be utilised to present quantitative data, while the paper report can serve as an appendix to the video to provide more in-depth details. The visualisation creates a greater impression and facilitates critical thinking and analysis by the audience. This demonstration was just one example of an EIA visualisation and could readily be applied to other aspects such as Air Quality Assessment, Terrestrial Ecology Assessment and Water Quality Assessment, etc.

ii. Digital Environmental Impact Assessment

A Digital EIA aims to streamline the process of data collection and EIA production with the use of digital tools and new technologies.

a. Centralised data share platform

A centralised data share platform to provide an efficient data flow for a project should be developed whereby all stakeholders can access, contribute and exchange raw data for use in the EIA process. For a shared platform to be successful, it will be essential to show key data information such as source, time of any modification, and data collection method, to ensure the data are reliable for users to use. In order to protect data providers, a disclaimer and statements of terms of use of the platform and the data will need to be established to specify the scope of obligations, rights of data use and to acknowledge users' responsibility in using data from the platform.

Data access levels relating to data sensitivity and ownership restriction should be established to control data access for different stakeholders. Public access should be limited to only viewing the data, while private companies and government can be granted with full access to view, access and modify the data for their own purposes.

For the long term development of the platform, advanced technologies could be applied to further enhance the usage and function of the centralised data exchange. An interactive map with a search engine, timeline bar and multiple layered data sets could be developed to visualise impacts on the map. By selecting an area on the map, specific data will be presented for the selected area. Predictive analysis and assessment could then be carried out with new technologies for new development plans based on experience from previous applications.

b. Digital workspace

Development of a digital EIA workspace in a common working environment would allow real-time collaboration between different stakeholders to collate, model and track progression in EIA projects. In the long term, expansion of such features should be encouraged, with the aim to develop plug-ins tools to assist in the EIA process.

5.7.7. Benefits

The use of Digital EIA would allow better collaboration and engagement between different stakeholders, and help to provide transparency of working and promoting a collaborative culture. It would also enhance efficiency by reducing the time spent on tracking changes. Digital EIA allows better environmental planning, mitigation and modification to be taken into account to reduce adverse impacts on the environment as much as possible in order to achieve sustainable development. In the long term this will play an important role for society as damages to the environment are often irreversible. By making sure that designs are compliant with the environmental standards, the credibility of the EIA process can be maintained, and the likelihood of penalties and costs of remedial treatment and compensation to society could be minimised or avoided.

Development of a digital EIA workspace would enhance the user experience, with interactive plug-in tools to analyse construction impacts on the environment, as well as help with 3D modelling and visualisation.

Visualisation of EIA allows clients to have a better knowledge of the negative impacts of construction on the environment as well as providing a deep visual impression. Moreover, it allows a non-technical audience (e.g. the public) to understand more about the environmental impacts during the consultation stage. It enhances public engagement and serves to generate mutual benefit between the industry and society.

5.8. BUILDING ENERGY MONITORING AND FACILITY MANAGEMENT

5.8.1. Brief Description of Use Case and Sub-Use Case(s)

As the pace of IoT development is increasing, lots of sensors are commonly installed inside buildings for energy monitoring or facility management. The amount of building data available in digital form is increasing rapidly and is owned by the proprietors. However, the use and utility of building information data, such as energy usage and water consumption, is not growing as rapidly, although they were proved to be of great interest to the business and academic sectors in the stakeholder engagement interviews.

The reason for showing a huge interest in the data is that proprietors can examine their building performance (in terms of energy, water, and equipment) by referring to other comparative data at a district/city level. Knowing the data from other buildings can also enable better management of the facility. Car park data is one type of data that is commonly requested. Therefore, having a centralised data platform could strongly motivate the industry, academic bodies, and the government to provide and share their owned data so that more applications can be developed based on a larger database.

5.8.2. Solution Deliverable Format

A Microsoft PowerPoint presentation was produced to demonstrate the constraints and way forward for this Use Case. Local and overseas examples of building energy monitoring and facility management were reviewed.

5.8.3. Data Required and Availability

The data required for this demonstration is listed in Table below.

Data	**File Format**	**Obtained from**	**Description**
3D Building Model	RVT /other BIM formats	The owner of the building	The data can be used for generated a map of 3D building and street view.
3DSD	3DS/FBX/ VRML	Purchase from LandsD	
Ambient environmental data: - temperature - humidity - solar radiation - wind speed - Wind direction	CSV	HK observatory	Weather data at the building location can help to assess the heat demand of the buildings and coefficient of performance of the facilities.

Building environmental data: - temperature - humidity	CSV	The owner of the building	/
IoT sensor: - lift - door - lighting - piping - HVPC. etc	CSV/ SQL sever	The owner of the building	The data contains the measurement of the facilities, e.g the working status (ON/OFF), flow rate, working pressure and temperature etc. It can be used for monitoring and predicting the demand.
Electricity smart meter data	CSV	The owner of the building/ CLP	/
Water smart meter data	CSV	The owner of the building/ WSD	/
Occupant profile data	/	The owner of the building	The feedback and activities from occupants can be used for comfort assessment.

5.8.4. Current Constraints

i. <u>Low incentive on sharing the building data</u>

Due to a lack of incentives, building developers and property management companies would usually choose not to share their data as they are highly concerned about the release of sensitive data and its privacy. Smart meter data, among all the available data, is of greatest concern in relation to the privacy issues. It is theoretically possible to detect occupancy and activity patterns based on load variations at resolutions as low as 10 or 30 minutes, which are common for most smart meters. With the assistance of AI and machine learning, powerful insights could potentially emerge through linking with other data sources, such as social media, IoT data, etc. If there are no regulations or guidelines, in general the public would not want to share their data to third parties. Also, they may consider that the cost effectiveness of providing the data is low since it might lead to increased operational costs for data processing. Also, currently there is no data exchange platform among the private sector, similar to Data.gov.hk, where stakeholders can provide their data and access the data from other building developers.

As a result, most building data currently is used just for monitoring the status of the existing facilities, instead of being applied in analysing trends and patterns to enhance the building performance. Relevant research on building energy assessment at the scale of large, multi-building developments or a district level is, therefore, currently impractical.

ii. Poor data quality – unorganised and unstructured

During the interviews with representatives from the industry and tertiary education, they mentioned that different types of data sources, such as BIM models, building electrical usages, etc., are difficult or impossible to access without the owners' permission due to liability issues. Even if the data source is identified, the data are most likely presented in PDF/picture format, which is inconvenient for further analysis.

As a result, it takes a lot of time to retrieve unstructured and unorganised data, time that could usefully have been used to achieve other research objectives. Also, large unorganised sets of data make it practically impossible for analysts to make accurate predictions regarding energy consumption, thereby creating a thread of poor decisions that have little basis in hard facts.

5.8.5. Way Forward

Centralised Data Sharing Platform

A centralised data sharing platform for building and facility data should be established to facilitate data exchange. The main purpose of the platform would be to facilitate data exchange between Government-to-Business (G2B) and Business-to-Business (B2B). The platform would be based on integrating all relevant building data sources and standardising the data format. The platform should also be capable of anonymising data and establishing several access levels for different users and purposes, such as the government, UtiUs, energy companies, building owners and private companies, to ensure privacy concerns are addressed/ and sensitive data are kept safe.

The platform should allow users to create and save custom peer group datasets based on specific variables, including building types, locations, sizes, ages, equipment, operational characteristics and more. Therefore, it should allow users to explore data across real estate sectors and regions and compare various physical and operational characteristics to gain a better understanding in the overall building performance.

As building data covers many aspects, the platform can be further developed to address some issues more specifically. Based on initial demand from the industry, it is suggested that the following three potential applications can be developed on the platform and used to provide new services.

1. Integrated Facility Management System

Several common facilities, such as lifts, HVAC system, piping system and fire control equipment are necessary in modern buildings. These are usually inspected and maintained regularly by a property management office (PMO). If any facilities are found to be broken or need to be repaired, the PMO needs to contact the maintenance contractors by themselves, which may mean a long time to carry out the repairs.

However, if information and data about the facilities from every building was shared in the platform, such as pumps, pipelines, air-conditioner, etc., estate developers could monitor the condition of several buildings at the same time and in real time. This would make the process of regular maintenance inspections more efficient by saving time and labour. By sharing data on the platform, manufacturers could also access real-time information about the condition of each machine and identify any deteriorated elements, for timely replacement or repair. Operational efficiency would be increased, therefore enabling a facility management company to make the best possible use of the company's resources to offer the best service packages and contracts to its customers.

Sharing building data can help providers reduce the workload in facility management, while requesters can obtain data on real cases to help them improve the product development.

2. Parking Space Finding system or Parking Space Reservation system

Real time parking vacancy data is currently available only within specific buildings in Hong Kong. If a system can be developed to combine car park data provided by different proprietors, drivers could then have access to t real-time information about parking spaces in a district, or even be able to make an online parking space reservation if necessary, for better management of overall spare parking spaces. Also, by combining real-time traffic data from multiple facilities, such a system could be configured to suggest the nearest parking space to drivers and help them to find the parking conveniently. This would reduce the time needed to find a parking space and ease the traffic congestion. The parking space finding system can improve traffic congestion in congested areas. This can also lead to better resource allocation by utilising all available car parking facilities in the same district.

By reviewing the feedback from the industry after the small group discussion, stakeholders like developers are supportive of sharing data about their car park and parking vacancies in a Parking Space Finding system or Parking Space Reservation system so as to optimise the use of car park spaces in their buildings and further ease traffic congestion. One developer further suggested that the shared parking data can be integrated into a mobile application.

However, they are doubts over the feasibility of sharing other data about building energy and facilities. Other representatives mentioned that it is hard to compare building energy profiles if the data comes from buildings with different energy grading levels, which may lead to an unfair result or biased comparison. Another developer added that each company has its guidelines and principles on facility management which affects the format and type of data provided. If the data format and data type have to be standardised to launch a centralised data platform, it may not be feasible for companies to adjust their data to fit the submission requirements.

3. Building Energy Estimation Platform (with algorithm tools)

From the interview results, companies in the construction industry and real estate developers would like to collect and manage building performance data (such as energy or water consumption efficiency) and use this data to inform decision-making strategies. Implementing these policies and programmes, however, requires tools and processes for collecting, mining, managing, analysing, and publishing the data. Industry rarely has the financial and technical resources to develop and deploy these tools. The data exchange platform can potentially be developed into an open-source secure, enterprise data platform for managing portfolio scale building performance data from a variety of sources. The platform could also/ provide data analysing tools for users to compare any two peer groups using statistical or actuarial methods. Selected results of data could then be shared directly with other software tools or public-facing dashboards.

A potentially useful current algorithm is RMV2.0, which is an open-source R package for performing advanced measurement and verification 2.0 (M&V 2.0) on energy saving for Commercial Buildings in the USA. Advanced M&V (AM&V) applications are characterised by: (i) use of energy meter data at very fine time scales with near real-time access; and (ii) processing large volumes of data via advanced analytics, to give more accurate and timely feedback on energy performance and savings estimates. Some key features of the M&V 2.0 are listed below:

1. Able to summarise and visualise smart meter data
2. Create energy consumption baseline models
3. Estimate energy savings
4. Identify potential non-routine events (NRE) in the post-installation period using statistical methodology.

Provision of a variety of energy algorithms tools could create incentives for stakeholders in the industry to share their data, for instance, if a company provides their data they will gain access to the platform to view and analyse other smart meter data.

Consideration

There are 3 primary areas that needed to be addressed when sharing data:

1. Documentation

During the process of gathering the data, the purpose of the data needs to be defined clearly. The importance of data collection is realised only when the data is used for addressing specific questions. Otherwise, data may end up being collected but never used and serves no purpose. Also, the data format and data type should be standardised, such as the format used for meter data and what degree of granularity the data should have. These critical questions need to be solved before sharing data.

2. Infrastructure

The support centre for data sharing can not only serve as the host of the platform, but also provide further support in the practice of sharing. For example, the centre can facilitate data transactions in which data held by the public or private sectors are made available to other organisations (public or private) for use and re-use. The centre can also focus on data security, identification and traceability of data sources, which can assist in ensuring swift implementation of data sharing practices to the benefit of all.

3. Legal Frameworks

A broad system of existing rules govern and regulate data sharing agreements, compliance, and laws, such as The General Data Protection Regulation (GDPR) from the European Union. The guidance states principles to guide contractual negotiations so that markets for IoT data and products remain fair and competitive. Some of the key guidance relates to:

- Transparency in contracts on access and use of data;
- Recognition of different roles in shared value creation;
- Respect for each party's commercial interests;
- No distortion of competition;
- Minimised data lock-ins.

5.8.6. Benefits

For industry, a centralised data sharing platform would greatly improve the current workflow for acquiring t district-level building energy, water consumption data scattered in various sources. It would also ensure that there is only a single source of data, which minimises data redundancy and leads to easy accessibility of the data. In the long term, the platform could facilitate the formulation of predictive and preventive maintenance plans or mitigation measures. For instance, developers, asset owners and facility managers could compare the data from other buildings which share the same characteristics (e.g. Building Type, Gross Floor Area). Through combining building data from different sources, this would assist stakeholders in responding quickly and properly to any changes that may affect their asset, and facilitate comprehensive analysis of their building in terms of energy performance and facility maintenance.

For the government, collecting data from the industry via a centralised platform could provide more updated references and facilitate better strategic planning, such as town planning and promotion of smart city or smart community initiatives.

For university researchers, data sharing would allow users to build upon the work of others, rather than repeat already existing research, which could lead to important new findings within the field. Sharing data would also enable them to perform meta-analyses at a district level during policy development or construction planning.

5.9. AIR VENTILATION ASSESSMENT

5.9.1. Brief Description of Use Case and Sub-Use Case(s)

Air Ventilation Assessment (AVA) involves estimating a wind velocity ratio *(VR has a different definition in the List of Abbreviations)* which is an indicator of wind performance, comparing the wind velocity at 2m above ground level with the wind velocity captured at a height without any impact from natural terrain and urban buildings, typically around 400m to 600m above the project area. The aim of applying AVA is to simulate the effect of regional air ventilation by visualising the air flow/wind speed in an area before and after proposed buildings at the planning and preliminary design stage. AVA facilitates selection of the location and the design of proposed buildings in a concerned area for development or redevelopment proposals.

According to the "Technical Circular No. 1/06 on Air Ventilation Assessments" jointly issued by Housing, Planning and Lands Bureau and Environmental, Transport and Works Bureau in 2006, the Government will take the lead to apply AVA in all major government projects which may have major impacts on the macro wind environment, including public housing projects, planning studies for new development areas and comprehensive redevelopment areas, preparation of new town plans, and major revision to town plans. Quasi-government organisations and the private sector are also encouraged to apply AVA to their projects on a voluntary and needs basis. For private developments, the private sector would usually conduct and submit AVAs to support their planning applications under the Town Planning Ordinance, to demonstrate that the proposed development would not bring about adverse air ventilation impacts to the pedestrian wind environment. AVA is also adopted as a criterion to earn credit in BEAM Plus Assessment and as an alternative approach for complying with the Sustainable Building Design Guidelines (SBDGs).

5.9.2. In general practice, there are two ways to perform quantitative AVA. One is by using a wind tunnel experiment, which is costly but strongly recommended in AVA guidelines Another is to use Computational Fluid Dynamics (CFD) methodology, which is more preferred by wind engineers and a convenient approach compared to a wind tunnel test. However, the preparation work for inputting raw data into the CFD model (such as Ansys Fluent) is extremely time-consuming Solution Deliverable Format, Selected Sub-Use Case and Location

A Microsoft PowerPoint presentation was produced to demonstrate the constraints, way forward, and potential application for this Use Case. Building footprints and spot heights of the Yau Tsim Wong district were applied to conduct CFD simulations using the Ansys Fluent platform. The outcome was illustrated as a wind velocity ratio contour map (2D).

5.9.3. Data Required and Availability

The data listed in Table below were compiled from the stakeholder engagement sessions. The basemap data can be ordered from LandsD, and wind data can be retrieved from a site wind availability website. However, building information and reports on new buildings under development may not be readily available, as building design may not yet have been confirmed and there are also confidentiality considerations.

Data	File Format	Usually Acquired From (Govt Project)	Usually Acquired From (Private Project)
iB1000 (Topographic Map)	CAD/GDB	LandsD	Purchase from LandsD
Building Height	SHP	LandsD	Purchase from LandsD
Building Outline + Height of under development projects	PDF/CAD	Project Owner	Project Owner
Site Wind Availability	JPG	Download from PlanD’s website	Download from PlanD’s website
AVA Projects’ Location & Report	PDF	Download from PlanD’s website	Download from PlanD’s website

5.9.4. Current Constraints

i. <u>Data Collection</u>

AVA involves a large number of datasets received among different sectors. Wind engineers need to communicate with different data providers to consolidate the data, including footprints of existing buildings and approved developments and topographical features within approximately at least 600m from the centre of the project area.

Normally, almost all existing building data in the form of 2D CAD building drawings and building heights can be ordered from LandsD by filling in a data request form project by project, regardless of project nature. For government projects, provision of the data is free of charge while commercial projects need to pay for it. For some planned and committed development, wind engineers may need to collect footprints/layouts of the building in 2D CAD or PDF (under development) from developers, but this is on a voluntary basis. As not all developers are willing to share their design layout the building layout may be not yet be confirmed and there are also confidentiality considerations. Besides, there is no easy-access platform to upload project data and update project information once there are any changes. Wind engineers often find it is difficult to access up-to-date information.

ii. Raw Data Pre-processing

After wind engineers receive datasets, time-consuming data pre-processing is necessary before the data are ready for CFD model input. In this Use Case, a CFD model (i.e. Ansys Fluent) is used to conduct the air flow simulation.

Building footprints of approved development areas, if received in PDF format, mean that wind engineers have to digitise and generalise the building outline with reference to PDF. If the data are received in CAD format, wind engineers just have to generalise the building footprint, as in terms of balancing time-cost and accuracy of results, for AVA detail of building footprints does not usually have much of an impact on the outcome of air flow simulation. As-built building data are generally received in 2D CAD format, and wind engineers just need to simplify the building outlines. After the simplification process, as illustrated in Figure 5-31, the engineers extrude each 2D building outline into a 3D building block manually based on its height.

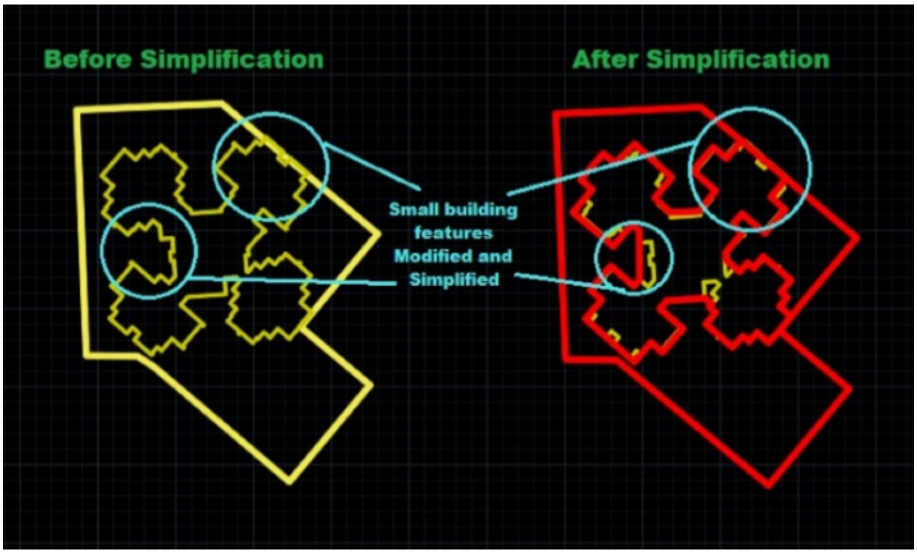

Figure 5-31 Simplification Process of building outlines

Another major CFD model input are contour lines demonstrating the shape of the natural terrain affecting the assessment site. Wind engineers extract spot heights from B1000 survey maps as formatted point data, e.g. x, y, z values, generate contour maps up to 2m-5m resolution in Surfer with an interpolation method, and final data input to the CFD model (e.g. Ansys fluent) is in the form of excel/csv values.

Overall, it usually takes around 2 weeks for a wind engineer experienced in data pre-processing to finish the data preparation process for a project size similar to the Yau Tsim Mong district.

iii. Wind Data

Wind speed, wind profiles and turbulence profiles are needed as inflow profiles to the CFD model. The site wind availability web platform currently provides data in JPG format, which needs further interpretation before it is compatible with air flow analysis software, e.g. as illustrated in Figure 5-32 wind engineers need to interpret wind roses of annual, summer and winter data into wind speeds in 4-directions in excel or csv format, which is then readable by machine and makes it easier to perform further calculation.

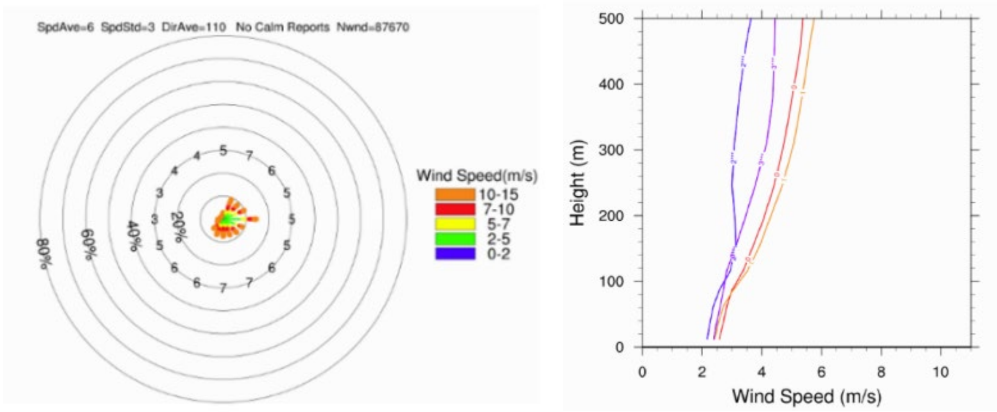

Figure 5-32 Wind Rose and Wind Profile. An additional process may be done before AVA CFD modelling, consisting of splitting wind data into small grids (typically 1000m x 1000m per grid) covering the whole territory of Hong Kong. Due to variation in the size of project sites, the wind data for certain large-scale projects covering several small grids may also have to undergo averaging procedures.

iv. AVA Project Data Sharing

According to the Technical Circular No. 1/06, PlanD maintains an AVA register open for public inspection, as illustrated in Figure 5-33. While PlanD will call for returns of AVA reports from government departments/bureaux at quarterly intervals, consent from private or quasi-government project proponents should be sought in order to release information contained in their AVA reports for public inspection. Therefore industry stakeholders sometimes find it difficult to obtain information from relevant projects which had not been disclosed due to confidentiality issues or lack of consent from private/quasi-government owners. Some private developers are inclined to not release AVA final reports unless it is a statutory requirement from the relevant authorities, or there are incentives that favour their development or business conditions. Moreover, since project locations are shared in pdf format, without spatial locations being shown on a common mapping platform, engineers are unable to search projects by defining a distance away from the assessment site for early-stage research or initial study, leading to difficulties in desktop review and early-stage work preparation.

It is suggested that development of a user-friendly centralised data sharing platform, accessible by both government and non-government sectors to upload their data, would be good to facilitate project information sharing.

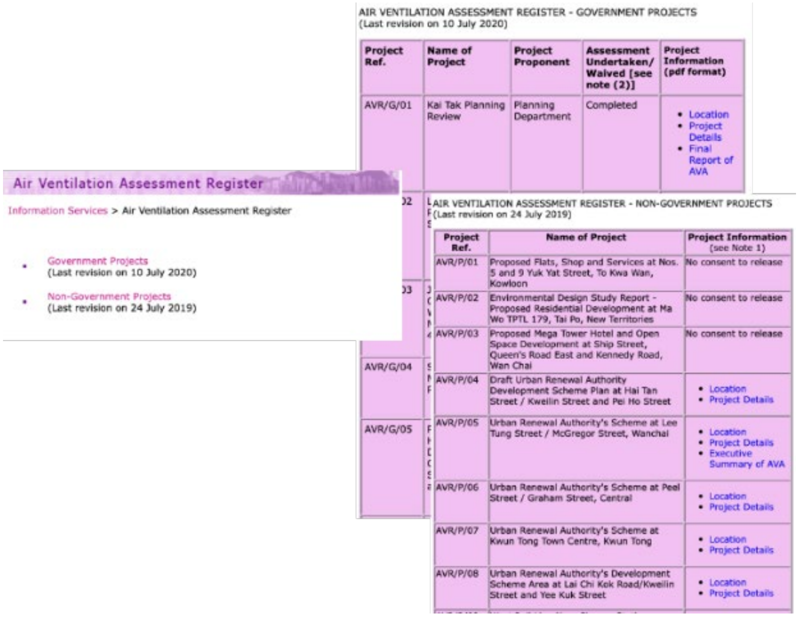

Figure 5-33 Air Ventilation Assessment Project Registry

5.9.5. Way Forward

i. <u>Comprehensive Data Sharing Platform</u>

It is recommended to set up a central platform for AVA to expedite data acquisition and data pre-treatment procedures. The purpose of the platform should be to act as a central repository to store/archive wind data, and approved AVA project information, and integrate the data with spatial 3D buildings and topographic features from the coming CSDI via an API map service. With such a platform, wind engineers could easily download or acquire the necessary data for AVA by area of interest.

The platform should provide a user-friendly interface to allow government departments and property developers, and project owners of AVA, to upload and update AVA project information for on-going projects. The ability to update the project layout continually, once any changes are made, would ensure that data downloaded to conduct a new AVA is up-to-date. It is suggested that relevant departments could assist in hosting the website.

With such a central repository, engineers working on government or non-government projects could easily conduct desktop review and summarise co-related project considerations by searching the platform for data on projects in the vicinity of the current study area. This process is illustrated in Figure 5-34.

Figure 5-34 Potential Application

ii. Enhanced Industry Guidelines

In the past decade, extensive AVA studies have been conducted using CFD and wind tunnel experiments, with these two approaches often supplementing each other, when referring to the guidelines stated in the AVA Technical Circular.

The best practice guidelines, and wind simulation CFD methods and potential platforms (e.g. ANSYS Fluent, AutoCAD CFD and SolidWorks Flow Simulation) have undergone rapid developments in the past ten years, and many successful studies have examined wind engineering problems using both CFD and wind tunnel experiments. This implies that both methods are now in a mature state of development and are supported by up-to-date international guidelines for performing air ventilation studies.

Although the content of the current Technical Circular is grounded in existing research, there is room to review and update the technical requirements for CFD modelling by taking into account the latest technological enhancements. Some potential refinements and improvements have been suggested in the report titled “Urban Climatic Map and Standards for Wind Environment”, which documented various suggestions, such as the inclusion of wind performance criteria for AVA studies in Hong Kong, provision of a set of standard site wind availability data, and informative documentation of the model settings for AVAs via CFD modelling. Moreover, one of the major challenges for carrying out AVA studies in Hong Kong is due to the high-density of tall buildings and complex topographic conditions, which differs from the cases usually analysed in other countries, where buildings are usually low rise in nature and located in relatively flat terrain. Therefore, it would be helpful if localised practice guidelines could be produced specifically for modelling steep terrain (i.e. terrain extent, resolution etc), and included in a future update of the AVA Technical Circular.

The above-mentioned way forward should be considered during the next review of the AVA Technical, with the aim of putting forward a refined and more complete circular for the industry to follow.

After comprehensive market research, it should be practical to develop a centralised platform for project data sharing, including model data (e.g. buildings in CAD format, terrain) and wind profile parameters, and the data shared in a compatible and digital format. This would greatly save the time needed for data pre-processing in CFD models for AVA studies and smooth the project process.

5.9.6. Benefits

Development of a comprehensive data sharing platform would be very effective in timesaving for data collection, data pre-processing and early stage project research. Spatial data and wind data relevant to a new assessment site could be downloaded from the website platform, which would save time in consolidating data from different providers and ensuring that it is up-to-date. It is envisaged that access to a centralised data sharing platform would save at least a (fifth, i.e. 20%/) of the time needed to conduct a typical AVA.

Knowledge sharing among government and private sector companies would also be enhanced as the related parties could access historical or on-going project information through the data sharing platform. Participating engineers would then better understand the known or reasonable assumptions and considerations made in assessments carried out for other projects, and this would contribute to greater consistency in urban design.

5.10. PREMIUM ASSESSMENT AND PROPERTY VALUATION

5.10.1. Brief Description of Use Case

Land premium is one of the most important sources of income of the Hong Kong Government. It comes mainly from land sales, lease modifications and land exchanges. Developers or customers are required to pay this charge when they purchase a property or a piece of land.

The market value of a property is estimated mainly by comparing the information and recent transactions with those of similar buildings in the neighbourhood. Valuations are repeated from time to time as the price of property in Hong Kong is fluctuated.

5.10.2. Solution Deliverable Format and Location

A Microsoft PowerPoint was produced for this Use Case, using an embedded video to show a mock-up for one of the ways forward for property valuation. The demonstration area chosen is near Kowloon Bay, as the whole Kowloon East area will be developed strategically to become another Central Business District in Hong Kong, including the establishment of new and major housing estates and redevelopment of the Kwun Tong area.

5.10.3. Data Required and Availability

Various reference data are required for the industrial practice of land premium assessment and property valuation. These data come from different organisations with different file formats as shown in Table below.

Data	File Format	Obtained from
iC1000 (Land status plan) with Lot Boundary	FGDB / DGN / XML	Purchase from LandsD/ View boundary, PRN and lot number in GeoInfo Map
Construction cost (unit rate per sq. metre on Gross Floor Area)	PDF	Request from ArchSD for government projects
Ownership Information, Building name, Transaction Record & Lease conditions	HTML / PDF	Purchase from LR
Plans (sale and purchase, assignments etc) – Black and white, Colour	PDF	Purchase from LR for government projects
Saleable Area, Building Age, Permitted Use and Rateable Value	PDF	Purchase from RVD but Rates / government rent payers can obtain the Saleable Area of their own residential property from the PIO free of charge.

		(Data owner for building age and permitted use: BD)
2D Floor Plan	Scanned TIFF/ PDF for GBP (PDF for minor works)/ Image	Purchase from BD / View from Property Agency websites
Copy of issued Occupation Permit (including temporary OP, if any) for existing and new buildings	PDF	Purchase from BD
Construction cost of development and buildings as provided by private owners/developers	CSV	BD's Monthly Digest Download from PSI (DATA.GOV.HK)
Date of commencement of foundation and super-structure building works for development sites	CSV	BD's Monthly Digest Download from PSI (DATA.GOV.HK) for superstructure works for private projects; Request from BD for foundation works
Census Data	GML/ XLSX / CSV	Download from CSD or Geodata Store
Boundaries of Constituency Areas (for Population By-census)	GML / GeoJSON / SHP	Download from Geodata Store
Permitted site coverage and plot ratio	Textual	Can be checked under First Schedule of Building (Planning) Regulations Cap 123F Approved GBP from BD's BRAVO for private development sites
Outline Zoning Plan (OZP), Maximum building height value	SHP / GeoJSON / GML	PlanD's Digital Planning Data website
Short Term Tenancy (STT) Boundaries & Conditions	XLSX	View boundary and download attributes from GeoInfo Map
Project Specific Data		
Special condition of the property	Textual report	Research
Nearby development plan/news	Textual report	Research

5.10.4. Current Constraints

i. Scattered data

In total, land or property owners have to go through three different online systems to inquire, purchase and obtain details about their properties.

When users look for information about a land/property, they need to first search by lot number on the GeoInfo map to get the boundary. As the location and boundary of the properties kept in LandsD does not directly link with the information stored in the Land Registry (LR), the GeoInfo map redirects users to IRIS established under the LR to search and purchase copies of the land register and land documents. Thirdly, further property information like building age and permitted occupation purposes can be purchased separately from the Property Information Online (PIO) system set up by the Rating and Valuation Department (RVD). This is done by searching the development/building name, street/village name and building number, lot details, assessment number, or LR's Property Reference Number (PRN) as shown in IRIS. Overall this is a tedious procedure to acquiring the data from various databases.

ii. Limited attributes and non-spatial data viewing in current online property valuation tool

It is not uncommon for the public or professionals to obtain an initial property valuation using an online bank property valuation tool. By searching the address or the name of building, these tools can usually provide an initial property valuation, together with gross floor area (GFA), saleable area and property age, as shown as Figure 5-35 below. However, since only a few items of information are listed on the bank valuation tool, the public or professionals will also need to visit several estate agency websites for more details about the estate, building or apartment, floor plans, photos, etc.

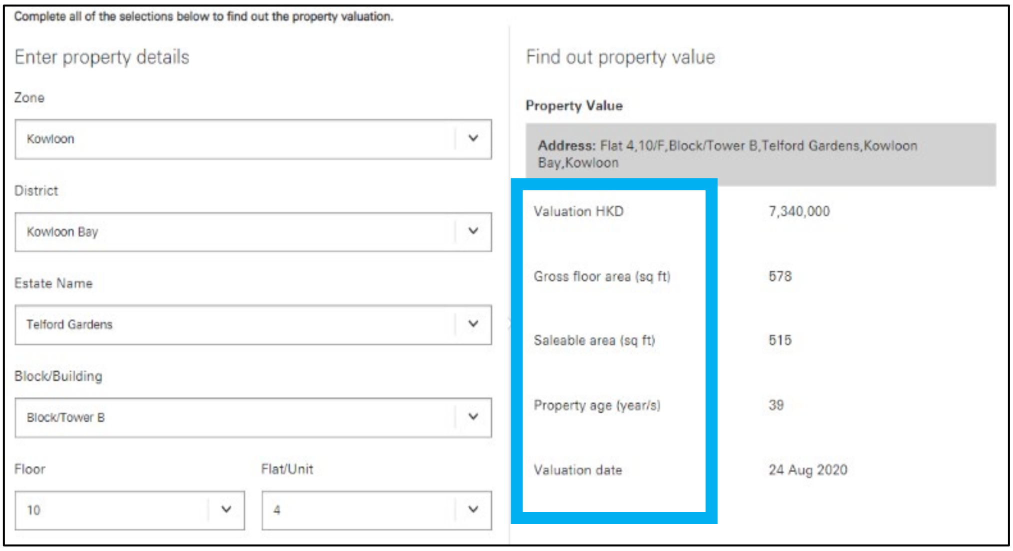

Figure 5-35 Example of the interface in one of the online property valuation tool

In addition, most of these online tools provide property searching by a street address or by a unique lot number, and only some provide 2D map viewing. With the recent advancement in digital technology, there is greater potential for valuers and the public to visualise the nearby neighbourhood and understand the spatial relationship between their properties and other places with 3D visualisation.

5.10.5. Way Forward

i. 3D GIS Web Property Information Platform

A 3D GIS web property information platform should be established to integrate information on property boundaries, individual property details and the neighbourhood. LandsD Map API can serve as a 2D base map, while 3D Spatial Data from LandsD or 3D photo-realistic buildings from PlanD can be used when viewing in 3D.

Furthermore, for enhanced functionality in this platform, basic 3D viewing, searching, and displaying of photos and floorplans should be supported. It is suggested that the "search by address" function should also provide options for other address formats, one of which could be to align with the standardised Geo Address format to be provided by CSDI. Analytical tools, for instance sunlight and shadow simulation, and view shed analysis can also be provided for potential consumers, buyers and valuers to have better visualisation.

The following series of images illustrated in Figure 5-36 demonstrates the proposed 3D GIS web property information platform. It contains layers of the population density by constituency area obtained from CSD, and lot boundaries from iC1000 from LandsD. When a particular lot is selected, attributes like lot number and PRN should also be displayed and users could add respective LR and RVD data to a shopping cart for batch purchase later in the same platform. To further reduce the procedures for acquiring data, it is suggested that these data can be made freely accessible to the public.

Users of the platform should be able to view the surrounding neighbourhood in 3D. When a building is selected, information about the estate, if any, and the building would be shown, together with an estate layout plan and building floor plan obtained from real estate agencies. Further details of single apartments, such as photos of the interior, floor area, etc., can also be displayed when the floor and flat details are entered in the platform.

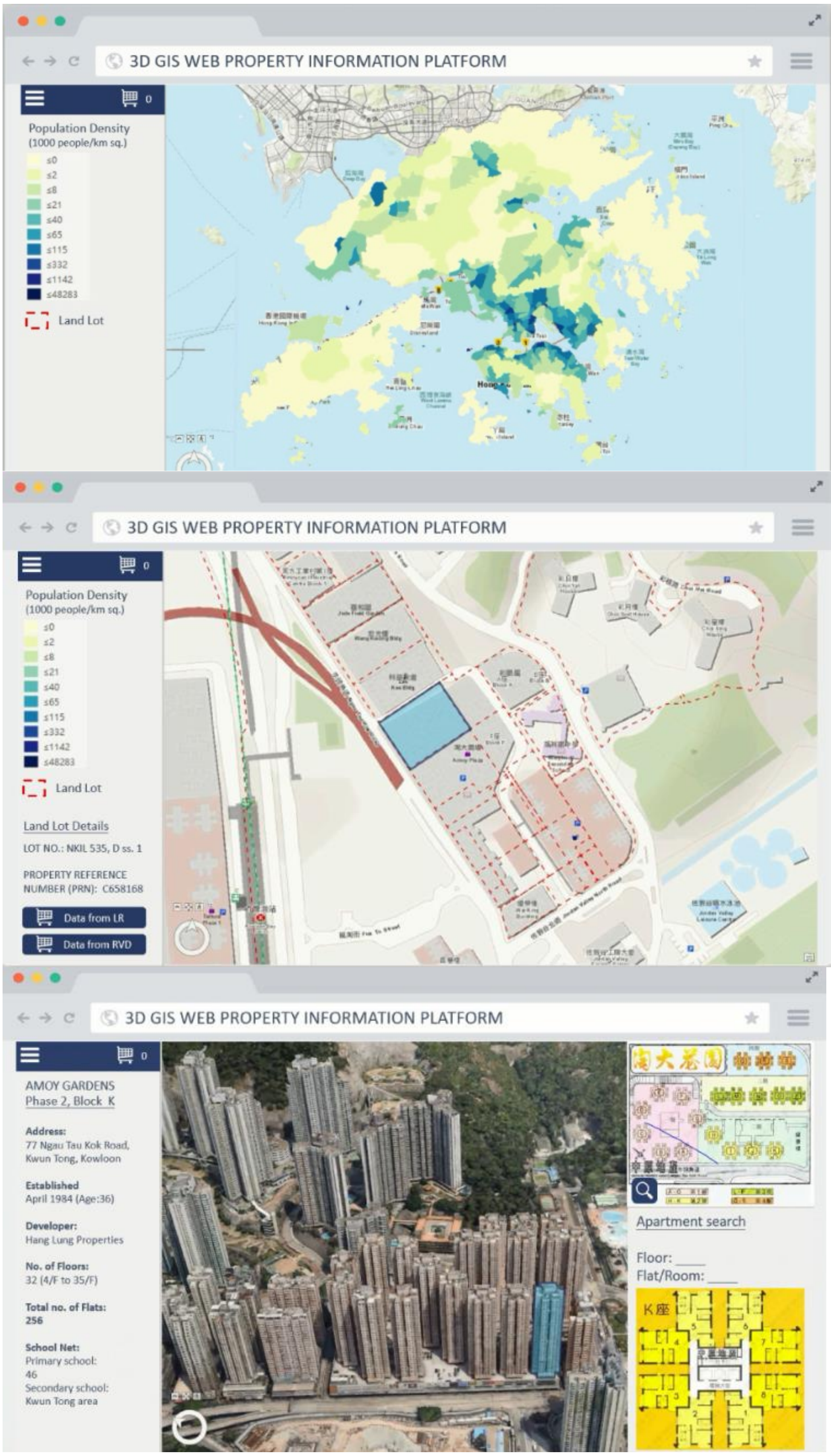
3D GIS WEB PROPERTY INFORMATION PLATFORM
Population Density
(1000 people/km sq.)
≤0
≤2
≤8
≤21
≤40
≤65
≤115
≤332
≤1142
≤48283
Land Lot
3D GIS WEB PROPERTY INFORMATION PLATFORM
Population Density
(1000 people/km sq.)
Land Lot
Land Lot Details
LOT NO.: NKIL 535, D ss. 1
PROPERTY REFERENCE NUMBER (PRN): C658168
Data from LR
Data from RVD
3D GIS WEB PROPERTY INFORMATION PLATFORM
AMOY GARDENS
Phase 2, Block K
Address:
77 Ngau Tau Kok Road, Kwun Tong, Kowloon
Established
April 1984 (Age:36)
Developer:
Hang Lung Properties
No. of Floors:
32 (4/F to 35/F)
Total no. of Flats:
256
School Net:
Primary school:
46
Secondary school:
Kwun Tong area
淘大花園
Apartment search
Floor:
Flat/Room:
K座

Figure 5-36 Series of figures showing the demonstrations of a 3D web property platform

<u>Considerations</u>

To avoid or reduce concerns over privacy issues, access levels should be set up for different users. For instance, the public, professional valuers and surveyors could use the platform freely for basic information, and then obtain LR and RVD data in the same platform upon purchase only. On the other hand, government users including LandsD should observe the "need-to-know" principle in accessing more sensitive information, such as tax records. The exact details of access levels should be subject to data owners' and relevant departments' considerations.

It is noted that some data provided in RVD's PIO, for instance building age and permitted use, are owned by BD. Therefore, communication across different departments and authorities will be needed on data access, sharing and revisiting related data sharing guidelines.

LandsD, LR and RVD plan to integrate their data for the public to have easy searching for graphical location and basic property attributes. Other than releasing datasets on a joint platform, which may take some time to arrange given the above considerations, RVD is also developing a hyperlink between the PIO and the GeoInfo Map of LandsD, with a view to providing an alternative path for the public to access the PIO data quickly and efficiently. The hyperlink enhancement work is targeted for completion in the 4th quarter of 2021. It is a positive sign that the constraints currently faced by stakeholders during the process of property estimation and land premium assessment can be alleviated soon.

ii. 3D Cadastral System

The long-term way forward for this Use Case is to establish a 3D Cadastral system. A general cadastral system should include details of the ownership, legal status (private and public) and tenure, dimensions, boundaries and areas of all land parcels/polygons.

In a 2D cadastral system, the registration of a land polygon is limited to representing stratum/common ownership, especially in densely built-up areas like Hong Kong. This is similar to viewing an object in plan view only, and the complexity of both the structure and the attributes that vary by levels are overlooked. It requires time and expertise to read and interpret such 2D cadastral maps, which often leads to disputes. On the contrary, a 3D cadastral system is based on parcels which can overcome this limitation, and can cater for more sophisticated architecture and large-scale underground infrastructure development in the future. Figure 5-37 below shows a prototype of a 3D cadastral system.

Figure 5-37 Prototype of a 3D cadastral system in Europe

(Source: The University of Melbourne)

From the small group discussion, stakeholders like developers and associations are supportive of establishing a 3D cadastral system as it is time consuming to carry out land survey for each project to generate plans in different levels for land grant application. The HKIS further suggested that the current 2D lot boundaries should be shared on CSDI for a short-term implementation. The government departments also support the developers and associations to share their information, such as sales price, lease information, management fee, usage, etc, at a 3D level in the platform.

Case Study – Singapore

Singapore is similar to Hong Kong in terms of land area, population, and the complexity of strata ownership. In addition, compared to other jurisdictions like Victoria in Australia and The Netherlands, Singapore has more emphasis given to underground space in their 3D cadastre framework, which is more similar to the Hong Kong urban context. Hence, Singapore was studied for reference in this Use Case to understand their Government plans and actions taken to develop a 3D cadastral system.

As shown in Figure 5-38 below, their 3D cadastral system enables overlapping and interlocking lots to be displayed and visualised at the same time, such as air space lots, land lots (surface parcel), and subterranean (underground) lots, etc.

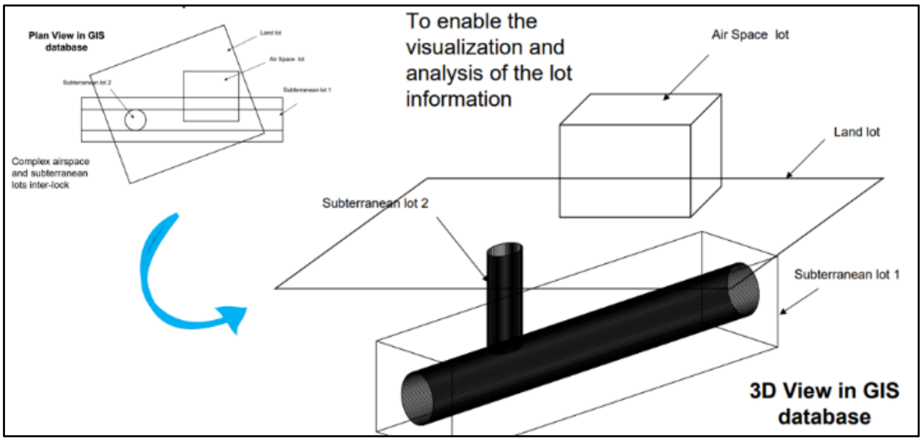

Figure 5-38 Different types of lots covered in the Singapore proposed 3D cadastral system
(Source: Singapore Land Authority)

The Singapore government has organised several rounds of consultation to raise stakeholders' awareness. By conferring with surveyors, developers and other related agencies, valuable information On the current industry practice and concerns have been collected. Workshops for Registered Surveyors are also being held to brief them on the common errors encountered, with a view to avoiding similar mistakes during future job submissions.

The Singapore Land Authority already had an implementation plan as far back as 2011. The first phase involved a feasibility study and data and requirement gathering; and the second phase was a pilot project, in which an initial small-scale implementation was used to prove the viability of the project idea. The third phase was intended to be the full system implementation, to include data conversion, system development and business process change[4].

In 2019, the legislation framework leading to the establishment of the 3D cadastre was revisited, while the technological aspects were under further investigation. The SG LandXML is a file format for cadastral submissions that has been tailor made to suit the local context. It is currently expected to have 3D parcel representations in SG LandXML and in 3D PDF within a few years. Procedures for spatial validation for 3D parcels will also be established. The submissions required from Registered Surveyors at various development stages

[4] Khoo, H. S. V. (2011) 3D Cadastre in Singapore. 2nd International Workshop on 3D Cadastres by International Federation of Surveyors (FIG). Retrieved from https://www.fig.net/resources/proceedings/2011/2011_3dcadastre/3Dcad_2011_40.pdf

will cover the entire lifecycle of a land parcel, instead of only at final stage as adopted by some other countries[5].

Considerations for Hong Kong

The recommendation to develop a 3D cadastral system is aligned with the development of digital Hong Kong as it is one of the long-term projects for LandsD. 2.5D data are currently stored in the LandsD database. Other than taking reference from overseas experience, international standards related to geospatial data and guidelines, such as ISO 19152 Land Administration Domain Model (LADM) and ISO 19131 Geographic Information, should also be referred to and applied in the local context.

Extensive local research and stakeholder engagement sessions will be needed to address the legal/statutory issues, including revision of the laws and regulations to support 3D, the extent of legitimacy and authoritativeness of the 3D model and system, transformation from an informal to a formal (i.e. legally binding) registration process, method of interpreting and visualising 3D digital models into the legal boundaries and physical boundaries, and much more.

Technical issues including data format, specifications and drawing practices will also have to be studied and developed to accommodate the complex land ownership in Hong Kong, for instance analysis and testing will be needed to decide whether to adopt LandXML, LandInfra, or another standardised file format, or to tailor make a new one for Hong Kong. There will also be some basic but time-consuming procedures, such as to digitising scanned PDFs of old building layout plans to vector files. The concept of Level of Detail (LOD) in 3D registration of parcels, and the BIM standards and format like CityGML would also need to be studied. Guidelines focused on the whole 3D registration lifecycle practice are also needed, especially to transfer BIM data at the design and construction phases into as-built, validated 3D data with legal status that can be registered in the cadastre. Last but not least, development of the central delivery and sharing platform for the cadastral data, for example in a web portal with functions such as cross-sectioning, indoor viewing, etc., would require making prototypes and extensive testing.

As technical advancements in BIM and GIS may be able to resolve some of the legal concerns, research on both aspects in parallel is needed to develop better practices and to explore new options.

[5] Stoter, J., Ho, S., & Biljecki, F. (2019). Considerations for a Contemporary 3D Cadastre for Our Times. ISPRS - International Archives of The Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-4/W15, 81-88. doi: 10.5194/isprs-archives-xlii-4-w15-81-2019

5.10.6. Benefits

3D GIS Web Property Information Platform

There are numerous potential benefits to be derived from developing a 3D GIS Web Property Information Platform. For the public and industry, such a one-stop service should greatly enhance efficiency in acquiring government data, and simplify the data acquisition process.

Use of a 3D GIS digital base map should help significantly in visualising the location and orientation of properties. Better understanding of an individual stakeholder's properties should facilitate making valuations of other similar premises, for both commercial and residential properties.

For the government, this platform could uplift the accessibility and transparency of land records by linking land boundary information and LR information directly, and improving access to high-quality and up-to-date land records. Valuers should then be able to carry out premium assessments more easily and more accurately. Also, shorter times will be needed to deal with public enquiries.

3D Cadastral System

For the industry, a 3D cadastral system could greatly reduce duplication of data and information acquisition processes across various departments in the government and public sector. For developers, the frequency and time required for conducting land surveys for land grant application could be substantially reduced. Instead, plans can be generated directly from the 3D system and would only require a simple field validation. As more data from different departments are stored in the system, property valuation and premium assessment for land exchange and lease modification will become more efficient.

The government will benefit through keeping up to date with the market as the current trend is for architects and engineers to adopt 3D and BIM technology. Accurate monitoring of land parcel quantities, areas and volumes would facilitate better land resource management. The system would allow land data to be shared, reused and analysed efficiently within an existing single and comprehensive database. In the future, LandsD's 3D floor plan database could be integrated to facilitate indoor mapping and storing of attributes.

As for the public, since multi-level ownership can be properly registered in the system, this should support residents in further understanding of their rights, restrictions and responsibilities (RRRs) through spatial representation, in addition to the Deeds of Mutual Covenant (DMCs) provided by developers and/or the Assignments signed for the respective properties. Disputes over ownership and spatial-related issues would be reduced. 3D registration makes it easier to comprehend and visualise space, which should enable better decisions to be made when owners fully understand their properties.

5.11. PRELIMINARY DESIGN FOR BUILDING (INCLUDING A&A WORKS) AND CIVIL ENGINEERING PROJECTS

5.11.1. Brief Description of Use Case

When it comes to building and civil engineering projects, whether A&A works excluding minor works are involved or not, data on the existing condition of the site and surroundings are usually required for design impact assessment and calculation at the preliminary design stage. Given current constraints in accessing existing data, some ways forward are suggested to make more use of the existing data for the benefit of industry and society in general.

According to the results of stakeholder engagement at the early stage of the Study, it was realised that there is high demand for A&A works in Hong Kong. As such, this use case will be focused on A&A works.

Examples of A&A works include:

- Constructing a new extension, vertically or horizontally, to an existing building, such as a footbridge or a lift
- Converting an existing building, including wholesale conversion of an existing industrial building.
- Adding water tanks, canopies, shelters, structural frames for advertisement signboards, air-conditioning plants, etc.
- Modifying means of escape, means of access and barrier-free access.

Currently, the workflow before starting any A&A work requires designers to collect a variety of existing data/records, such as but not limited to:

- As-built records,
- Structural records to confirm the approved live loads,
- Fire Resistance Rating (FRR),
- Foundation capacity,
- Design code used,
- Capacity of existing structural elements,
- Fire escape capacity, and
- License or permit

After collecting existing data/records, site inspection and verification have to be conducted in order to determine the reliability of the collected data according to the project needs. A site survey may also need to be conducted to check existing environmental factors, and re-survey carried out in cases of unreliable data if necessary. Preliminary design and analysis can only commence once all the mandatory data are accessible for use.

5.11.2. Solution Deliverable Format

A Microsoft PowerPoint presentation was produced for this Use Case to present the current constraints and way forward.

5.11.3. Data Required and Availability

Table below lists the data required for this Use Case.

Data	File Format	Obtained from
Building plans and documents of private buildings	PDF	BD
As-built BIM models	RVT, DWG etc.	BD, Housing Authority, ArchSD, URA, CEDD, HyD, LandsD (Available for Government projects only)
Existing Drawings and Reports: • Architectural drawings • Structural drawings • Building service drawings • Foundation drawings • Structural design / calculation report	PDF	
LandsD 3D Spatial Data	3DS, 3ds MAX, FBX and VRML	Lands Department
CEDD Terrain LiDAR Data	LAS	CEDD
Project Specific Data		
Laser Scan Point Cloud	LAS, LAZ, PCS	Site Survey
Drone photos and reality models	JPEG, 3MX, FBX	Site Survey

5.11.4. Current Constraints

i. <u>Scattered data sources for as-built records</u>

There are several common sources for obtaining as-built records in Hong Kong:

1. BRAVO – BD's online record retrieval system
   Private building records can be obtained online from BD, with charges.
2. Request to AccessInfo.hk
   Data obtained from government and public projects may be made available for public use upon request at this website
3. Data possessed by project owners
   e.g. - as-built BIM models owned by Housing Authority and URA
   - civil-engineering drawings and models held by CEDD and HyD
4. ArchSD
   Printed building records for government-owned buildings may be made available by ArchSD on request, with charges.

In general, land or property owners have to go through a lengthy and time-consuming process in order to acquire relevant existing data for A&A projects, as outlined below.

Firstly, data users need to browse the locations of data sources and may obtain some basic data from the owners, while in some cases users also need to apply for data access rights from the owners. Secondly, after access rights are granted, users may be able to view useful data and then request copies for their own needs, hence requiring another wait for approvals to be granted. Thirdly, downloading, transforming and converting data into suitable formats is also time consuming. Users often need to repeat these procedures in order to obtain all the data they would need from several different sources.

ii. Scanned As-built Records

Currently most drawing records are retained as scanned copies and the content cannot be read, searched or snapped in PDF or CAD software, hence extra manual work is required for digitising existing data. A&A works (especially for historical conservation projects) often involve works in old buildings that are only documented in hand-drawn record copies, as illustrated in Figure 5-39, and sometimes the handwriting in these copies is incomprehensible and may consequently lead to different interpretations.

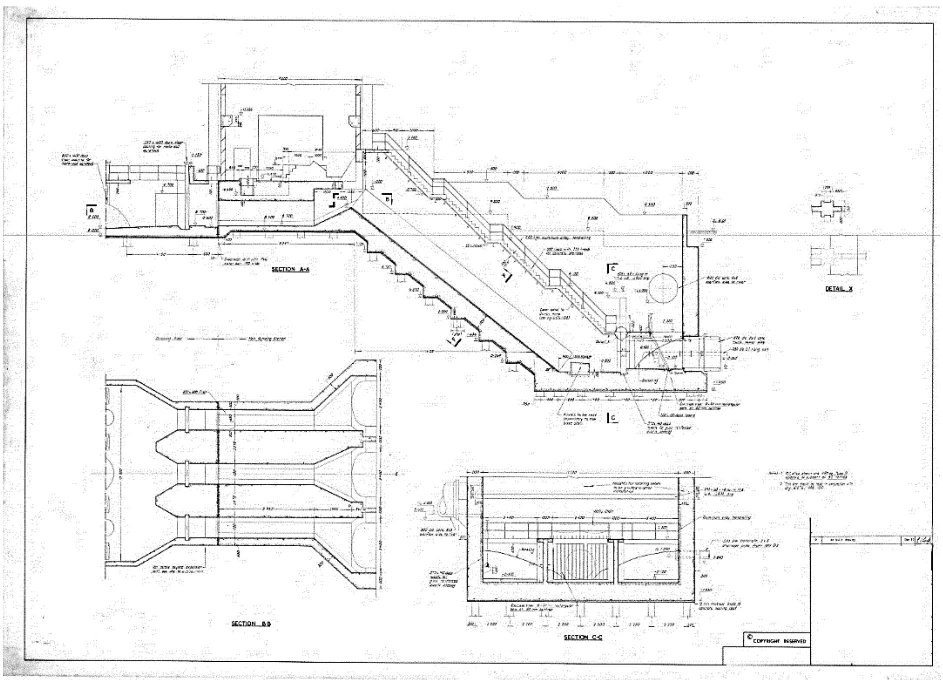

Figure 5-39 Example of hand-drawn copies

iii. 2D As-built Records

Existing designs/as-built records are mostly in 2D format, which makes it difficult to visualise the spatial relationship between the MEP system, structural and architectural components, etc. Data users need to 'visualise' these components purely by cognition, thus requiring additional time for communication, collaboration and decision making.

In addition, field validation of 2D as-built records is a time-consuming process because of the extra effort required in interpreting and comparing the 2D data against the existing site conditions.

iv. Inconsistency in As-built Records and Existing Site Conditions

It is almost certain that discrepancies/inconsistencies exist between as-built records and existing site conditions, which then demands extra labour and time for re-surveying. Since the reliability of past records are in question, existing resources and data are not utilised to their full extent, hence create improvidence.

Considering the nature of A&A works, building MEP systems are already present and are often covered up due to design considerations. Therefore, if discrepancies are identified in a sample validation of an MEP system, a set of more complex procedures will then have to be established to validate the condition of the whole existing building/site.

v. Data Management and Maintenance

Interviewees often noted that existing records were maintained in a poor manner. Sometimes updates of existing records, such as historic A&A works, exist in separate versions which often cover only part of the site. Hence the latest versions of the records do not necessarily display the entire updated on-site situation. This may lead to spending extra resources for verification of different versions and in forming a holistic view of the site.

Other than the lack of holistic records, there are also cases of as-built BIM models which are not regularly updated due to the project nature. Since A&A updates are not stored in a BIM database, the BIM model would then not be of much use in the project due to the unaligned on-site conditions. Extra manual work is also required in such cases to obtain more accurate on-site information.

5.11.5. Way Forward

i. Digitising data

It is suggested that hand-drawn and scanned records are converted to digital and 3D spatial data types so that the data could be searched, snapped, computed and scaled. The digitised data can then facilitate further 2D/3D visualisation in a 3D GIS / BIM environment for better insights.

Considerations

There are several aspects to consider for digitising large volumes of historical data. In view of the amount of non-digitised data in Hong Kong, the resources required for complete digitisation of all relevant building and civil engineering records would be undeniably extremely large. Furthermore, digitising existing records involves the participation of different parties, hence leading to issues of different interpretations and standards of the data to be digitised.

ii. Advance data capturing for the existing site conditions

Advanced technologies such as Terrestrial 3D Laser Scanning and Drone Mobile Mapping and Scan-to-BIM could be used to capture existing site conditions. This will not only help to minimise large discrepancies between as-built records and existing building/site conditions, but also improve clarity, communication and collaboration, and facilitate decision making.

Considerations

Although advanced technologies may provide a higher degree of data accuracy, their application is often found to be impractical if an inappropriate data capture methodology is adopted and forms an unrealistic record. In consideration of the large volumes of data, the data post-processing time could also become a matter of concern, along with the large storage space required and compatibility of data between different application software. As mentioned under the current constraints above, MEP systems and structural components are usually covered up in existing buildings, which then also becomes an issue in preventing Use of 3D laser scanning and Scan-to-BIM approaches for capturing existing building/site conditions.

iii. Integrating BIM and GIS

By using advanced technologies, scanning and surveying data may be acquired and converted to BIM, i.e. Scan-to-BIM is adopted for design, construction, operation and maintenance. By doing so, BIM data could be integrated with surrounding information and GIS data, in order to facilitate analysis for preliminary design, and could potentially be further integrated with loT data for FM/AM and smart city applications. For instance, as shown in Figure 5-40 point cloud data could be converted to a BIM model and integrated with information such as pedestrian data, traffic flows, wind/solar directions. etc., in order to provide a more holistic dataset. These data would benefit design analysis such as TIA and AVA, and also facilitate site monitoring with temporal analysis and change detection if the site data are surveyed repeatedly from time to time. The combination of BIM and GIS data allows more comprehensive network analysis across indoor and outdoor areas, providing insights for improved linkage across neighbourhoods, points of interests and universal design. Moreover, by integrating scanned and surveyed data for historical buildings and BIM models of proposed works, scenario analysis can also be carried out for different A&A works proposals for conserving historical architecture. This will allow better visualisation of the interfaces between old and new elements for architects, engineers, and stakeholders.

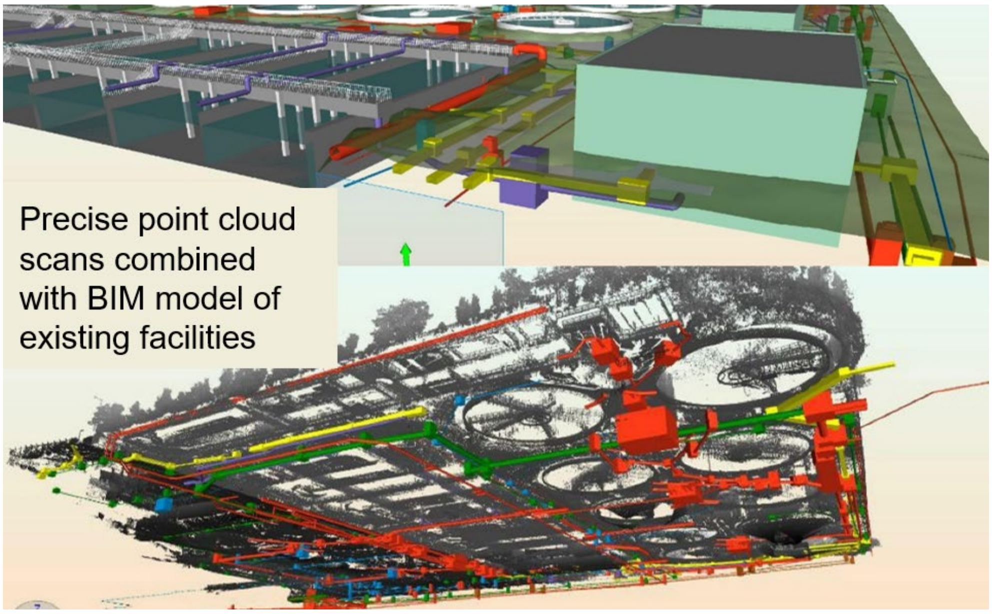

Figure 5-40 Point cloud scans combined with BIM model of existing facilities

iv. <u>Enhance as-built data quality assurance and update mechanism</u>

For good construction management practice, project owners should be encouraged to keep their as-built data regularly updated, even for minor A&A minor works. With timely updating, if complete and accurate databases are stored in their internal file system, this would greatly enhance the workflow and efficiency of future works.

On the other hand, it is suggested that BD's statutory submission requirements should be reviewed to consider including the following:

1. BIM models submitted for referencing
2. Updates of BIM models in A&A Projects (excluding minor works)

These ways forward could help build and upkeep a holistic and updated database for version tracking and storage of A&A histories.

v. <u>Establish an as-built data portal</u>

In order to accelerate the process for requesting and accessing data, it is recommended that a portal for associated as-built data should be established by LandsD. Data such as as-built BIM models and 2D records, including past A&A works from Housing Authority, BD, URA, ArchSD, CEDD, HyD etc., should be included, along with other related information such as materials and quality testing. The portal should be responsible for projecting related data onto a single interface by calling or linking data from different sources and departments while still maintaining a single source of truth for each item. For private projects, data owners such as developers could upload unclassified as-built data voluntarily to the portal, and optionally update the data as necessary, e.g. upon completion of

A&A works. An opt-in/out sharing option could also be provided during statutory submissions to BD. This data portal could then be further integrated with LandsD's 3D Digital Map and CSDI in the future to allow the public to access as-built data.

Considerations

Creating a comprehensive as-built data portal would be bound to face hindrances and practical issues, not least the time and cost required for developing the portal. If the portal only serves as an interface for linking documents for users, issues such as incompatible data standards, data format, data presentation formatting and units may still be a significant inconvenience. For private projects, if data are voluntarily uploaded to the portal, disclaimers will be needed to state that data are for reference only and may not be regularly updated. In addition, since many A&A works are typical of small scale and carried out by small professional firms, the requirement and value in regular updating of BIM models or associated information for small A&A works should be carefully reviewed in order to strike a balance among the resources, cost and benefits for the industry. The SDOs[6] of both DEVB (PLB) and DEVB (WB) should explore possible incentives to encourage the industry to submit 3D and BIM data. On the other hand, further studies should be carried out to assess the technical feasibility/constraints of an as-built data portal for consolidating different paper records, electronic records and BIM models of approved plans, in particular to ensure/ maintain a single source of truth for each type of data.

5.11.6. Benefits

Creating of an as-built data portal could potentially have a major impact and allow workflows to be greatly streamlined and simplified for data users. Data digitisation and 3D data visualisation would help substantially in terms of efficiency of data processing and decision making, while enhancing the as-built data updating mechanism and quality checking, along with use of advanced technologies to capture existing site conditions, would lead to significant improvement in overall data quality. In turn this should mean that time and project costs could be greatly reduced, thereby bringing benefits to the entire industry.

[6] SDO - Spatial Data Office of Development Bureau is responsible for overseeing the development and management of the Common Spatial Data Infrastructure (CSDI) portal, identify and prioritising spatial data to support the development of CSDI

5.12. SUMMARY OF THE 11 USE CASES

5.12.1. Availability of Data

According to feedback from the stakeholder engagements, various types of 3D or BIM data (e.g. building BIM models, road and bridge 3D models, 3D laser scanned existing ground models, etc.) are generated and regularly made available in the construction industry. The data are generated during different stages of construction and development and are usually created by the project users, either developers, contractors or operators, to facilitate their operations.

In general, most participants in the Hong Kong construction industry, in both the public and private sectors, are skilful in creating the relevant data/information using their own methods to facilitate their operations.

5.12.2. Sharing of Data

Even though abundant data are available, particularly in the public sector, there is a general lack of mechanisms or guidelines for sharing the data. With the promotion of the CSDI of the Smart City Initiative by the HKSAR Government, increasing amounts of data from the public sector will be progressively shared with the public. However, currently most of the shared data are in 2D format.

Concerns about sharing data include ownership, accuracy, liability and security issues. In addition, there is a general lack of incentives for industry participants or data owners to share data, as sharing may induce additional operational costs and many stakeholders are unable to perceive the full benefits of data sharing.

5.12.3. Data Standard

It is observed that some data, especially BIM and 3D data, is prepared or made by most stakeholders to be software-oriented, i.e. usually in proprietary formats. One of the biggest challenges/obstacles for data sharing is if similar types of data are prepared using different software and cannot be readily shared due to incompatible formats or data processing issues.

In addition, most data available in the industry does not include metadata, which creates issues of uncertainty and accuracy for both data providers and users. As a consequence data providers may become increasingly unwilling to share their data.

5.12.4. Data Agent

Another issue for data collection and sharing among private practice stakeholders is that a common platform/repository for data sharing is not yet available. It is understandable that there will be cost and resource implications for upkeep of a common data platform. In addition, business secrecy and a natural desire to restrict the sharing of sensitive data, is another critical issue for a private company/organisation to consider when uploading their data to a platform storing data from other business competitors. Neutral data agents may need to be appointed for individual businesses/disciplines, and it is may be necessary to ensure that the host of a common data sharing platform has no commercial interest using the data.

5.12.5. Summary of data Required for the 11 Use Cases

Table 5-1 below lists the data required for the 11 Use Cases grouped by the respective parties. It also summarises the constraints of the currently available data, in terms of format, and whether the data are digitally available, or scattered across different departments that may lead to long retrieval times. The ways forward given in Sections 5.1 to 5.11 above are also summarised in the table for each type of data, including the relevant parties recommended to consider measures to improve the current situation.

Table 5-1 Summary of data required from Use Cases and concerned stakeholders

Concerned Parties	Data required from industry	Issue/Constraints	Way Forward	Related Use Case
ArchSD	Construction cost (unit rate per sq. metre on Gross Floor Area)	Scattered data	Support setting up 3D cadastral/property platform to store all data	10
	As-built drawings and records for Government-owned buildings	Only scanned records available for printing with a fee, scattered data.	Revisit statutory requirements and data sharing ordinance Collect consent from data owners and concerned parties. Consider adding new resources for digitising old building plans Support setting up as-built data platform to store all data	11
BD	Floor Plan / Building Layout / As-built drawings and records for private buildings	Only TIFF and scanned PDF available. CAD/BIM models are not available for deposit and sharing	Revisit statutory requirements and data sharing ordinance Collect consent from data owners and concerned parties. Consider adding new resources for digitising old building plans	9,10, 11
		Scattered data	Support setting up 3D cadastral/property platform to store all data	10
	Construction cost of development and buildings as provided by owners/developers			
	Date of commencement of foundation and super-structure building works for development sites			10

Concerned Parties	Data required from industry	Issue/Constraints	Way Forward	Related Use Case
	Building age, permitted use as provided in RVD's PIO			
	Copy of issued Occupation Permit (including temporary OP, if any) for existing and new buildings			10
CEDD	GI Report and Data	Not digitally available: GI report in scanned PDF and not all GI borehole data is in AGS format	Digitizing old GI reports, OCR for scanned PDF	3,5
		Users need to reach to CE Library for hardcopy and BD's BRAVO for TIFF/PDF copy.	Review the electronic submission requirement so that data can be disseminated to the industry	
	Old research and study reports	Softcopy not available for private projects	Consider having digital data for private projects to acquire upon request	3
	Project specific landslide mitigation works BIM Models/3D GIS data		Develop a 3D Mapping System to support 3D viewing	3
	Historic and current aerial photo	Softcopy not available (unless purchase from LandsD)	Consider scanning aerial photo and adding an approximate location for easier access	3
DEVB	N/A	No standard on survey methodology and accuracy, no standard on drawing presentation, no update since installation completed, 2D line drawings errors and sometimes missing depths and sizes	Formulate a Survey Specifications for public utilities	1,6

Concerned Parties	Data required from industry	Issue/Constraints	Way Forward	Related Use Case
DSD	As-built UU Record (2D Traditional)	No update since installation completed, 2D PDF line drawings errors.	As-built record updating mechanism, digitisation of record plans, policies support to promote 3D as-built UU record	1, 6
EPD	EIA data (Noise, air pollution, vehicle emission, habitat survey, vegetation map, marine ecology data, etc...)	Environmental data is not stored in 3D format,	Establishment of a centralised data exchange platform for data exchange and sharing. Digitalisation of EIA. Standardisation of 3D data format.	7
HyD	XP works area, XP period, excavation depth	The works boundary is in 2D format.	Transfer the 2D data to 3D interface; share the XP location information to a common data platform and link up the XP location data with UU data for better road works coordination.	6
LandsD	Installation of Public Utilities	Application of block licence without detail utilities information	Proposed UU data in 3D should be provided for licence application and as-built record is recommended to be provided	6

Concerned Parties	Data required from industry	Issue/Constraints	Way Forward	Related Use Case
	3DSD (Building, Terrain & Infrastructure)	Not aware of this data and unfamiliar with the data format and compatible software; Data conversion also is needed for CFD program; Technical issues like overlapping and tiny gaps between buildings and between buildings and terrain causes long running time for CFD program, so it is only served as reference to understand the shape of buildings in 3D	Education to public/industry; Review	2,4,9,11
LR	Ownership Information	Scattered data for property valuation	Support setting up 3D cadastral/property platform to store all data	10
	Transaction History and lease condition			
	Colour plans (sale and purchase, assignments etc)			
PlanD	AVA Project information (full report, input and output of CFD model in digital format, building outlines in CAD) from Private sectors	Project data as private property, and it is shared by project owners on voluntary basis	Encourage industry actively engage in data sharing Recommend reviewing the Technical Circular 1/06	9
	Outline Zoning Plan (OZP)	Not aware that digital formats are available for download	Education to public/industry; Set up 3D cadastral/property platform to store all data	3,4,10
	Historic and current planning and rezoning applications and decisions	Scattered data for property valuation	Support setting up 3D cadastral/property platform to store all data	10
	Permitted site coverage and plot ratio			

Concerned Parties	Data required from industry	Issue/Constraints	Way Forward	Related Use Case
RVD	Saleable area of Residential Properties	Scattered data for property valuation	Support setting up 3D cadastral/property platform to store all data	10
	Rateable Value			
TD	Annual Traffic Census		Set up a centralised platform to store all data required for TIA	2,4
	Road Network/Alignment			
	Traffic aids and traffic signs			
	Traffic Volume	Pedestrian traffic not included		
	Base District Traffic Model (BDTM)	Update frequency is low. Traffic consultants would prefer to do a new traffic model by themselves		
WSD	As-built UU Record (2D Traditional)	Line drawings in 2D PDF format	3D visualisation of record plans, policies support to promote 3D as-built UU record	1, 6
Developers	Building energy data	1. Each company have their own regulation/guidelines/standards to manage their properties and buildings, the interest of data format and types may be different.	/	8
	Facility data (collected by IoT sensors)	2. Developers may have some agreements with the occupants. The energy data cannot be fully provided to the sharing platform	/	8
	Sales Brochures (1st hand)	Scattered data	Support setting up 3D property platform to store all data	10
Real Estate Agents	Sales Brochures (1st hand)	Scattered data	Support setting up 3D property platform to store all data	10

Concerned Parties	Data required from industry	Issue/Constraints	Way Forward	Related Use Case
Public Utilities Companies	As-built UU Record (2D Traditional)	No standard survey methodology, survey accuracy, drawing presentation among utilities companies. No update since installation completed, 2D line drawings errors and sometimes missing depths and sizes	Common survey standard. As-built record updating mechanism, digitisation of record plans, policies support to promote 3D as-built UU record	1, 6
Private Companies	As-built BIM models	No BIM models sharing between companies	Establishment of a centralised data exchange platform	2, 11

6. RECOMMENDATIONS

6.1. WAYS TO IMPROVE THE CURRENT SITUATION

The 11 Use Cases considered in this Study reflect the general situation of sharing and utilising data in Hong Kong during the period from 2020 to mid-2021. Having realised there are gaps between demand and supply of 3D and BIM data in the construction industry, this section presents some high-level approaches to improve the current situation for both Data Requesters and Data Providers to consider and follow up. These recommendations are not confined only to the selected Use Cases.

Continuous Review of all Use Cases

20 consolidated Use Cases were identified in the Study. However, due to limitations in time and resources, in-depth review and analysis were performed only for the 11 selected Use Cases. The remaining consolidated Use Cases should not be overlooked. More resources should be allocated to monitor the industry practice on all the consolidated Use Cases to obtain a full, comprehensive analysis and recommendations that may benefit more stakeholders.

Continuous Information Exchange with Spatial Data Office (SDO), DEVB(PLB)

After the in-depth study for each Use Case and the data required, the report for this Study should be used as a reference for SDO of DEVB (PLB) to take a lead to collaborate with concerned data contributors to provide geospatial data in different batches, subject to availability via the CSDI. Secondly, the Study indicated that industry stakeholders are generally willing to share certain data, and thus facilitate follow up actions such as data standardisation and provision of sharing mechanisms, etc. It is recommended that CIC should maintain constant communication with the SDOs of both DEVB (PLB) and DEVB (WB), and other key parties to ensure effective and up-to-date information flow.

Review and Update of Polices/ Guidelines

As the Use Cases in the construction industry are closely related to statutory submission requirements, policies and assessment guidelines, it is recommended that the responsible authorities should review and update these items regularly to monitor and facilitate the use of 3D data, either geospatial or geospatial-related textual data, so as to boost the incentives to produce and accumulate more 3D data. Hence, use of 3D datasets and databases can become an ever-growing part of the Smart City initiative and will ultimately lead to achieving the digital twin in Hong Kong.

On the other hand, it is mandatory for new and large-scale projects to submit 3D project data, for instance BIM models for new buildings and infrastructure to be created/generated in the design phase of the New Development Areas of Kwu Tung North and Fanling North. If additional guidelines can be established for as-built surveys, e.g. laser scanning of built areas, the additional representation of real-world objects with 3D data will facilitate more accurate asset management, operation and maintenance, and future implementation of the 3D cadastral system.

Data Standardisation

As mentioned in several of the Solutions, collection of 3D BIM and GIS data requires compilation of new data standards and drawing practice guidelines. The data format, suggested to be an open format, together with metadata should be aligned with the data shared in the CSDI portal. The conversion of existing data from proprietary to open formats should also be studied and developed when more resources can be allocated.

Government departments and the CIC could also explore potential beneficial inputs from related projects, e.g. the BIM Horizontal Harmonisation Study for BIM/GIS Integration for Development of Kwu Tung North and Fanling North, New Development Areas, which involves data conversion to a shareable BIM and open GIS format. Regarding other data types, such as textual and non-spatial data, other parties with respective expertise should be involved with relevant projects as a reference or pilot study, and the data should also be aligned with other data standards if specified by the SDO of DEVB (PLB) or CIC.

Public/Industry Engagement with more Efficient Data Sharing and Usage

To familiarise more stakeholders with useful data and increase utilisation of available data, education of the public and the industry should cover data available for retrieval, the mechanism or workflow to acquire data from industry and from relevant government departments, and compatible software for use of different data formats, etc. CIC could act as a proactive platform to facilitate such information exchange. Regular workshops should be organised to keep the public and industry up to date with the development of 3D and BIM data and associated technologies. This will also be an effective way of promoting newly- released Government datasets for public/industry use. In parallel, public engagement may inspire further inputs from new communities to expand the knowledge base and future applications.

Data Agents for the Construction Industry

To efficiently collect 3D and BIM data to be shared among industry, government departments and the public, it is suggested that specific government departments such as LandsD should become Data Agents to ensure common data standards are achieved and to monitor data handling between stakeholders. It is expected there will need to be multiple Data Agents for different types of dataset. Responsibilities of Data agents should preferably include:

a. Acting as a central point of contact for disseminating information and data
b. Working proactively with data owners to formulate and implement data standards and guidelines applicable to the industry
c. Setting up data exchange policies

d. Data quality checking to ensure that data provided by owners comply with the relevant standards and specifications
e. Ensuring correct handling of data to avoid liability issues
f. Liaising and communicating with stakeholders and government departments regarding data sharing

List of recommended 3D and BIM Data for sharing

Table 6-1 below lists the types of 3D and BIM data identified in this Study as worthwhile for sharing

Table 6-1 Recommended 3D and BIM Data for sharing

Data	Format
Currently available but not shared	
Road alignment	3D GIS/BIM
As-built BIM model for new/recent projects	BIM
Currently available, but a sharing mechanism is needed (usually project data and academic research)	
Topographical data (site-specific)	3D GIS
Geological model (site-specific)	3D GIS
Foundation/Pile model (site-specific)	BIM
Laser scanned data (site-specific)	3D GIS
Data collection/digitisation/conversion from 2D to 3D is needed	
Underground Utilities	3D GIS/BIM
GI records in AGS format	AGS
Wind data	3D GIS
As-built BIM model for old projects	BIM

6.2. ROAD MAP

Attempting to account for the construction industry's different opinions in terms of 3D and BIM data collection and sharing, some actionable recommendations are proposed below for concerned government officials to consider. These cover short-term and long-term views in identifying actions that could be taken soon to lay the foundations for future improvements, including new insights according to policy priorities.

6.2.1. Short Term Actions (1-3 years)

Identify Key 3D Data and BIM Data for the Industry

CIC should further identify the top 10 or more types of 3D data from the recommended list and initiate a conversation focused on how to practically collect and share the required data with the relevant data requesters, either private or public or government departments.

Industry / Public Engagement

Collaborations with the Geospatial Lab[7] should be conducted via various campaigns and workshops arranged for industry stakeholders to promote the sharing of 3D and BIM data. Government departments and private sector companies should be invited to participate and contribute.

Setting up a Liaison Group with Regular Review

CIC should consider setting up a Liaison Group with members from the SDOs of DEVB (PLB) and DEVB (WB), and other concerned government departments (on a needs basis) to host regular reviews on following up progress on the recommendations made in this Study, such as establishing standards for BIM, GIS, 3D and other types of data, exchanging views on policies, guidelines and practices, sharing of findings from on-going relevant consultancy studies, etc. The Liaison Group may also be used as a channel for continuous dialogue between SDO of DEVB (PLB) and the industry for information exchange, e.g. in relation to new/planned/retiring datasets from CSDI/other departments, and other datasets the industry can provide.

Formulate Survey Standards/Specifications for Public Utilities

Public utilities data is ranked first in the demands from Data Requesters in this Study. It is recommended that the SDOs of DEVB (PLB) and DEVB (WB), LandsD and JUPG jointly consider and take the lead to collaborate with the relevant professional institutes, such as HKIA, HKIE and HKIS, and academic institutes to formulate standards or specifications for public utilities, e.g. for survey methodology, utilities geometry, data accuracy, data attributions, metadata, etc, with the aim to provide guidelines or common ground for public utilities stakeholders or undertakers to follow. This would pave the way for improved collection and wider sharing of data on utilities in long run.

Coupled with the Audit Review's Report No. 70 on "Government's effort in managing excavation works on public roads", published by the Audit Commissioner in April 2018, it is recommended to collect data on public utilities in the New Development Areas (NDAs). There are three NDAs currently in progress in New Territories North, Yuen Long South and Hung Shui Kiu. The study on BIM harmonisation for the New Territories North NDA could be a pilot study for public utilities standards and specifications, and provide a framework for future discussions on the subject.

6.2.2. Medium Term Actions (3-5 years)

Provision of Data in Digital Formats

[7] Geospatial Lab was established in May 2021 and opened in July 2021 by Spatial Data Office, DEVB to encourage the public to make use of spatial data and promote spatial data technology with commercial partners.

Government departments/Bureaux, when identified as major data providers, should investigate and review various data formats, e.g. open formats or commonly-used formats, to be provided to the public, so as to facilitate industry stakeholders in data processing and daily operation. It is recommended that government departments should make arrangements to accept digital copies and machine-readable forms of some common types of data/reports/results currently submitted and shared in hard copy or scanned copy formats. CIC should work with the government and all stakeholders to develop open formats for standardisation.

Government departments should mandate/encourage data owners to share their data and reports to other industry stakeholders, upon request until data exchange mechanisms are fully established by appointed data agents.

Resources Planning

Given the recent rapid technological developments, large volumes of 3D and BIM data are now being generated and are potentially available for sharing. Both government departments and relevant private organisations are recommended to carry out detailed resources planning for the technological upgrades, staff upskilling and training, financial implications, etc., and to obtain support from their senior management for the potential development and changes.

6.2.3. Long Term Actions (over 5 years)

Guidelines/Statutory Requirements and Practice Review

To boost the development of the Digital Hong Kong, open public and inter-departmental data sharing will inevitably require new guidelines, policy changes and reviews of good practice.

Some existing guidelines and practices of government departments related to data collection and sharing of interest to industry stakeholders have been identified in this Study. Relevant departments are recommended to actively participate in public engagement and collect opinions from industry stakeholders to review the current guidelines and practice, to further facilitate information exchange without adversely affecting data liability, security and privacy.

Establishing Data Agents

Taking into account that several ways forward for the 11 Use Cases involve the collection of voluntary data, relevant departments should explore incentives to encourage the industry to submit and share data. Channels should be established to receive voluntary submissions or provision of BIM or 3D Data, which are currently not included in the first CSDI data set, from industry stakeholders, e.g. developers or property management companies, to promote data sharing.

It is recommended that government should formulate the necessary policies and allocate resources for LandsD to act as the Data Agent to collect voluntary submission of BIM or 3D data from industry stakeholders, as LandsD will collect private data in the long run and is a suitably neutral and non-profit making organisation. This should lay a cornerstone for new public-private partnership in data sharing and dissemination. In serving as the Data Agent, LandsD should be responsible for formulating data standards, ensuring quality and security, and setting up procedures to handle and exchange data.

Further coordination and collaboration between the SDO of DEVB (PLB), LandsD and other concerned government departments should be established to work out the data exchange and dissemination strategies and implementation schedules between the private and public sectors, given that increasing volumes of data are expected to be collected from the private sector under the Smart City Initiatives for the Digital Hong Kong Development.

Alignment with CSDI and 3D Digital Map Development

The SDO of DEVB (PLB) and LandsD are currently developing the CSDI and 3D Digital Map to support Digital Hong Kong, in which government departments will ultimately share their spatial data to the public via CSDI and permit visualisation via the 3D Digital Map.

To align with development of the CSDI and 3D Digital Map, the roles and responsibilities of the SDOs of DEVB (PLB) and DEVB (WB), LandsD, concerned governments departments, Data Agents, and private sector companies with respect to BIM and 3D data provision in the construction industry should be clearly defined. In particular the policies for sharing BIM and 3D data from multiple sources, such as the essential data standards, intellectual property rights, fair usage policy, etc., should be referenced to the current CSDI implementation objectives. All data collected by Data Agents should follow CSDI requirements so that the standards can be aligned in a single system. In theory, Data Agents will mainly focus on collecting data from various sectors and ensuring that relevant standards have been met before sharing data to the CSDI. Intensive consultations between potential data providers on types of data, attributions, formats, frequencies, etc., should be conducted by Data Agents and the CIC to minimise issues which could arise due to data sensitivity, security, privacy and ownership.

APPENDIX A – LIST OF INVITATIONS & RESPONSES

Data Requester

This table lists invited stakeholders and their responses (sorted by business nature, and then name of organisation):

Organisation Name	Business Nature	Response Status
DEVB/EKEO	Government	No Response
OGCIO	Government	No Response
AAHK	Quasi-Government	Questionnaire and Interview
CIC	Quasi-Government	Questionnaire and Interview
HA	Quasi-Government	Interview Only
HKHS	Quasi-Government	No Response
MTRC	Quasi-Government	Questionnaire and Interview
HKJC	Quasi-Government	No Response
URA	Quasi-Government	Questionnaire and Interview
WKCD	Quasi-Government	Questionnaire Only
CityU	Academic	Questionnaire and Interview
IVE	Academic	No Response
LingU	Academic	Interview Only
THEi	Academic	No Response
CUHK	Academic	Questionnaire Only
PolyU	Academic	Questionnaire Only
HKUST	Academic	Questionnaire Only
HKU	Academic	Interview Only
VTC	Academic	No Response
AIIB	Professional Association	No Response
ACEHK	Professional Association	Questionnaire Only
BEAM	Professional Association	Questionnaire Only
CIAT	Professional Association	Questionnaire Only
ICES	Professional Association	No Response
CommENV	Professional Association	No Response
HKABAEMIA	Professional Association	Interview Only
HKCA	Professional Association	No Response
HKGBCA	Professional Association	Questionnaire Only
HKGISA	Professional Association	No Response
HKIBIM	Professional Association	No Response
HKICBIM	Professional Association	No Response
HKILA	Professional Association	No Response
HKIP	Professional Association	Questionnaire Only
HKIUD	Professional Association	Questionnaire and Interview

Organisation Name	Business Nature	Response Status
HKIUS	Professional Association	No Response
JUPG	Professional Association	Questionnaire
REDA	Professional Association	Questionnaire
RICS	Professional Association	Questionnaire and Interview
AAP	Professional Association	No Response
ACQS	Professional Association	No Response
CIOB	Professional Association	Interview
HKFEMC	Professional Association	No Response
HKIA	Professional Association	Questionnaire
HKIS	Professional Association	Interview
HKIE	Professional Association	Questionnaire
AECOM	Consultant	Questionnaire and Interview
HOK	Consultant	Interview
LWKP	Consultant	Questionnaire
Mott MacDonald	Consultant	Questionnaire and Interview
ARUP	Consultant	Interview
Build King	Contractor	Questionnaire and Interview
Gammon	Contractor	No Response
Hip Hing	Contractor	Interview
Leighton	Contractor	Interview
Chinachem	Developer	No Response
Henderson	Developer	No Response
Disneyland	Developer	No Response
Hysan	Developer	No Response
Nan Fung	Developer	Questionnaire
New World	Developer	Questionnaire
Ocean Park	Developer	No Response
SHKP	Developer	Interview
Swire	Developer	Questionnaire and Interview
Wheelock	Developer	Questionnaire and Interview

Below table shows the referral responses to the Study:

Organisation Name	Business Nature	Response Status
Cundall	Consultant	Interview
P&T	Consultant	Questionnaire and Interview
Wecon	Contractor	Questionnaire
Fraser	Contractor	Questionnaire
HK Electric	Developer	Questionnaire

Data Provider

This table lists invited stakeholders and their responses (sorted by business nature, and then name of organisation):

Organisation Name	Business Nature	Response Status
CityU	Academic	Questionnaire
IVE	Academic	No Response
LingU	Academic	Questionnaire
THEi	Academic	No Response
CUHK	Academic	No Response
PolyU	Academic	Questionnaire
HKUST	Academic	No Response
HKU	Academic	No Response
VTC	Academic	No Response
Chinachem	Developer	No Response
Henderson	Developer	No Response
Disneyland	Developer	Responded as Non-Data Provider
Hysan	Developer	No Response
Nan Fung	Developer	No Response
New World	Developer	No Response
Ocean Park	Developer	Questionnaire
REDA	Developer	Questionnaire
SHKP	Developer	No Response
Swire	Developer	Questionnaire
Wheelock	Developer	Questionnaire
ArchSD	Government	Questionnaire
BD	Government	Questionnaire
CEDD	Government	Questionnaire
DEVB	Government	Responded as Non-Data Provider
DSD	Government	Questionnaire
EMSD	Government	Questionnaire
DEVB/EKEO	Government	Responded as Non-Data Provider
EPD	Government	No Response
FSD	Government	Responded as Non-Data Provider
HyD	Government	Questionnaire
HKO	Government	Questionnaire
HKPO	Government	Responded as Non-Data Provider
Housing Authority	Government	Questionnaire
ITB	Government	No Response
LandsD	Government	Questionnaire
OGCIO	Government	Responded as Non-Data Provider
PlanD	Government	Questionnaire
TD	Government	Questionnaire
WSD	Government	Questionnaire
AAHK	Quasi-Government	No Response
HA	Quasi-Government	Questionnaire

Organisation Name	Business Nature	Response Status
HS	Quasi-Government	No Response
MTRC	Quasi-Government	No Response
HKJC	Quasi-Government	No Response
URA	Quasi-Government	Questionnaire
WKCD	Quasi-Government	No Response
CLP	UU Company	Interviewed
HGC	UU Company	Interviewed
HK Electric	UU Company	Interviewed
HKT	UU Company	Interviewed
NWT	UU Company	Interviewed
Towngas	UU Company	Interviewed

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Organisation Name	Business Nature	Response Status
BD	Government	Interviewed
Housing Authority	Government	Interviewed
CIOB	Quasi-Government	No Response
URA	Quasi-Government	Interviewed
HKABAEIMA	Professional Association	Interviewed
HKGISA	Professional Association	Interviewed
HKIA	Professional Association	Interviewed
HKIBIM	Professional Association	Interviewed
HKIE	Professional Association	Interviewed
HKIP	Professional Association	No Response

Below table shows participants of different interview sessions in the Study:

#	Date (DD.MM.YYYY)	Time (HH.MM)	Organisation Name(s)	Participant Name(s)
1	25.03.2020	09.30	AECOM, Swire	Again WEI (AECOM), Raymond KWOK (Swire)
2	26.03.2020	14.30	CIC, LingU	Thomas TONG (CIC), Paulina WONG (LingU)
3	26.03.2020	15.00	Leighton, Wheelock	Michael WONG (Leighton), Brian CHIU (Wheelock)
4	26.03.2020	15.45	CIOB	Kelvin CHOI, Hon Fai WONG
5	01.04.2020	11.00	HKU	Alain JF CHIARADIA
6	01.04.2020	14.30	Mott MacDonald, MTRC	Klocek MARCIN (MTRC), Ewan CARMICHAEL (Mott MacDonald)

#	Date (DD.MM. YYYY)	Time (HH. MM)	Organisation Name(s)	Participant Name(s)
7	01.04.2020	16.00	SHKP, ARUP	David LAU (SHKP), Vicki LAU (ARUP)
8	02.04.2020	09.30	AAHK	Kelvin WONG
9	02.04.2020	10.15	Build King	Ying Hung WONG
10	02.04.2020	11.00	CityU	Jung In KIM
11	07.04.2020	11.45	HOK	Emily CHANG
12	07.04.2020	19.30	HA	Ray CHAN
13	09.04.2020	10.00	Hip Hing	Billy WONG
14	16.04.2020	15.30	URA	Edmond LAM, Clarice HO, Rebecca LI, Nick CHAN, Elvis HUI
15	17.04.2020	14.45	IUD	Aaron CHAN
16	20.04.2020	16.00	HKIS	Tak Shing KOO, Paul TSUI, YC CHAN, Charlie HUNG
17	20.04.2020	17.00	HKABAEIMA	Ada FUNG, Wendy LEE, Paulina WONG, Kevin WONG, Weifeng LI, Michael WONG
18	21.04.2020	15.15	RICS	Alvin CHEUNG
19	10.07.2020	11.15	Cundall	Jonathan YAU
20	06.05.2021	11.00	BD	Nok-ki TSANG, Frankie WAI
21	06.05.2021	15.30	HKIA	Aaron CHAN, David FUNG, Marcin KLOCEK, Rachel
22	11.05.2021	15.30	HKIE	P L YUEN
23	18.05.2021	14.30	URA	Edmond LAM, Nick CHAN, Christine YIP
24	20.05.2021	17.00	HKABAEIMA + HKIBIM + HKGISA	Ada FUNG, David FUNG, Paulina WONG, Kenneth TANG
25	31.05.2021	10.30	Housing Authority	Antony CHAN

APPENDIX B - USE CASE MENTIONED BY STAKEHOLDERS

Use cases being mentioned by the stakeholders (ranked by descending frequency):

No.	Use Case	Govern-ment	Quasi-Government	Academic	Professional Association	Consultant	Contractor	Developer	Total
1	Underground Utilities Study		Hospital Authority, URA, WKCD, CIC	CUHK	CIOB, JUPG, IUD, ACEHK, HKABAEIMA, HKIA, HKGBCA, RICS	AECOM, Mott MacDonald, Arup, Cundall, LWKP	Leighton, Build King, Hip Hing, Fraser	Swire, Wheelock, Nan Fung, SHKP	26
2	Land Survey		WKCD, MTRC, CIC	CityU, CUHK	ACEHK, IUD, RICS	AECOM	Hip Hing, Leighton, Build King	Swire, Nan Fung, Wheelock, SHKP	16
3	Geotechnical Survey		MTRC, CIC, Hospital Authority, URA	CUHK	CIAT, IUD, ACEHK	Mott MacDonald, Arup	Build King, Hip Hing	Swire	13
4	Site & Surrounding Visualisation		MTRC, URA		ACEHK, IUD, HKIE, REDA	AECOM, Arup, HOK	Hip Hing	SHKP, Wheelock	12
5	Urban Study and Planning Analysis / Layout Design Assessment		URA	LingU, HKUST, HKU	HKABAEIMA, ACEHK, HKIP, IUD	Arup, Mott MacDonald			10
6	Site logistics planning, swept path analysis		CIC	HKUST	CIOB, HKABAEIMA, RICS, CIAT	LWKP	Hip Hing	Swire	9
7	Wind simulation and analysis/ CFD Analysis		CIC, MTRC		IUD, ACEHK	Cundall, Mott MacDonald		Swire	7

No.	Use Case	Govern-ment	Quasi-Government	Academic	Professional Association	Consultant	Contractor	Developer	Total
8	Environmental Impact Assessment		URA	CityU	CIOB, HKIP, ACEHK, CIAT			Swire	7
9	Construction program planning		URA, MTRC		ACEHK, CIOB, RICS		Hip Hing	SHKP	7
10	Data Enrichment		URA, CIC, AAHK		HKIS, IUD	LWKP	Fraser		7
11	Traffic Impact Assessment		CIC, Hospital Authority, URA		CIOB			Nan Fung, Swire	6
12	Building Energy Analysis			HKUST, CityU	BEAM Society, CIAT	Cundall, Mott MacDonald			6
13	Building Concept design		MTRC		HKIA, IUD, CIOB	Mott MacDonald		Swire	6
14	Noise Impact Analysis		Hospital Authority, URA	CityU	HKIP	LWKP			5
15	Preliminary design and study		AAHK		HKIS, HKIA, RICS			Swire	5
16	Foundation Design		Hospital Authority		HKABAEIMA		Build King, Fraser		4
17	Site context, site constraint				HKIA, IUD	HOK		Swire	4
18	Structural A&A design				IUD	AECOM, Mott MacDonald	Fraser		4
19	Sunlight Analysis		MTRC		CIOB	Mott MacDonald		Swire	4
20	Civil Schematic design				RICS	AECOM	Fraser		3
21	Micro-climate study		CIC		BEAM Society			Swire	3
22	Air Ventilation Assessment/ street canyon study		Hospital Authority	HKU, LingU					3

No.	Use Case	Govern-ment	Quasi-Government	Academic	Professional Association	Consultant	Contractor	Developer	Total
23	Excavation permit Application				HKABAEIMA			Swire	2
24	3D Environmental Impact Assessment		URA		HKIP				2
25	Road Alternation, diversion				CIOB	Arup			2
26	Flow Analysis			CityU		Arup			2
27	Bus Route Study and Planning			LingU	HKABAEIMA				2
28	Pedestrian walkability and path finding on 3D map		Hospital Authority	HKUST					2
29	Asset management		URA		HKABAEIMA				2
30	Underground Space Planning			CityU		Arup			2
31	Disease study			HKU, LingU					2
32	Building demolishment				HKGBCA				1
33	Embodied Carbon Calculation				CIAT				1
34	Tree Survey		WKCD						1
35	Sewage System Upgrade		Hospital Authority						1
36	Virtual Site Supervision						Build King		1
37	Prevention of geological disasters			PolyU					1
38	Traffic Forecast					LWKP			1
39	Traffic road characteristics Analysis			HKUST					1

No.	Use Case	Govern-ment	Quasi-Government	Academic	Professional Association	Consultant	Contractor	Developer	Total
40	Emergency Response Management/Safety Planning			CityU					1
41	Redevelopment Site Selection		URA						1
42	Architectural A&A design				HKIA				1
43	Visibility and sustainability review							Nan Fung	1
44	GIS Research			PolyU					1
45	Drain Survey				CIAT				1
46	Flight planning		AAHK						1
47	Backward study on the productivity data and benchmark for future project		CIC						1

Description of the Use Cases:

No.	Use Case	Brief Description
1	Underground Utilities Study	Obtaining information from UU survey result or using as-built record directly design and clash analysis for urban renewal or development / construction planning. Investigation includes utilities' locations, depth, alignments, conditions, as well as the network, etc.
2	Land Survey	No Use Case is specified by interviewee. LandsD data can be used during preliminary design/ feasibility study stage instead of information traditionally obtained from land survey (e.g. Topographic Survey)

No.	Use Case	Brief Description
3	Geotechnical Survey	No Use Case is specified by interviewee. Information traditionally obtained from geotechnical survey including groundwater table and GI plus topographical survey, could be stored in a centralised data repository for designer and contractor's retrieval.
4	Site & Surrounding Visualisation	Visualisation and simulations of construction site and adjacent environment during different phase of construction works, to facilitate designer and contractor's understanding of the environment. Application: Visualise the interface between proposed works and the surrounding area; location to install site camera by understanding site surrounding environment.
5	Urban Study and Planning Analysis /Layout Design Assessment	Town and regional planning and the statutory requirements and submission; master planning studies; research and analysis to facilitate urban design decisions, layout design assessment with 3D proposed buildings
6	Site logistics planning, swept path analysis	Planning for site logistics to and from construction site to other locations, and to estimate the manoeuvring space when transporting MiC materials
7	Site context, site constraint	To understand site context and site constraint for new building design, including monument protection, traffic condition and capacity of surrounding area, railway protective zone etc.
8	Environmental Impact Assessment	According to the existing statutory requirements, EIA is conducted to avoid, minimize and control the adverse impact on the environment of designated construction projects through proactive early considerations of environmentally friendly designs, options and alternatives. It covers various aspects such as air and water quality, noise, ecology, waste etc.
9	Construction program planning	General planning at planning stage before the start of construction works on site by considering various factors such as the traffic status of adjacent area to determine its effect on the construction programme
10	Data Enrichment	No Use Case is specified by interviewee. Textual Information/ attributes was mentioned to enhance existing data integrated with 3D model/ spatial environment for easier access and enable potential future Use Cases, for example height restriction, owners' corporation data etc.

No.	Use Case	Brief Description
11	Wind simulation and analysis/ CFD Analysis	To simulate the effect on proposed buildings for regional air ventilation by visualizing the air flow / wind speed in an area before and after its development in the planning and preliminary design stage. It facilitates location selection and design of proposed buildings in a concerned area for proposed development.
12	Traffic Impact Assessment	Based on existing traffic condition, estimate the traffic generated by construction activities. The suggested framework provides reference for construction engineers and site engineers in developing a traffic management and impact mitigation plan for construction projects.
13	Building Concept design	To build a 3D model for concept design of a new building project e.g. view analysis, solar analysis
14	Building Energy Analysis	To collect different environment data, such as temperature and humidity, energy usage and consumption, e.g. electricity and water, of a building will assist facility management or O&M in assessing a building's performance and efficiency. The information will facilitate the formulation of predictive and preventive maintenance plan for the building. In return, these data will serve a good reference for a building of similar design.
15	Noise Impact Analysis	Assess noise level and impact generated by construction activities
16	Preliminary design and study	Site selection and preliminary project design by considering adjacent area traffic flow & volume, adjacent terrain using readily available maps or models with high z-level accuracy,
17	Foundation Design	With reference to geotechnical and geological investigation of existing site of proposed development, types, size, numbers, respective location and depth can be determined and designed.
18	Structural A&A design	Structural design and the information required for the design process
19	Sunlight Analysis	Analyse and visualise the sun path and shadows that a site or building element receive during a specific time to facilitate the installation of solar panels

No.	Use Case	Brief Description
20	Civil Schematic design	Civil infrastructure conceptual design using software (e.g. Infraworks) to model, analyse, and visualise their design concepts within a real-world context of the built and natural environment
21	Micro-climate study	Assess the effects of urban planning and building development for instance the location, distribution and green coverage of parks, on urban thermal comfort and wind environment
22	Air Ventilation Assessment/ street canyon study	Assess the effects of urban planning and building development on external air movement and temperature mainly in pedestrian level
23	Excavation Permit Application	The application of Excavation Permit (XP) to Highways Department (HyD) by the promoter of the excavation works prior to commencement of excavation work in streets maintained by HyD.
24	3D Environmental Impact Assessment	Environmental Impact Assessment integrate with GIS data with robust 3D calculations and simulations
25	Road Alternation, diversion	Identify the impact of road alternation to pedestrian and vehicle flow
26	Flow Analysis	Identify the driving paths of vehicles to understand the traffic volume from one point to another
27	Bus Route study and Planning	Existing bus route evaluation and planning
28	Pedestrian walkability and path finding on 3D map	Analyse walkability of pedestrian and navigation in a 3D environment
29	Asset management	Manage building assets to reduce risk and maintenance cost
30	Underground Space Planning	Planning and design for underground area development (urban master planning)
31	Disease study	Analyse the relationship between demography, health and urban design and predict health condition of the community
32	Building demolishment	Demolish existing building structure
33	Embodied Carbon Calculation	Carbon footprint of materials, for material selection and analysis in order to refine design decisions
34	Tree Survey	Record tree location, properties, status and geo-tagging

No.	Use Case	Brief Description
35	Sewage System Upgrade	Improve existing sewage design and capacity
36	Virtual Site Supervision	Site supervision works using VR to monitor construction progress and to have faster response for risks and issues
37	Prevention of geological disasters	Research project on the prevention of geological disasters for instance landslides
38	Traffic Forecast	Predict the trend of traffic flow of a certain road
39	Traffic road characteristics analysis	Identify features of main roads such as road width, restrictions, traffic flow, traffic volume by vehicle types etc.
40	Emergency Response Management/ Safety Planning	Planning on evacuation routes and safety management of a building/construction site
41	Redevelopment Site Selection	Selecting a feasible and suitable site for urban redevelopment with multi-criteria analysis such as the building age, population, number of landowners etc.
42	Architectural A&A design	A&A works architectural design
43	Visibility and sustainability review	Determine visibility on a surface from point to point across the entire surface in a viewshed
44	GIS Research	Research project on 3D GIS
45	Drain Survey	Survey and monitoring of existing drainage system using CCTV and IoT sensors
46	Flight planning	Flight schedule optimisation
47	Backward study on the productivity data and benchmark for future project	Evaluate construction project for future reference, such as the project size, quantity of material used etc.

APPENDIX C – DATA MENTIONED BY DATA REQUESTERS

Rank	Information Required	Demand	Brief Description	Usually Obtained from	Type of Data
1	3D Topographical Data/Digital Terrain (Vector and Raster)	27	3D topographical data or model, or digital terrain, from LandsD	Field Survey, LandsD, Open Source	GIS, CAD, Imagery
2	As-built UU record or UU model	23	As-built UU either in 2D drawings or 3D model obtained from utilities company or UU survey	Field Survey, DSD, WSD, CEDD, MTRC, CLP, Town gas, HK Electric	BIM, GIS, Scanned PDF
3	Simplified models for buildings	17	Simplified building models showing only the height/ mass/ façade with an acceptable location accuracy	Open Source Data, LandsD	BIM
4	Traffic Census and data (including vessel and pedestrian) *	14	Traffic census and data including both vessel and pedestrian data. Real-time or static. Historical data included.	Field Survey, TD	Textual/Table, GIS
5	As-built/Design BIM model for buildings*	12	Full as-built BIM model of buildings. Historical data included.	Owner/Developer, Works Departments	BIM
6	Geological Model/data with strata	11	3D geological model showing soil properties, slope information, strata, etc	Field Survey, CEDD	GIS
7	Road size and alignment*	11	Size, width and alignment of roads in HK, including for vessel and pedestrian. Historical data included.	TD, LandsD, Field Survey	GIS, Textual
8	Weather Data (sun radiation, wind, temperature, humidity, precipitation)*	11	Weather related data including sun radiation, wind, temperature, humidity, precipitation, etc	HKO, Open Source, CEDD	GIS
9	Digital record plans	10	Record plans or approved plans of building, MEP, structural plans in digital format e.g. CAD	BD, EMSD	Scanned PDF

Rank	Information Required	Demand	Brief Description	Usually Obtained from	Type of Data
10	Soil/ water conditions*, GI record*	10	Textual, 2D GI record including soil and water conditions. Historical data included.	Field Survey, CEDD	GIS
11	OZP/land use/Statutory Plans	8	Statutory planning submission materials including OZP, land use, etc	PlanD	GIS, Hardcopy
12	Traffic Census and data (vessel only)	8	Traffic census and data for vessel only.	Field Survey, TD, Open Source	Textual/Table, GIS, API
13	Air Quality/pollution data*	7	Data related to air quality or air pollution	Field Survey, EPD	GIS
14	Existing E&M Installations	7	Existing/ as-fit E&M installations record	Field Survey, EMSD, CEDD, CLP	BIM, GIS, Scanned PDF
15	Digital basemap	6	Basemap of HK in digital format (2D GIS/CAD), e.g. Digital 1:1000 topographic map	Open Source Data, LandsD	GIS, CAD, Imagery, API
16	Noise Data	6	Noise statistics over time received from noise sensor	Field Survey	Textual/Table
17	Material Data (spec, performance and cost)	5	Construction material data including their specification, past performance, cost, etc	Supplier, software templates	Textual/Table
18	Energy and water consumption data*	4	Energy/water consumption of a building, with statistics grouped into AC, lighting, fans etc, or by floor/room	Owner/Developer	Textual/Table
19	Existing Infrastructure model	4	Models of existing infrastructure including highways, bridges, MTR tunnels, etc	HyD, CIC, CEDD, LandsD, Open Source	BIM, GIS
20	Pedestrian Network	4	Existing pedestrian network	Field Survey, Open Source	GIS
21	Groundwater table*	3	Groundwater table including historic data	Field Survey, CEDD	CAD, GIS
22	Health and Census data	3	Census data by Constituency Area/district, including demographic, life-expectancy, household income etc.	CSD	Textual/Table
23	Land Grant, Owners' Corporation data	3	Record of landowner, and whether a certain building has Owners' Corporation	LR	Textual/Table

Rank	Information Required	Demand	Brief Description	Usually Obtained from	Type of Data
24	Parking data	3	Locations, capacity, usage, etc. of existing carparks (Static) and parking spaces real-time availability (Dynamic)	Owner/Developer, Open Source	Table, GIS
25	Pedestrian Traffic Count Data (Telecom/ IoT)	3	Pedestrian count by IoT sensors located at site/building entrances or from mobile data signal provided by telecom companies	Field Survey	Textual/Table, GIS
26	Site surrounding building data	3	Data on buildings including their usage	Field Survey, LandsD, Open Source	Textual/Table, GIS
27	Slope Information	3	Properties of slop including gradient, aspect, vegetation cover, status etc.	CEDD, HyD	Textual/Table, GIS
28	Wind speed/pressure and air movement data	3	Wind speed, wind pressure from HKO or field check with an anemometer	HKO, Open Source	Textual/Table, GIS
29	3D laser scanned data	2	LiDAR/point-cloud data of a certain area	LandsD	LAS
30	BD order, OP Year, GFA	2	Statutory orders issued by BD record of occupation permit, Gross Floor Area concession	BD	Table
31	Road Limitations	2	Restriction on roads such as speed limit, types of vehicles allowed, certain time to access etc.	TD, HyD	GIS
32	Scheduled area and protection information	2	Boundary of protected zone under scheduled area 1-5, including the alignments and levels of protected structure e.g. MTR structure for scheduled area 3	MTRC	Scanned PDF
33	2D Topographical contour plan	2	Topographical plan in the form of 3D contour plan	CEDD, LandsD	GIS, CAD
34	Vehicle Specifications (dimensions and handling)	2	Vehicular specifications including length, width etc for swept path analysis	Manufacturer, software templates	Textual

Rank	Information Required	Demand	Brief Description	Usually Obtained from	Type of Data
35	3D laser scanned data (building)	1	LiDAR /point-cloud data of a certain building	Field Survey, LandsD	LAS
36	360 photos	1	Photos captured by a 360 camera	Field Survey, Open Source	Imagery
37	Aerial/ satellite imagery/ orthophotos	1	Aerial photographs, satellite imagery, orthophotos	LandsD	Imagery
38	Environment Data	1	General environmental data	EPD	GIS
39	Existing catchment information	1	Existing catchment location record/ information	LandsD, CEDD	GIS, Table
40	Landslide Statistics	1	Historical data on landslides in HK	CEDD	Table
41	Monuments Information	1	AMO data on Grad 1-3 historic buildings and declared monuments	AMO	Textual/Table, GIS
42	Plot ratio, height restriction	1	Development restrictions including plot ratio and height restrictions based on OZPs.	PlanD	Textual/Table
43	Property data (contract)*	1	Property contractual data including historical data.	Owner/Developer	Textual/Table
44	Rateable Value down to interest level (PRN)	1	Estimated annual rental value of a property at a designated valuation reference date,	RVD	Textual
45	Street Furniture Inventory GIS Data	1	Vector data of street furniture such as benches, traffic lights, lampposts, bollards etc.	Field Survey	GIS
46	Surface water and foul drain survey data (videos taken by CCTV)	1	CCTV video record on surface water and foul drain survey	IoT	GIS
47	Tree Record	1	Record of location of trees in an area	Field Survey	GIS
48	Water flow/discharge rate	1	Direction and volume of water flowing past a given point in the stream in a given period of time	Field Survey, IoT	GIS

*Historical data included

APPENDIX D – DATA AVAILABLE BY DATA PROVIDERS

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
1	Academic	CityU	3D Topographic map	2D CAD/ 2D GIS	DWG	0.3m	As it	Y
2	Academic	LingU	Roadside Air Quality Data	2D GIS/ Textual/Table	CSV	30sec	As it	Y
3	Academic	LingU	Roadside Meteorological Data	2D GIS/ Textual/Table	CSV	1min	As it	Y
4	Academic	PolyU	(TENTATIVE) 3D Model of Key Traffic Junctions	3D GIS	SHP	Unspecified	Unspecified	Y
5	Academic	PolyU	3D Geodatabase Framework	3D GIS	Unspecified	1m	Month(s)	Y
6	Developer	Ocean Park	EIA/EP	2D CAD	PDF	N/A	As it	Y
7	Developer	Ocean Park	General Building Plan	Textual	PDF	N/A	As it	Y
8	Developer	REDA	General Building Plan	2D CAD	DWG/DXF	According to requirement of BD	As it	Y
9	Developer	Swire	3D Topographic map	BIM	NWD	As detailed as GBP	As it	Y
10	Developer	Swire	As-fit BIM model (massing only)	BIM	NWD	As detailed as GBP	As it	Y
11	Developer	Swire	General Building Plan	Hardcopy/ Scanned PDF/ Image	PDF	As detailed as GBP	As it	Y
12	Developer	Wheelock	Design Drawing	Hardcopy/ Scanned PDF/ Image	PDF	1m	As it	Y
13	Government	ArchSD	(TENTATIVE) Approved statutory submission plans	Hardcopy/ Scanned PDF/ Image	PDF	Unspecified	Unspecified	Y
14	Government	ArchSD	As-built BIM models	BIM	RVT	50mm	As it	Y

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
15	Government	ArchSD	As-built layout plans	2D CAD/ 2D GIS	Unspecified	50mm	As it	Y
16	Government	BD	Building Records Access and Viewing On-line (BRAVO) System	Hardcopy/ Scanned TIFF or PDF(for GBPs and Scanned PDF for minor works)/ Image/	PDF (for minor works)	N/A	As and when necessary	Y
17	Government	CEDD	(TENTATIVE) List of Natural Hillside Catchments with Works Being Upgraded or Pending Upgrading Under Current Contracts	Table	CSV/XLSX	Unspecified	Monthly	N
18	Government	CEDD	(TENTATIVE) List of Study Areas Being Studied or Scheduled for Studying Under Current Agreements	2D GIS	FGDB	Unspecified	Monthly	N
19	Government	CEDD	(TENTATIVE) List of Substandard Government man-made Slopes Being Upgraded or Pending Upgrading Under Current Contracts	2D GIS	FGDB	Unspecified	Monthly	N
20	Government	CEDD	As-built BIM Models	2D GIS	FGDB	Subject to specification of the as-built structure	As it	Y
21	Government	CEDD	Landslide Warning Sign – Road with a History of Landslides	2D GIS	FGDB/SHP/ CSV	Unspecified	Yearly	N

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
22	Government	CEDD	Landslide Warning Sign – Slopes Affecting Squatters	2D GIS	FGDB/SHP/ CSV	Unspecified	Yearly	N
23	Government	CEDD	LiDAR Data	3D GIS	LAS	About 0.3 m (95%CL)	As and when necessary	Y
24	Government	CEDD	Registered Man-made Slopes	2D GIS	FGDB/SHP/ CSV	Unspecified	Monthly	N
25	Government	CEDD	The Quantity of Natural Sand from Mainland used in Construction Industry	BIM	NWD/NWC	Unspecified	Monthly	N
26	Government	DSD	(TBC) Underground Utilities 2D Drawings	Table	CSV	Unspecified	Unspecified	N
27	Government	DSD	(TENTATIVE) Chemical Dosage	Table	CSV	Unspecified	Half yearly	N
28	Government	DSD	(TENTATIVE) Effluent Quality	Table	CSV	Unspecified	Half yearly	N
29	Government	DSD	(TENTATIVE) Sewage Flow Data	Table	CSV	Unspecified	Half yearly	N
30	Government	DSD	As-built BIM model	Table	CSV	Unspecified	Unspecified	Y
31	Government	DSD	BIM Objects (shared with CIC)	Table	CSV	Unspecified	Unspecified	N
32	Government	DSD	Drainage Records	Table	CSV	Unspecified	Quarterly	N
33	Government	DSD	Expenditure of Project	Table	CSV	Unspecified	Yearly	N
34	Government	DSD	Factsheet (Environmental Management & Performance)	Table	CSV	Unspecified	Yearly	N
35	Government	DSD	Factsheet (Flood Prevention)	2D CAD	DWG/DXF	Unspecified	Yearly	N
36	Government	DSD	Factsheet (Sewage Services Charges)	Textual	JSON	Unspecified	Yearly	N
37	Government	DSD	Factsheet (Sewage Treatment)	Textual	JSON	Unspecified	Yearly	N
38	Government	DSD	Factsheet (Social Performance)	Textual	JSON	Unspecified	Yearly	N
39	Government	DSD	Factsheet (Stakeholder Engagement)	Textual	JSON	Unspecified	Yearly	N

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
40	Government	DSD	Laboratory Data and Sewage Flow Data	Textual	JSON	Unspecified	Monthly	N
41	Government	DSD	List of Facilities (Sewage Treatment Facilities, Stormwater Pumping Stations and Inflatable Dams)	BIM	RVT	Unspecified	Yearly	N
42	Government	EMSD	BIM Objects	BIM	RFA	Unspecified	Ad-hoc	Y
43	Government	EPD	Beach Water Quality Grading	Table	CSV	N/A	< 2 days	N
44	Government	EPD	Current Air Quality Health Index of individual Air Quality Monitoring stations	Table	CSV	Unspecified	Hourly	N
45	Government	EPD	Current air quality health index range and forecast	Table	CSV	Unspecified	Hourly and as necessary	N
46	Government	EPD	Historical Beach Water Quality Data	Table	CSV	Unspecified	Yearly	N
47	Government	EPD	Historical E. coli levels in Victoria Harbour from Central/Wan Chai to Siu Sai Wan since 2004	Table	CSV	Unspecified	Yearly	N
48	Government	EPD	Historical Marine Water Quality Data	Table	CSV	Unspecified	Yearly	N
49	Government	EPD	Historical River Water Quality Data	Table	CSV	Unspecified	Yearly	N
50	Government	EPD	Municipal solid waste generation quantity	Table	CSV	Unspecified	Yearly	N
51	Government	EPD	Municipal solid waste recovery quantity	Table	CSV	Unspecified	Yearly	N
52	Government	EPD	Past 24-hour Air Quality Health Index of individual Air Quality Monitoring stations	Table	CSV	Unspecified	Hourly	N

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
53	Government	EPD	Past 24-hour Pollutant Concentration of individual Air Quality Monitoring stations	Table	CSV	Unspecified	Hourly	N
54	Government	EPD	Past Record of Air Pollution Index	Table	CSV	Unspecified	Hourly	N
55	Government	EPD	Past record of Air Quality Health Index	Table	CSV	Unspecified	Half yearly	N
56	Government	EPD	Per capita waste disposal rates of selected waste categories	Table	CSV	Unspecified	Yearly	N
57	Government	EPD	Recent E. coli levels in Victoria Harbour from Central/Wan Chai to Siu Sai Wan	Table	CSV	Unspecified	Monthly	N
58	Government	EPD	Recent Marine Water Quality Data	Textual	JSON	Unspecified	Monthly	N
59	Government	EPD	Recent River Water Quality Data	Textual	RSS	Unspecified	Monthly	N
60	Government	EPD	Smart Lampposts Air Quality Data	Textual	RSS	Unspecified	5 minutes	N
61	Government	EPD	Total solid waste disposal quantity	Textual	RSS	Unspecified	Yearly	N
62	Government	EPD	Total solid waste disposal quantity by waste category	Textual	XML	Unspecified	Yearly	N
63	Government	EPD	Waste Less - Recyclable Collection Points Data	Textual	XML	Unspecified	As and when necessary	N
64	Government	HKO	9-day weather forecast	Table	CSV	Unspecified	Twice daily and as necessary	Y
65	Government	HKO	Climate change observations and projections	Table	CSV	Unspecified	Unspecified	Y

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
66	Government	HKO	Climate data (historical records) - free	Table	CSV	Unspecified	Unspecified	Y
67	Government	HKO	Climate data (historical records) - paid service	Table	CSV	Unspecified	Unspecified	Y
68	Government	HKO	Current weather forecast, warnings and observations in XML - paid service	Table	CSV	Unspecified	Unspecified	Y
69	Government	HKO	Current weather report	Table	CSV	Unspecified	Hourly and as necessary	Y
70	Government	HKO	Data of almanac information	Table	CSV	Unspecified	Yearly	Y
71	Government	HKO	Data on daily global solar radiation	Table	CSV	Unspecified	Monthly	Y
72	Government	HKO	Data on daily maximum and mean UV Indices	Table	CSV/API	Unspecified	Unspecified	Y
73	Government	HKO	Data on daily maximum, mean and minimum temperatures	Table	CSV/API	Unspecified	Monthly	Y
74	Government	HKO	Data on daily total bright sunshine	Table	CSV/API	Unspecified	Unspecified	Y
75	Government	HKO	Data on lightning locations	Table	CSV/DSV	Unspecified	Real-time	Y
76	Government	HKO	Data on predicted tides at 14 locations in Hong Kong	Table	CSV/DSV	Unspecified	Yearly	Y
77	Government	HKO	Data on visibility	Table	CSV/DSV/ API	Unspecified	Real-time	Y
78	Government	HKO	Latest 15-minute mean UV index from 7:00 a.m. to 6:00 p.m. Hong Kong time	Table	CSV/DSV/ API	Unspecified	Unspecified	Y
79	Government	HKO	Latest tidal information	3D GIS	JSON/API	Unspecified	Unspecified	Y
80	Government	HKO	Lightning count over Hong Kong territory in the past hour	Textual	JSON/API	Unspecified	Unspecified	Y
81	Government	HKO	Local weather forecast	Textual	JSON/API	Unspecified	Unspecified	Y
82	Government	HKO	Locally felt earth tremor report	2D GIS/	JSON/RSS/	Unspecified	Unspecified	Y

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
				Textual/Table	API			
83	Government	HKO	Quick earthquake messages	Textual	JSON/RSS/ API	Unspecified	Unspecified	Y
84	Government	HKO	Regional Weather in Hong Kong - the latest 10-minute mean visibility	Textual	JSON/RSS/ API	Unspecified	Unspecified	Y
85	Government	HKO	Regional Weather in Hong Kong - the latest 1-minute mean air temperature	Textual	JSON/RSS/ API	Unspecified	Unspecified	Y
86	Government	HKO	Regional Weather in Hong Kong - the latest 1-minute mean relative humidity	Textual	JSON/RSS/ API	Unspecified	Unspecified	Y
87	Government	HKO	Regional Weather in Hong Kong - the maximum and minimum air temperature from 1-minute mean temperatures since midnight	Textual	JSON/RSS/ API	Unspecified	Unspecified	Y
88	Government	HKO	Smart Lampposts Experimental Meteorological Data	Hardcopy/ Scanned PDF/ Image	PNG	Unspecified	10 minutes	Y
89	Government	HKO	Special Weather Tips	Textual	XML	Unspecified	Real-time and as necessary	Y
90	Government	HKO	Tropical cyclone track information	2D GIS/ Textual/Table	XML	Unspecified	Real-time and as necessary	Y
91	Government	HKO	Weather and radiation level report	2D GIS/ Textual/Table	Unspecified	Unspecified	Unspecified	Y
92	Government	HKO	Weather warning information/summary	2D GIS/ Textual/Table	Unspecified	Unspecified	As and when necessary	Y

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
93	Government	Housing Authority	Family Library Components (Revit) (Currently sharing with CIC)	BIM	RFA	Unspecified	As it	Y
94	Government	HyD	As-built BIM models	BIM	RVT	Mainly LOD 300	Ad-hoc	Y
95	Government	HyD	BIM Objects	BIM	RVT/NWD/ DGN/IFC/	50mm	Ad-hoc	Y
96	Government	LandsD	(TENTATIVE) 3D Digital Map	3D GIS	3Ds/FBX/ CityGML/ OBJ/OSGB/ Cesium 3D Tiles/TIFF/ LAS	Component not smaller than 50mm	Unspecified	Y
97	Government	LandsD	(TENTATIVE) 3D Indoor Map	3D GIS	3Ds/FBX/ VRML	Unspecified	Unspecified	Y
98	Government	LandsD	(TENTATIVE) 3D Pedestrian Network	2D CAD/ 2D GIS	FGDB/GML/ ASCII/DGN/ DWG	Unspecified	Unspecified	Y
99	Government	LandsD	3D Spatial Data	2D CAD/ 2D GIS	FGDB/GML/ DGN/DWG	Unspecified	< 2 months	Y
100	Government	LandsD	3D Visualization Map	2D CAD/ 2D GIS	FGDB/GML/ GeoTIFF/ DGN/DWG	1m	Unspecified	Y
101	Government	LandsD	DAP	2D CAD/ 2D GIS	FGDB/GML/ GeoTIFF/ DGN/DWG	1m	Ad-hoc	Y
102	Government	LandsD	DOP5000	3D GIS	GDB/XML	N/A	Ad-hoc	Y
103	Government	LandsD	DOPM50-L0	Hardcopy/ Scanned PDF/ Image	GeoTIFF	0.2m	Ad-hoc	Y

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
104	Government	LandsD	iB1000/5000	Hardcopy/ Scanned PDF/ Image	JEPG with world file	5m	2 weeks	Y
105	Government	LandsD	iB10000/20000	3D GIS	OSGB/OBJ	N/A	Half yearly	Y
106	Government	LandsD	iC1000	3D GIS	SHP/ GeoJSON	N/A	2 weeks	Y
107	Government	LandsD	iG1000	Hardcopy/ Scanned PDF/ Image	TIFF	N/A	2 weeks	Y
108	Government	LandsD	iGeoCom	Table	XLS/MDB	N/A	Quarterly	Y
109	Government	PlanD	3D Photo-realistic Building Models	3D GIS	OBJ, OSGB, Cesium 3D tiles and GeoTIFF	0.4m	As and when there is update	Y
110	Government	PlanD	Boundaries of New Towns (for 2016 Population By-census)	2D GIS	GeoJSON	N/A	1-2 Years	Y
111	Government	PlanD	Boundaries of Planning Data Districts	Hardcopy/Scanned PDF/Image / 2D GIS	GeoJSON	N/A	As and when there is update	Y
112	Government	PlanD	Cross-boundary Travel Survey 2017	Hardcopy/Scanned PDF/Image / Table	CSV	N/A	2-3 Years	Y
113	Government	PlanD	Departmental Plans (Adopted Outline Development Plans /Layout Plans)	Hardcopy/Scanned PDF/Image / 2D CAD / 2D GIS	DGN and GeoTIFF	N/A	As and when there is update	Y

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
114	Government	PlanD	List and Information of Statutory Plans Gazetted	Table	XML	N/A	As and when there is update	Y
115	Government	PlanD	Planning Applications Considered by the Town Planning Board	Table	XML	N/A	Quarterly	Y
116	Government	PlanD	Projections of Population Distribution2019-2028	Table	CSV	N/A	1-2 Years	Y
117	Government	PlanD	Raster Grids on Land Utilization	Hardcopy/Scanned PDF/Image / Table / 2D GIS	GeoTIFF and CSV	N/A	Year(s)	Y
118	Government	PlanD	Satellite Imagery	2D GIS	TIFF	6m	Year(s)	Y
119	Government	PlanD	Site Wind Availability Data	Hardcopy/Scanned PDF/Image / Table / 2D GIS	CSV, GeoJSON and GeoTIFF	N/A	As and when there is update	Y
120	Government	PlanD	Statutory Plans	Hardcopy/Scanned PDF/Image / 2D GIS	SHP/GML/ GeoJSON	N/A	As and when there is update	Y
121	Government	PlanD	Strategic Viewing Points	Hardcopy/Scanned PDF/Image / 2D GIS	GeoJSON	N/A	As and when there is update	Y
122	Government	PlanD	Territorial Population and Employment Data Matrix	Hardcopy/Scanned	CSV and PDF	N/A	2-3 Years	Y

No	Business Nature	Organisation Name	Data Name	Format	File Extension	Accuracy	Update Frequency	Mentioned in Questionnaire
			(2016-based Generalised Version)	PDF/Image / Table				
123	Government	PlanD	Tertiary Planning Unit and Street Block/Village Cluster Boundaries (2006/2011/2016)	Hardcopy/Scanned PDF/Image / 2D GIS	GeoJSON	N/A	As and when there is update	Y
124	Government	TD	Base District Traffic Models	Textual	DAT	N/A	Unspecified	Y
125	Government	WSD	Point cloud records of watermains	3D GIS	PTS	Unspecified	As it	Y
126	Government	WSD	Standard drawings	Hardcopy/Scanned PDF/Image	PDF	Unspecified	As and when there is update	Y
127	Government	WSD	Underground waterworks assets	2D GIS /3D GIS (partially available)	SHP	Unspecified	As and when there is update	Y
128	Government	WSD	Waterworks BIM models	BIM	RVT/RFA, DWG	Unspecified	As and when there is update	Y
129	Quasi-Govt	Hospital Authority	(TENTATIVE) 3D Building Envelope	BIM	Unspecified	Unspecified	Unspecified	Y
130	Quasi-Govt	Hospital Authority	Building line layout	2D CAD/2D GIS	DWG	from as-built records	As it	Y
131	Quasi-Govt	Hospital Authority	Sound receiver locations	Hardcopy/Scanned PDF/Image	PDF	approx. location	As it	Y
132	Quasi-Govt	Hospital Authority	Topographic survey drawing	2D CAD/2D GIS	DWG	from as-built records	As it	Y
133	Quasi-Govt	URA	BIM model	BIM	RVT/IFC	50mm	As it	Y

Membership List

Member	Representing Organisation / Remarks
Ar. Ada FUNG Ir Dr Richard PANG Mr. Alex HO Mr. Ron NG Mr. Lok FUNG	Construction Industry Council
Mr. Vincent CHOW Mr. Boris YIU Mr. Eric CHAN Mr. Kennis WAN	Development Bureau (Works)
Ms. Winnie SHIU Mr. YC Chan	Development Bureau (PLB)
Mr. Alex CHU Mr. Nelson YAM Mr. Michael LAU	Lands Department
Mr. Joseph Jerry AUSTIN Mr. WONG Wai Yin, Vincent Mr. Rico TSANG Ms. Jenny LAI	Planning Department
Mr. AU YEUNG Hoi-pang Ms. CHAN Yuen Ming Mr. Mark LAI Mr. Patrick WONG	Buildings Department

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- Buildings Department
- City University of Hong Kong
- Civil Engineering and Development Department
- Chartered Institute of Architectural Technologists
- Cundall
- Development Bureau
- Drainage Services Department
- Electrical and Mechanical Services Department
- Fraser Construction Co., Ltd.
- Highways Department
- Hong Kong Housing Authority
- HK General Building Contractors Association Ltd
- Hospital Authority
- Hip Hing Construction Company Ltd
- Joint Utilities Policy Group
- Lands Department
- Lingnan University
- LWK & Partners (HK) Ltd
- Leighton Contractors (Asia) Ltd
- MTR Corporation
- Mott MacDonald
- Nan Fung Group
- New World Development Company Ltd
- New World Telecommunications Ltd.
- Office of the Government Chief Information Officer
- Ove Arup
- Planning Department
- P&T Group
- Royal Institution of Chartered Surveyors
- Sun Hung Kai Properties Ltd
- Swire Group
- The Airport Authority Hong Kong
- The Association of Consulting Engineers of Hong Kong
- The Chartered Institute of Building
- The Association of Consulting Engineers of Hong Kong

- The Hong Kong Institute of Architects
- The Hong Kong Institute of Building Information Modelling
- The Hong Kong Institution of Engineers
- The Hong Kong Institute of Surveyors
- The Hong Kong Construction Association
- The Hong Kong Federation of Electrical & Mechanical Contractors Limited
- The Hong Kong Institute of Architects
- The Hong Kong Institute of Building Information Modelling
- The Hong Kong Institution of Engineers
- The Hong Kong Institute of Surveyors
- The Mass Transit Railway Corporation
- The Real Estate Developers Association of Hong Kong
- The West Kowloon Cultural District
- The Chinese University of Hong Kong
- The Hong Kong Polytechnic University
- The Hong Kong Institute of Planners
- The Hong Kong and China Gas Company Limited
- The University of Hong Kong
- Hong Kong Institute of Urban Design
- Hong Kong University of Science and Technology
- Hong Kong Electric Company
- HGC Global Communications
- Hong Kong Telecom
- Urban Renewal Authority
- Water Supplies Department
- West Kowloon Cultural District
- Wheelock Properties (Hong Kong) Limited
- Wecon Construction & Engineering Ltd

The CIC thanks all stakeholders who have participated in the Seminars / Webinars and/or Forums and offered opinions

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Comprehensive	❑	❑	❑	❑	❑
Useful	❑	❑	❑	❑	❑
Practical	❑	❑	❑	❑	❑
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	❑	❑	❑		
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	❑	❑	❑		
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CIC Secretariat – BIM
E-mail: bim@cic.hk;
Address: 38/F, COS Center, 56 Tsun Yip Street, Kwun Tong, Hong Kong
Fax No.: (852) 2100 9090

Construction Industry Council

Address : 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