

# Development and Challenges of Spatial Data Infrastructure in Hong Kong

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**Key words:** Spatial Data, Spatial Data Infrastructure (SDI), Common Spatial Data Infrastructure (CSDI), Framework Spatial Data (FSD), Common Sharable Data (CSD)

## **ABSTRACT:**

Opening up and wider sharing of spatial data is strategic for the future of Hong Kong. In 2017, after over two decades where the first spatial data infrastructure was initiated, the Hong Kong SAR government finally set out its Smart City Blueprint in the need of formally establishing a Common Spatial Data Infrastructure for the city (OGCIO, 2017). It aims to empower the Government and the society as a whole with convenient, easily accessible, high quality and up-to-date spatial data, applications and spatially enabled services.

This initiative is expected to have the ability to support the long-term vision of Hong Kong through the provision of a critical spatial data infrastructure that maximizes innovation, knowledge sharing and value creation for different segments of the society starting from the Government. Properly planned, coordinated and executed, the availability of diverse types of spatial data could possibly foster the development of Hong Kong into a more liveable, competitive, innovative, sustainable and smart city.

In support of the CSDI initiative, new institutional arrangement has been set up. Bureaux and Departments (Departments) currently collecting, providing or using spatial data joined hands in different working groups to develop data standards and prepare spatial data for wider sharing.

Challenges exist in this cross-sector, cross-organisation initiative which involves different stakeholders. The data exchange standards development, the data preparation works, the new workflows, the new responsibilities of the data owners and the SDI platform development works are some of the major challenges. The alignment of the CSDI with the Hong Kong 3D Digital Map project, which is going on in parallel, is another challenge. They are logically part of the same larger objective to create the Hong Kong Digital Twin. They are also the foundation to support the development of Smart Hong Kong for effective and sustainable development and

city management. Furthermore, besides technical issues to be overcome, the paper will also share how the institutional, resources and cultural issues are handled in the CSDI development in Hong Kong.

# **Development and Challenges of Spatial Data Infrastructure in Hong Kong**

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## **1. Background/Introduction**

The Hong Kong Special Administrative Region (HKSAR) have been committing in data interoperability and data sharing among different government departments and/or public since 2000's. One of the examples is the project called Data Alignment Measures (DAM). This project led by the then Housing, Planning and Lands Bureau of the HKSAR government in 2004, aims to improve the efficiency and effectiveness in exchanging of planning, lands and public works related data owned by relevant government departments. The project also address deficiencies arising from data definition, compatibility of data format, data quality, turnaround time and etc.

Survey and Mapping Office (SMO) of the Lands Department (LandsD) has been actively involved in collecting, processing and managing spatial data for decades. Spatial data are being applied in a wide range of land related activities since the adoption of Geographic Information System (GIS) technology and the digitisation of topographic maps and cadastral records in the early 90's. Understanding the needs and benefits of wider sharing of spatial data, SMO has initiated the development of the Geospatial Information Hub (GIH) service in 2002 which has greatly improved the accessibility of a wide range of spatial data across government agencies and minimized duplicative effort in spatial data handling and applications development (Tsoi, 2007). To further improve the availability of spatial data to the public, SMO has also launched the GeoInfo Map service on the Internet in 2010 which is a sophisticated web-based geographic information sharing service to facilitate the discovery, viewing, retrieval and use of different spatial data from different sources by the public. Spatial data on the GeoInfo Map cover the public facilities, land, environment, government services, public health and transportation domains. It also enriches textual addresses presented on government websites with interactive web maps. (Tsoi, et al. 2013)

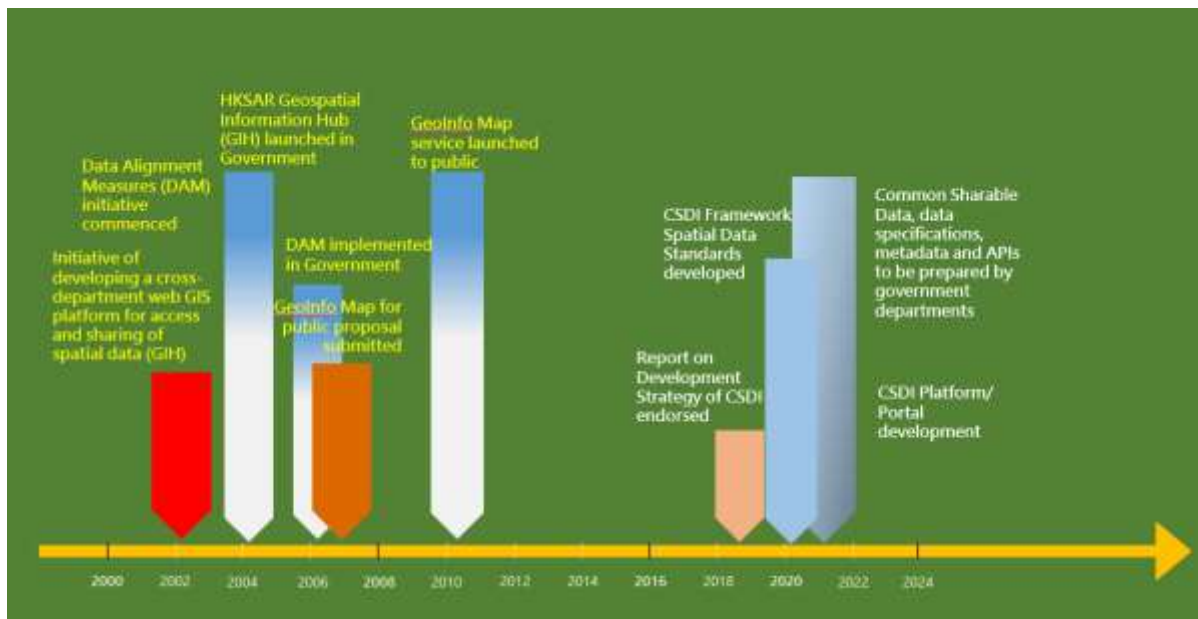


Fig. 1 Major and large scale spatial data access and sharing initiatives in Hong Kong

Apart from the digital topographic map and land parcel datasets, SMO continues to offer new spatial data, such as the geo-community data, digital orthophoto, 3D mesh models and 3D pedestrian network data to the society.

In 2016, LandsD started on the implementation of Map API, allowing government users to develop their GIS applications without the need of acquiring and processing the raw spatial data on their own. Since 2019, the Map API has been made available to government departments for trial uses and this new service is gaining attention from government agencies for supporting their mapping application development. The service was extended to the community, private sectors and academia in late 2020.

In 2018, SMO launched the Hong Kong GeoData Store (HKGDS) which facilitates the discovery and dissemination of geospatial data in open format together with Application Programming Interfaces (APIs), including Location Search API, Identity API, etc.

All of the above spatial data initiatives facilitate and support various socio-economical activities as well as smart city initiatives and applications. They also foster innovative use of geospatial data by government departments, software application developers, academia, research and consulting firms and the public.

With the HKSAR government supports in 2019, a green light was given for the development of a CSDI to support the advancement of smart city development in Hong Kong.

## **2. Objectives of the CSDI initiative**

To embrace innovation and technology in building a Smart Hong Kong, the Government published the *Smart City Blueprint for Hong Kong* (OGCIO, 2017) and *Smart City Blueprint for Hong Kong 2.0* (OGCIO, 2020) to set out the development strategies and initiatives to enhance the city management measures and services under the six smart areas, including “Smart Mobility”, “Smart People”, “Smart Environment”, “Smart Living”, “Smart Government” and “Smart Economy”. To support the adoption of technology by the Government, business sector and the public, the development of CSDI and the use of open data were encouraged to facilitate sharing of geo-spatial data and to develop more innovative applications and services.

The development of CSDI aims to support Hong Kong to become a smarter city. Through the provision of spatial information and services, different stakeholders including Departments, business sectors and the community are expected to benefit in the following aspects:

For Departments – the development of CSDI aims to increase interoperability, accessibility and usability of spatial data among different Departments for reducing duplicative efforts in service delivery and work processes. It also promotes the use of geospatial intelligence and shared applications within the Government. The use of geospatial data also enriches the geospatial capability and foster a collaborative culture within the Government.

For business sectors and community – the implementation of CSDI increases accessibility of spatial data. It encourages the business sector and start-ups to make use of spatial data to explore innovative applications and create value-added spatial products. It can also promote the use of geospatial intelligence and shared applications in the society.

## **3. Institutional setting**

The CSDI is not merely about building a digital infrastructure for consolidating and sharing spatial data, but a paradigm shift and capability-building exercise requiring spatial data owners and users to adopt new mindset and openness to share data, overcome inertia and break silos.

In 2018, the Development Bureau (DevB) of the Government commenced a consultancy study on the development strategy of a CSDI with an aim to recommend the way forward and roadmap for the Government to development a CSDI (refers to Section 4 for details of the study).

In terms of the institutional setting, the consultancy report recommends and the Government accepts to establish a three-tiered governance structure for the development, implementation and operation of CSDI. The proposed three-tiered governance structure is illustrated at Figure 2.



Fig. 2 Organisation Framework of CSDI

**Top Tier**

The top tier is the existing Steering Committee on Innovation and Technology (SCIT) which is responsible for steering the holistic smart city development of Hong Kong, involving different policy areas and requiring co-operation and co-ordination across bureaux. SCIT can ensure that CSDI, being a key component and infrastructure of smart city development, could fit together with the latest strategy for promoting smart city, draw synergy with other government initiatives, and capitalize on the existing institutional framework at high-level. Placing the CSDI strategic framework under the steer of SCIT also ensures that it will be taken forward as a cross-bureau

and whole-government initiative, which is essential to the success of CSDI.

### **Middle Tier**

The middle tier is the Common Spatial Data Steering Committee (CSDSC), co-chaired by the DevB and the Innovation and Technology Bureau, which serves as the key body for providing CSDI policy and strategic oversight. It is also the key body for providing the strategic oversight for the establishment and development of CSDI as a government-wide infrastructure for spatial data management. The CSDSC is responsible for setting out the objectives and guiding principles of CSDI, steering the policy formulation and developments related to spatial data, coordinating the various work streams that are undertaken by the working groups initiating studies, surveys, reviews and other initiatives in relation to the development of CSDI. It also take up the roles in resolving conflicts across different Departments and preventing overlapping or duplicating work amongst government agencies.

A Spatial Data Office (SDO) has been formed under the DevB to serve as the executive arm of CSDSC to oversee the building and management of the CSDI, identifying and prioritizing spatial data to support the phased development of the CSDI, and monitoring the execution of capacity building, outreach and partnership initiatives.

The Common Spatial Data Advisory Committee (CSDAC) has been setup to advise the Government, through the CSDSC, on the development of the CSDI in Hong Kong. The committee is chaired by the Director of Lands and comprised of the representatives from Departments and non-official members from construction industry, geospatial and IT related groups, academics, public utilities and etc. The committee can also share the leading industry and international practices, know-how, standards and trends for the development of spatial data infrastructure, initiatives for sharing of spatial data in the society, potential applications of spatial data under CSDI and the formulation of engagement plans for relevant stakeholders and the public.

### **Third Tier**

Three working groups have been set-up with involvement of key government agencies from 18 Departments for planning, implementing and reviewing the key components of CSDI from different aspects. All strategies, plans, programmes and initiatives proposed by the working groups should be reviewed and approved by CSDSC.

The CSDI Data and Application Working Group (DAWG) is responsible for the formulation and implementation of spatial data policy related to spatial data generation, collation, management and sharing in relation to CSDI. DAWG is also responsible for identifying spatial datasets for releasing to use, steering consultancy studies commissioned by LandsD or any other Departments on establishment of data standards for CSDI, reviewing guidelines, data definition and standards, technical specifications of the spatial data to facilitate spatial data alignment, sharing and applications. Recommendation and advice on the common application which involves the use of spatial data from CSDI and the coordination among Departments on data sharing and integration to support Departments applications would be discussed in DAWG.

The CSDI Portal Working Group (PWG) is responsible for steering and monitoring the development and implementation of the CSDI Platform and Portal, including a cloud-based platform, a web portal and a range of spatial data services and tools.

The CSDI Capacity Building and Promotion Working Group (CBPWG) is responsible for building up the capacity of various Departments in the awareness and the adoption of the CSDI and promoting the same to business, the academia and the general public to suit the needs of society and economy. Capacity building and engagement programme for power up Departments' capabilities and engaging business, academia and wider community would be initiated and formulated by CBPWG to increase the awareness on the adoption of the CSDI for data-driven decision making and boosting digital economy and spur innovation.

To facilitate the implementation of CSDI, SMO, with its wealth of experience in GIS data management and system implementation, takes up the key role in the implementation of CSDI including: 1) to establish spatial data standards for compliance by Departments in releasing and sharing their spatial data onto the CSDI Platform; 2) to review and explore new Framework Spatial Datasets which will be included in the CSDI Platform and discoverable via the portal; and 3) to design and implement a modern, scalable, resilient and secure CSDI Platform. SMO is working together with the Departments in the implementation of data standards and CSDI platform for the Government.

#### **4. Key Building Blocks of CSDI initiative**

To formulate an effective CSDI development strategy, a consultancy study namely "*Consultancy Study on Development Strategy of a Common Spatial Data Infrastructure*", was



conducted in July 2018. The local context for CSDI development, potential vision and mission, objectives and guiding principles for a future CSDI were recapitulated in the study. 5 key building blocks have been identified as essential components for the development of CSDI, including:

#### Leadership and governance

The governance framework as stated in Section 3 above is formed for the development, implementation and monitoring of CSDI. A clear mandate from SCIT has been given, which requires the department to open up their spatial data through the CSDI unless there is a confidential, privacy or other reasonable justifications. This clear policy mandate is the key to sustain the development of CSDI and provides the authoritativeness to make decisions, resolve conflicting issues amongst different stakeholders and allocate responsibilities.

#### Framework Spatial Data (FSD) and Common Shareable Data (CSD)

FSD and CSD of priority interest were selected and identified through the consideration of possible use cases and applications. LandsD commenced a consultancy service, namely “*Establishment of Data Standards for Framework Spatial Data and Design of Process, Mechanism and Architecture of a Common Spatial Data Infrastructure (CSDI) Platform*” in mid-2018, to establish standards for FSD to ensure a common understanding and language. FSD provides fundamental context and reference information to the city and builds the foundation for which other spatial data are linked. Regarding CSD, these datasets are usually needed in common by a smaller number of organisations and the criticality of this information is less than one would find with FSD. Detailed descriptions of the development of each FSD and CSD are provided in Sections 5 and 6 of this paper.

#### Operating model and technology

The objective of this building block is to provide a scalable, technically feasible and secured sharing platform with a portal for the exchange of quality and up-to-date spatial information, services and applications in a readily accessible manner. The design of the CSDI Platform will facilitate users with different needs to access and consume the data and service effectively. It is expected that the CSDI Platform can provide services to maximize benefits for the public as a whole.

A conceptual operating model for the CSDI Platform was designed to facilitate effective exchange of spatial information and services for the users. The model was intended to be setup

as a multi-tier architecture to separate each tier from the rest. A more detailed description on the operating model is provided in Section 7 of this paper.

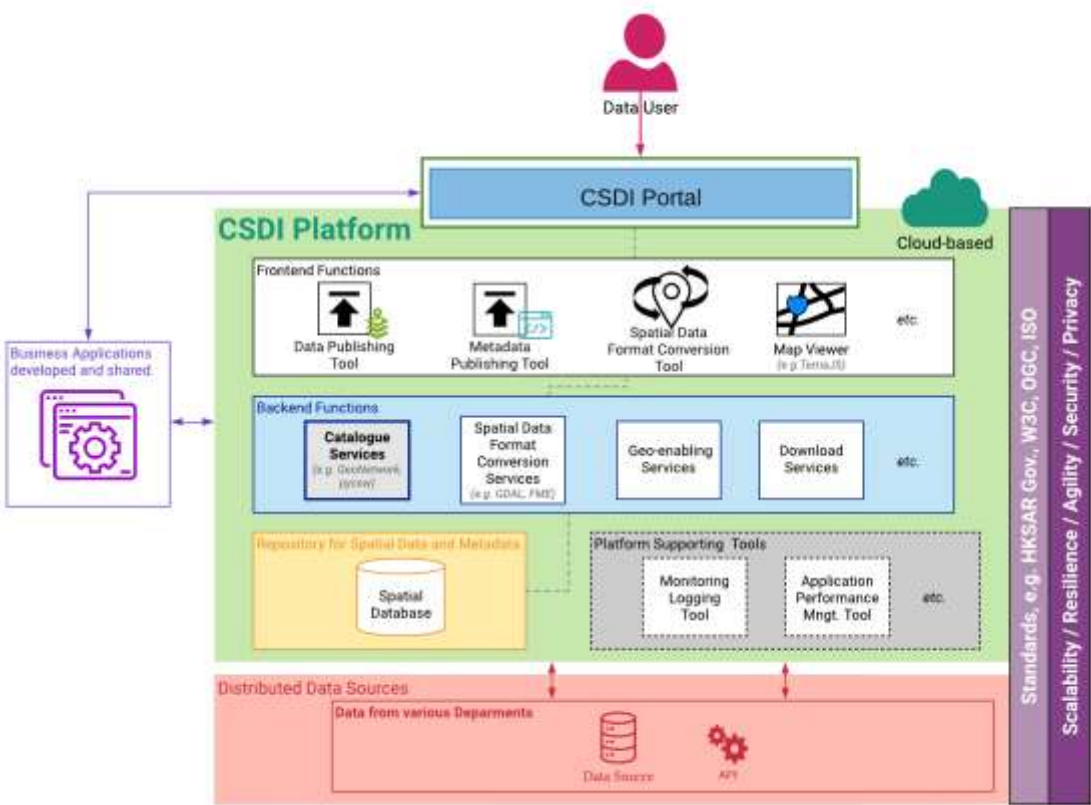


Fig. 3 Conceptual Operation Model for CSDI Platform.

The layers contained in the CSDI operation model were listed below:

Layers	Descriptions
Data Sources	Spatial data or non-spatial data with metadata stored and managed in the individual systems are linked to the envisioned CSDI Platform. Geo-enablement is required for the non-spatial data
CSDI Platform	A cloud-based platform which comprises of infrastructure, software and services, includes access controls, authentication and user management functions.
Repository of spatial data and metadata	Spatial data and the metadata are stored in the repository for quicker access and easier discovery. The repository for spatial data and metadata in CSDI Platform is designed with flexibility to support both centralised and distributed data dissemination.
Business	Applications developed by users will be linked to the CSDI portal for

applications	sharing.
Standards	Commonly recognized standards (i.e., OGC and ISO standard) will be adopted in CSDI Platform.
Privacy/security	Built-in security measure and privacy protection will be provided.

Table 1 Layers contained in CSDI Operation Model

### Funding and charging

To motivate different organisations including the public, business sectors, research institutions and application developers for exploring the value and benefit of spatial data, funding will be allocated to different area for enabling collaboration across government agencies, expanding the implementation of geospatial services, promoting the development of spatial applications, creating sustainable value for public service delivery, etc.

### Capacity building, outreach and partnership

The participation and collaboration in the sharing and using of spatial data and service among the Government, businesses, the academia and the wider community is the key to foster the development of smart Hong Kong, and the environment enabling different stakeholders' groups to engage in the CSDI is important. Although the access to CSDI would be limited to government agencies at the beginning, access to spatial data, service and application would be granted to more stakeholders eventually. Since some of the data of public interest may be held by the private sector, potential partnership programme can be explored and initiated by the Government or business sector to address issue of mutual interest.

## **5. Framework Spatial Data standards development**

In support of the CSDI initiative, a consultancy service, namely "*Establishment of Data Standards for Framework Spatial Data and Design of Process, Mechanism and Architecture of a Common Spatial Data Infrastructure (CSDI) Platform*", was completed in June 2020 for developing data standards for FSD, design and formulate the mechanism and the CSDI architecture to support the effective discovery, sharing, conversion, retrieval and use of spatial data. Totally 21 FSD are identified and they are grouped into 7 Framework Spatial Data Themes (FSDTs). These 7 FSDTs form a standard geographic framework for geocoding or referencing by other data sets. A summary of the 7 FSDT is listed below:

Framework Spatial Data Theme		Framework Spatial Data
A	Coordinate Reference System	1 Coordinate Reference System
B	Geographic Name	1 Place Name 2 Hydrographic Name 3 Relief Name 4 Street Name
C	Administrative Area	1 HKSAR Boundary 2 18 District Council Districts 3 Tertiary Planning Unit
D	Land Parcel (Cadastral Data)	1 Lot 2 Short Term Tenancy (STT) 3 Government Land Allocation (GLA) 4 License 5 Slope Maintenance Responsibility Boundary
E	Building	1 Proposed Building/Podium 2 Active Building/Podium 3 Demolished Building/Podium
F	Transportation	1 Road Centreline 2 Road Network 3 Digitised Traffic Aids Drawings 4 Traffic Census
G	Address	1 Address

Table 2 CSDI Framework Spatial Data Themes

The scope and data definitions, data contents and structures, data specifications, quality and accuracy, respective metadata specifications and templates, data compilation processes and workflow, and requirements on data validation for the 7 FSDTs were developed with the joint effort of participating departments. Additionally, 5 new potential FSDTs namely Imagery, Elevation, Geomorphology, Places and Basemap, were identified. The scope and exchange standards of these potential FSDTs will be separately studied in a later stage.

Using Building FSDT as an example, representatives from 7 government departments who are the current users and providers of the related spatial data are invited to participate in the establishment of data exchange standards of the Building FSDT. A working group was formed to discuss the data specifications for effective exchange, creation and updating of both geometries and attributes related to buildings. Similarly, representatives from different government departments also participated in the preparation of the other 6 FSDTs.

Under the Building FSDT, 4 major sub-themes (i.e. Building Footprint, Building Shell, Floor and Unit) were defined. The Building Structure under Building Footprint sub-theme is associated with Building Installation sub-theme, which can be bounded by Building Surface such as roof and wall. The Building Shell sub-theme contains various Building Installation, Surface and Opening. For Interior spaces, they are defined as Floors and Units sub-themes, which can also be bounded by Surfaces and contain Openings. The Logical Data Structure of the Building FSDT, Physical Data Model (Partial) and Entity Description (Partial) are shown in Figures 4 - 6 below for illustration.

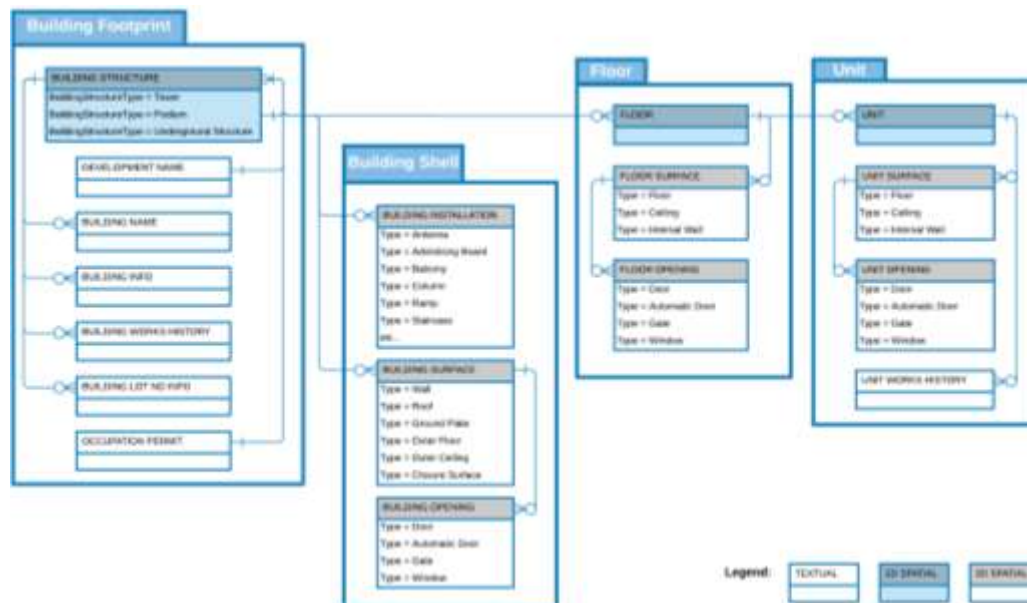


Fig. 4 Logical Data Structure – Building Theme

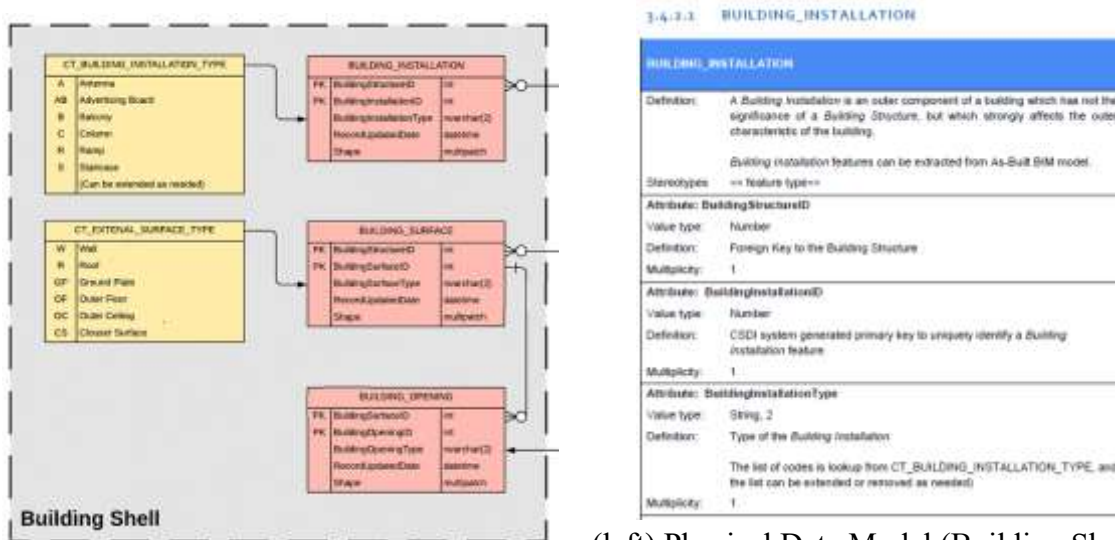


Fig. 5

(left) Physical Data Model (Building Shell) and

Fig.6 (right) Entity Description (for Building Installation under Building Shell)

## 6. Thematic (or Common Sharable Dataset) scope and requirements

CSD contains spatial features on specific topics or themes. The SDO continuously liaises with different Departments to explore more suitable spatial datasets to be published on the CSDI Platform and accessed via its portal. In early-2021, more than 300 sets of CSD contributed by over 30 Departments are identified and will be released via the CSDI portal for free download (*refer to Fig. 7*). SDO will continuously liaise with different Departments to identify more spatial data to be released on CSDI portal. An annual exercise will be carried out to invite Departments to review their office's latest situation with an aim to further open up more spatial datasets. In the long run, public or commercial organisation will be invited to open up their spatial data and share with others through the CSDI portal. Summaries of the identified datasets are listed in the charts below for reference:

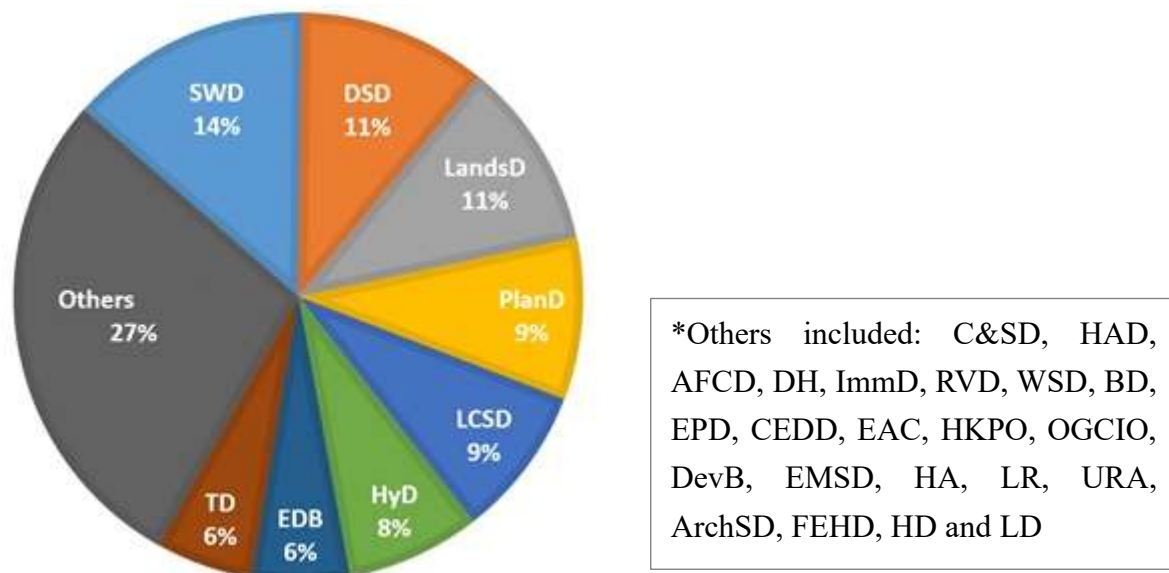


Fig. 7 Collaborative Effort of Departments<sup>1</sup> in Opening Up Spatial Data for the Public

<sup>1</sup> Others included: Agriculture, Fisheries and Conservation Department (AFCD), Architectural Services Department (ArchSD), Building Department (BD), Civil Engineering and Development Department (CEDD), Census and Statistics Department (C&SD), Development Bureau (DevB), Department Health (DH), Drainage Services Department (DSD), Electoral Affairs Commission (EAC), Education Bureau (EDB), Electrical and Mechanical Services Department (EMSD), Environmental Protection Department (EPD), Food and Environmental Hygiene Department (FEHD), Hospital Authority (HA), Home Affairs Department (HAD), Housing Department (HD), Highways Department (HyD), Hong Kong Post Office (HKPO), Immigration Department (ImmD), Labour Department (LD), Lands Department (LandsD), Leisure and Cultural Services Department (LCSD), Land Registry (LR), Office of the Government Chief Information Officer (OGCIO),

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Planning Department (PlanD), Rating and Valuation Department (RVD), Social Welfare Department (SWD),  
Transport Department (TD), Urban Renewal Authority (URA) and Water Supplies Department (WSD).

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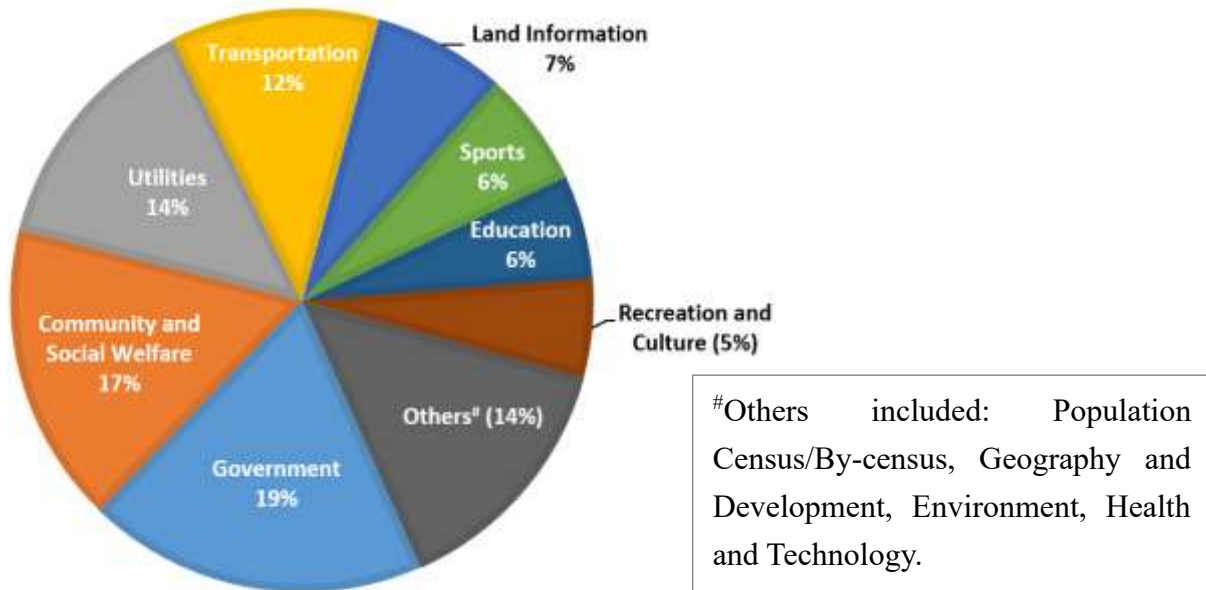


Fig. 8 Different Categories of Spatial Data

In order to enable the data users to readily explore, discover and consume the CSD, all the CSD which will be published on the CSDI Platform and access via the portal have to fulfill 5 basic requirements which are as follows:

- Spatially-enabled datasets  
The datasets to be released on the CSDI Platform will be spatially enabled. Geo-tagging of textual/non-spatial data involves the adding of geographical information such as latitude, longitude, grid coordinates, or administrative boundaries and addresses.
- Provided with a Data Specifications  
Spatial data to be released on the CSDI Platform must meet the established data specifications with detailed description of the data, including the data definition, content and structure, quality, workflow, maintenance, delivery and exchange.
- Metadata  
Spatial data released on the CSDI Platform will contain metadata which describe the source and definition of the dataset, update time and contact information, etc.



- Open and machine-readable format(s)  
Open and machine readable data format can be processed automatically by software without human intervention to facilitate programming and spurring community innovation. The data format of typical spatial data released on the CSDI Platform will be in GeoJSON, GML, KML and CSV formats which are commonly used.
- Application Programming Interface (API)  
API tool enables software application to share its data and functions with other software applications. It can greatly facilitate application development by allowing application developers to integrate specific functionalities and data to their applications without having to “reinvent the wheel” and spending time to create functionalities and data that already exist.

## **7. Operating Model**

Different options on the operating model has been considered in the early state of system architecture design including centralized hub, curated cloud, distributed model, etc. Different models have their strengths and weaknesses. After a full consideration of the options, it is decided to adopt a hybrid model as it will be most appropriate for Hong Kong.

In this hybrid model, a set of policies and roles and responsibilities of different stakeholders (e.g. data owner, data agent, system owner, system administrator, etc) have been discussed and agreed among the participating departments. SMO takes up the role of data agent to support the data owners to publish their spatial data on the CSDI Platform and make them accessible through CSDI portal. Tools which facilitate the data owners to geo-tag their non-spatial data, to prepare their metadata and data specifications have been developed and provided by SMO. Besides, a new system for data validation would also be designed and developed to support data owners in validating their datasets before they are published on the CSDI Platform and Portal. In addition, the validated datasets will also be published as web map services via the CSDI Platform.

Besides, the CSD are hosted in either centralized or distributed approaches. For centralized approach, the spatial data will be stored in a repository maintained under the CSDI Platform. The Department who created the data would be responsible for updating and maintaining their own data and passing the data physically to the CSDI central repository. For distributed approach, the spatial data will be hosted by the data owner’s system. To enable data users to

discover the data, the data owners are required to provide the related metadata to the CSDI Platform through a catalog service so that the platform can harvest the spatial data for the discovery, exploration and consumption by data users.

Cloud based architecture will be adopted in developing the CSDI Platform and portal as it provides the CSDI with lower operating costs over time while maintaining the same level of reliability that an on premise system can provide. Cloud based architecture would also provide scalability and flexibility to expand system capacity over time on an as-needed basis. Utilizing Cloud-based services from its marketplace, such as automated service management, system monitoring and backups, will make the implementation and operation efficient.

## **8. Challenges**

### Policy and Governance Support

A comprehensive and detailed CSDI Programme Design including many interrelated policy, institutional, operational and technical factors are yet to be defined in Hong Kong. Therefore, there is a need for an integrated Programme Design for the CSDI in the near future, with close coordination and oversight with the other Smart City initiatives, to ensure that the CSDI programme can be carried out in the most effective manner possible. With reference to the international SDI examples, an effective SDI actually comprises an architecture of many interdependent parts that must be planned and implemented by the Government in a well-researched and coordinated manner for the programme to run effectively.

### Revamping of Existing Systems

The CSDI Platform targets to promote effective data sharing and avoid duplication of effort. After the launching of the CSDI Platform and portal, Departments may review their operation of their existing systems, in consultation with the relevant stakeholders to explore any integration or revamping could be done to best use of the government resources.

### Sustainability of 3D Digital Map

For the development of a true 3D Smart City Digital Twin database for Hong Kong and to initiate 3D capture for new buildings and major renovations, effort should be undertaken to develop GIS-ready CAD and BIM architectural design and as-built drawing data submission standards as part of the building permit processes in Hong Kong. This is an area to be further explored and developed with consultation of relevant bureaux, departments and stakeholders.

### Sustainable Development of CSDI

The alignment of the CSDI and the Hong Kong 3D Digital Map projects which are logically part of the same larger objective to create the Hong Kong Digital Twin database that will provide the foundation for Smart Hong Kong as an advanced, integrated system for effective sustainable development and city management. It is also paramount to set up a supportive ecosystem among the Government, business, academic and the wider community which are spatially knowledgeable in tapping on the potential of CSDI.

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