Development of the Government BIM Data Repository in Hong Kong

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Key words: BIM data repository; BIM harmonisation; BIM data standard; BIM data validation; BIM to GIS data conversion; smart city development; digital twin

SUMMARY

With the increasing adoption of Building Information Modelling (BIM) in the construction industry and the growing importance of data-driven decision-making, the establishment of a centralized BIM data repository becomes crucial for developing Hong Kong into a world-class smart city to enhance the effectiveness of city management and sustainable development.

Pursuant to the release of Smart City Blueprint for Hong Kong in 2017 which sets out the overall framework and strategy for the use of innovation and technology to develop Hong Kong into a spatially enabled smart city including the adoption of BIM in capital works projects and the development of Common Spatial Data Infrastructure (CSDI) and 3D Digital Map, the Government of the Hong Kong Special Administrative Region further promulgated policies to mandate the use of BIM for all government capital works projects over HK$30 million in 2019 and formulated a harmonized BIM data standard for the works departments to adopt when preparing their design and as-built models for submission to the Lands Department to facilitate the development of the Government BIM Data Repository.

In order to further foster BIM adoption in Hong Kong, the Lands Department has taken up the key roles in establishing and maintaining the Government BIM Data Repository as the centralized data sharing and collaboration platform for all BIM data collected from government departments; facilitating the BIM standard harmonization amongst government departments; and spearheading the development of BIM/GIS integration to support smart city applications. This paper will walk through the journey of the Lands Department in establishing the Government BIM Data Repository as spatially enabled digital twins for Hong Kong and discuss the challenges encountered in BIM data management, validation, and conversion.

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1. INTRODUCTION

The Smart City Blueprint for Hong Kong published in 2017 sets out the overall framework and strategy for developing Hong Kong into a spatially enabled smart city including the adoption of BIM and the development of Common Spatial Data Infrastructure (CSDI) and 3D Digital Map.

Since then, the Government of the Hong Kong Special Administrative Region (HKSAR) has been formulating BIM policies to drive the adoption of BIM technology in capital works projects, including the promulgation of policies to mandate the use of BIM for all capital works projects with estimates over HK$30 million in 2019 with a view to enhancing the overall productivity of the construction industry, and the publication of a set of harmonised BIM data standard, namely the "Development Bureau BIM Harmonisation Guidelines for Works Departments" (BIM Guidelines) in 2021 governing the information requirements and standards of the design and as-built BIM models and objects for interoperable and efficient BIM data exchange across the Government. Recently, the HKSAR Government has laid out a roadmap, to provide a basis for consultation with stakeholders, for full adoption of BIM in the preparation and approval of building plans for private development projects.

With the increasing adoption of Building Information Modelling (BIM) in the construction industry and the growing importance of data-driven decision-making, the establishment of a centralized BIM data repository becomes crucial for developing Hong Kong into a world-class smart city to enhance the effectiveness of city management and sustainable development. Being the central authority for land survey and mapping services, the Lands Department has taken up the role of establishing and maintaining the Government BIM Data Repository (GBDR) as the common data collaboration platform for territory-wide BIM data sharing across the Government in support of BIM Harmonisation and continuously uplifting BIM data quality for BIM/GIS data integration to support various government smart applications.

The GBDR collects, validates, and stores design and as-built BIM models in both native and open formats. It supports the conversion of validated BIM models to openBIM format and openGIS format to facilitate the building up of the 3D Digital Map. Since its launch in May 2022, there are more than 100 nos. BIM models of capital works projects currently housed in the GBDR. It is estimated that the GBDR will house about 800 nos. of BIM models from capital works projects by 2028.

To ensure the effective retrieval, management, and sharing of BIM data among the different government departments through the GBDR, continuous improvements have been made to the platform. These enhancements include the introduction of new data validation tools to support

BIM harmonisation, the development of new functions for BIM data visualization, spatial query and analysis, and the provision of BIM Application Programming Interfaces (APIs) to simply system integration by developing interfacing of departmental common data environments (CDEs) with the GBDR. These ongoing improvements and features cater to the increasing needs of the govenrment departments in terms of BIM data sharing, visualization, and support for further smart city applications using the GBDR as a service.

Figure 1 3D visualization platform of the GBDR

2. ROLES OF LANDS DEPARTMENT IN LOCAL BIM DEVELOPMENT

The Lands Department has undertaken a number of initiatives to further foster BIM development in Hong Kong. First, the Lands Department maintains the GBDR for storing territory-wide BIM data from capital works projects, facilitating BIM data sharing among government departments. The GBDR consists of various modules, including a common data environment module for BIM data upload and download, 2D and 3D visualization platforms for visualizing geospatial distribution of BIM models (refer to *Figure 1*), customized web applications for spatial query and BIM data submission management, a BIM data validation module for checking compliance of BIM data submission against the BIM Guidelines, and the conversion engine module. Through the BIM data validation and conversion engine modules, validated and harmonized native BIM data can be converted to Industry Foundation Classes (IFC) and City Geography Markup Language (CityGML) formats within the GBDR. Users can then navigate and download the converted data back to their CDEs for further applications. Additionaly, the GBDR supports BIM data analysis by providing basic GIS analysis tools, such

as spatial search of BIM data availability, and integrated BIM and GIS data on temporal and site analysis.

Second, the Lands Department spearheads the local development of BIM and GIS integration through the development of the GBDR to extend the use of BIM beyond individual projects to smart city planning and applications. BIM data is simplified, converted and re-processed for updating 3D digital maps. Learning from the international experiences and use cases of BIM and GIS integration for government decision-making, such as the Dynamic Digital Twin for Sewerage and Flooding in the Netherlands for urban disaster management using dynamic 3D models, I-Urban Revitalization in Japan visualise urban development and revitalization using 3D maps (Ishimaru et al., 2020) to support urban planning, the Lands Department aims to leverage these experiences to further advance the development of BIM and GIS integration in Hong Kong and to keep extending the benefits of adopting BIM technology to a wider spectrum. On the other hand, the Lands Department has recently released a "BIM and GIS Data Integration Guidelines, which provides a reference guide with a set of generic rules for the betterment of the conversion process of data from BIM to GIS platforms, for reference by practitioners of the Architectural, Engineering, and Construction (AEC) sectors. The Guidelines recommend general guidelines and good practices, focusing on high-level requirements for BIM and BIM-to-GIS data conversion, and target to facilitate interoperable geospatial data management and seamless integration of GIS data derived from BIM into the 3D indoor map so as to support various smart city applications requiring 3D geospatial data.

Furthermore, the Lands Department actively supports BIM standards harmonization works among the government departments and the local BIM industry to promote efficient BIM data sharing. Through intensive collaboration and engagement with BIM stakeholders, including workshops and interviews, the Lands Department gains insights into the local industry's needs for a harmonized BIM standard for different construction projects. With the user requirements acquired, the Lands Department steps firmly in supporting the updates of the harmonized BIM guidelines and fostering OpenBIM adoption in the GBDR.

2.1 Challenges in BIM Data Management and the Corresponding Strategies and Solutions

2.1.1 First Challenge: Transitioning from Centralized to Semi-Decentralized Approach for BIM Data Submission

According to the prevailing BIM policies, submission of design and as-built BIM models from capital works projects to the Lands Department (LandsD) is mandated for facilitating BIM data sharing across the Government through the GBDR and ongoing production and updating of 3D digital map. Each year, there are hundreds of government-funded capital works projects with BIM adoption to commence the construction design and complete the construction life cycle. To effectively manage the continuous submission of BIM data from capital works projects throughout the design and as-built stages of the construction life cycle, the GBDR was

originally designed to receive native BIM data from a centralized departmental responsible officer via email, manual dispatch and upload to the common data environment of GBDR.

Recognizing the evolving operational needs of various government departments in BIM data submission and the increasing size of BIM data for each project, a semi-decentralized BIM data submission approach has been adopted. This approach allows authorized departmental officers to submit BIM data to the GBDR, relieving the burden on a single departmental responsible officer for all BIM submission, validation and liaison works. Such semi-decentralized approach for BIM data submission lowers the administrative costs of both inter- and intra-departments and provide additional channels for BIM data submission.

To support the semi-decentralized BIM data submission approach, a new web-based user interface (UI) for BIM data submission (refer to Figure 2) has been developed and implemented on the GBDR. The UI incorporates a set of rules for intelligent BIM submission completeness checks. Users can validate the completeness of their BIM submission before proceeding to the next step, ensuring that all the required information is submitted. Consequently, the completeness of BIM data submission on the GBDR has significantly improved. The combination of centralized and semi-decentralized approaches for submitting BIM data provides a more efficient and user-friendly BIM data submission workflow to goverment departments.

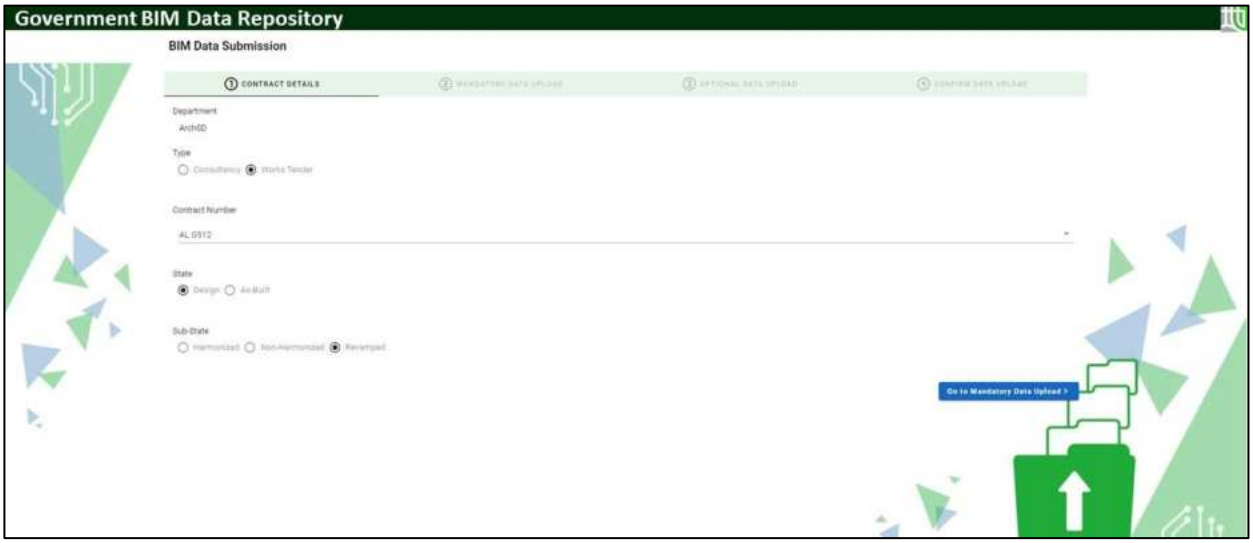

Figure 2 Web-based user interface for submitting BIM data to the GBDR

Furthermore, as more CDEs or common data collaboration platforms (CDCPs) of government departments began integrating with the GBDR, the Lands Department has also developed the Basic BIM Application Programming Interface Services (the Basic BIM API Services) of the GBDR to enable direct system-to-system connection. The Basic BIM API Services, depicted in *Figure 3* below, provides features such as login, uploading, downloading, checking upload status, etc. These Basic BIM API Services align with the semi-decentralized BIM data submission approach, facilitating system-to-system BIM data submission. To support the

development teams of government departments in utilising the ongoing system interfacing, testing and integration, the Basic BIM API Services have been deigned to allow secure and seamless data exchange across various platforms. Furthermore, BIM API Sandboxes have been developed, enabling the development teams of government departments to create simulated responses from the BIM APIs, facilitating the system interfacing with GBDR using the Basic BIM API Services.

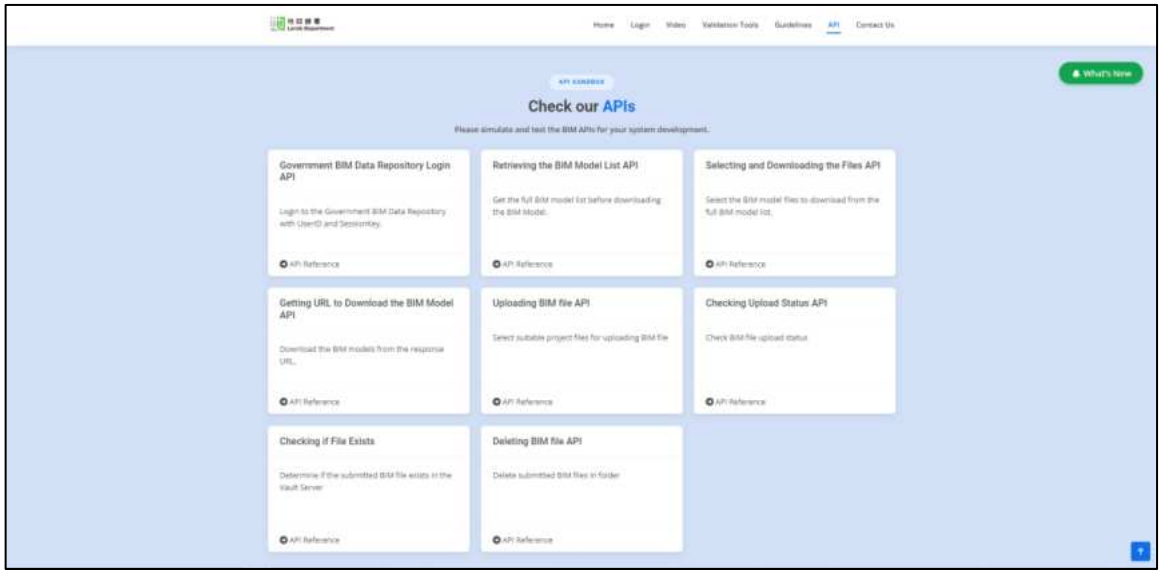

Figure 3 GBDR BIM API Sandbox

2.1.2 Second Challenge: Enabling BIM and GIS Data Interoperability across Diverse Proprietary BIM Software Used by Different Government Departments

The global market offers a wide range of well-developed and structured BIM software that supports sophisticated civil, structural, and architectural designs. However, accommodating BIM data authored in various modeling software within the GBDR poses challenges due to the high costs associated with licenses, maintenance, and administration for each proprietary BIM software. Moreover, managing multiple BIM software simultaneously in a cloud-based repository increases the complexity of managing the BIM to GIS data conversion engines and databases, making it difficult for users to browse and download BIM elements.

Therefore, it becomes crucial to establish a method that enables data sharing among government departments while promoting software neutrality. Instead of solely relying on software version upgrades, a more effective approach is to adopt open-source formats such as IFC and CityGML that allow data sharing and data upgrading in accordance with international standards. This ensures data interoperability across different BIM software and platforms.

To address this challenge and enable the sharing and reusability of BIM data prepared in various BIM software on the GBDR and on the CDEs or CDCPs of government departments, the folder hierarchy in the GBDR file database has been re-organised. This re-organisation allows for a wider range of BIM data submission formats such as .pln, .dgn and .skp. Users

with the respective software licences can download, view and reuse the proprietary format BIM models on their desktop viewers, CDEs or CDCPs.

More importantly, the folders for storing IFC and CityGML have been expanded to facilitate data sharing in open standards. Since software versions change periodically, certain versions of proprietary file formats may become unsupported. In contrast, open-source formats are always supported for longer durations, ensuring the applicability of BIM data in the GBDR for future projects.

Figure 4 illustrates the conversion workflow from native BIM data to IFC and CityGML. A conversion engine is embedded in the GBDR to enable the conversion of some native BIM data to IFC and CityGML formats. The development of the powerful conversion engine is a significant milestone in the history of the GBDR development because detailed configuration and mapping tables are implemented after reviewing over hundreds of BIM files to minimise data loss in the data format conversion process. Moreover, considering the limited availability of best practices for exporting meaningful and specific IFC models in the BIM industry, the Lands Department is developing step-by-step best practices for recommending users to export IFC models with appropriate configurations and settings. The promotion of IFC and CityGML enhances data interoperability in the GBDR and foster collaboration among government departments in the long run.

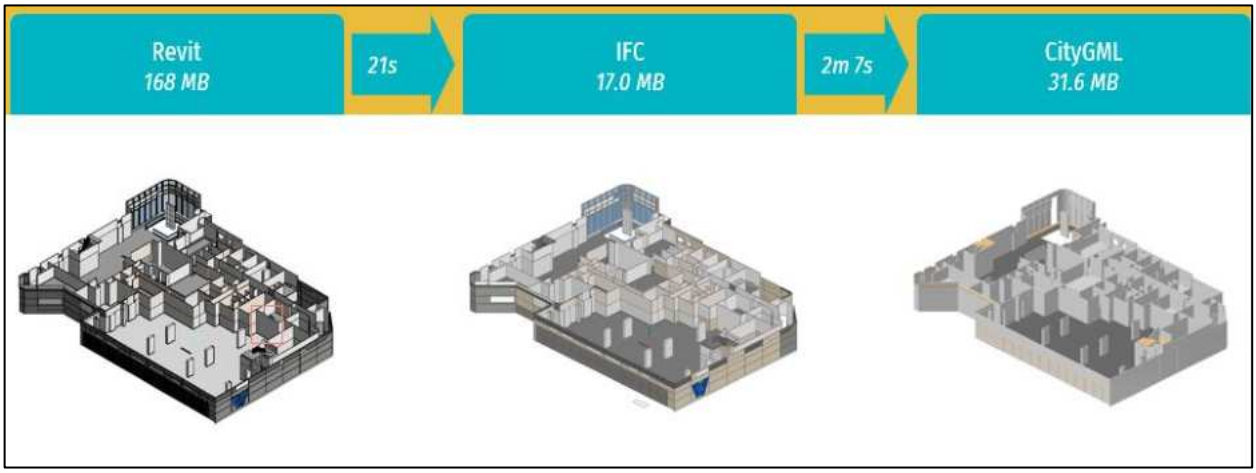

Figure 4 Conversion of a BIM data to OpenBIM and OpenGIS with simplification

2.1.3 Third Challenge: Transitioning from Textual Searching to Geographical Searching for BIM Models in the GBDR

GBDR users often face challenges and inefficiencies when browsing through numerous BIM submission folders to find suitable BIM models for their specific applications. Before the system enhancement, users could only search for BIM models by manually entering the project name or number, making it necessary to have precise information to locate the desired BIM file. However, many users struggle to provide the correct project name or number, or they may not have access to such information when searching for BIM files from other government departments. Thus, they face difficulties in efficiently locating projects in the repository,

especially when there is a large volume of BIM data available for searching and downloading in the GBDR.

To enhance the searching function of the GBDR, the system has been enhanced to incorporate the Geographical Searching function. As part of the submission process, government departments are now required to include a project boundary file along with their BIM submissions to the GBDR. The project boundary submitted would be used to enable visualisation of the project site extent and boundary in the 2D map web interface. As such, users who may not have knowledge of specific project names or numbers can navigate and review areas of interest on the map, identifying suitable BIM data, as illustrated in *Figure 5*.

Figure 5 Display of project boundaries on the 2D map web interface of the GBDR

However, it has been observed that some project boundary files submitted by government departments are not geo-referenced in the HK1980 Grid System used in Hong Kong. While other defects are found in the project boundary files, such as containing intersecting lines, incomplete polygons, etc. These lead to ambiguity when displaying the project boundaries on the GBDR 2D map interface. To address this issue,the Lands Department is developing a checking tool for verifying the quality of the project boundary submitted, which will be integrated into the GBDR.

With the implementation of this quality-checking mechanism in the GBDR, whenever new BIM data submissions are received, the system will automatically check the compliance of the project boundary file against predefined rules. Furthermore, predefined rules for checking the presence of configuration or modeling errors are also embedded in the GBDR. As a result, data providers will receive prompt notifications via system-generated emails in case of submission failure, allowing them to initiate the re-submission of BIM files. The introduction of geographical searching for BIM models improves the user experience in searching for BIM data

in the GBDR, while the new checking tool ensures the data integrity of project boundaries within the GBDR.

2.1.4 Fourth Challenge: Automation of BIM Data Checking

The BIM Guidelines outline the requirements for modelling and information needed in BIM objects and BIM models under capital works projects. These requirements lay the foundation for information exchange and data analysis among different data providers. With the citywide rich context of the semantic BIM models in the GBDR, the ultimate goal in supporting the decision-making processes through developing analytical functions in GBDR can be achieved. Despite there is comprehensive BIM Guidelines, checking on whether the BIM models submitted by government departments have complied with BIM Guidelines was done with manual efforts, object by object and such manual checking method is considered inefficient, labour intensive, and may involve duplicated efforts by government departments and their consultants and contractors. This slow manual checking process can lead to delays in BIM submissions by government departments, hindering subsequent decision-making processes with limited and outdated data.

To address this issue, it is critical to provide a set of organized and automatic BIM data checking tools to BIM project teams of government departments, as well as their consultants and contractors, so that BIM data can be checked, verified and reported accordingly and accurately.

Recognizing the importance of BIM data quality on the GBDR, the Lands Department has developed and released BIM data checking tools that allow for self-checking of compliance with native BIM and IFC formats before data submission to the GBDR. These automatic checking tools are designed based on the BIM Guidelines and generate a summary of checking results in spreadsheets, highlighting non-compliant objects with element IDs and file names, as depicted in *Figure 6*. This empowers users to review the files and rectify any issues with the concerned elements before submitting them to the GBDR, streamlining the BIM submission checking.

In addition to enabling self-checking, the GBDR also utilises BIM data checking tools to verify the BIM data before publishing them on the GBDR. These checking tools are continuously updated in line with regular revisions of the BIM Guidelines. This iterative process of tool

enhancement contributes to the ongoing improvement of BIM data quality, ultimately facilitating efficient data retrieval and analysis on the GBDR.

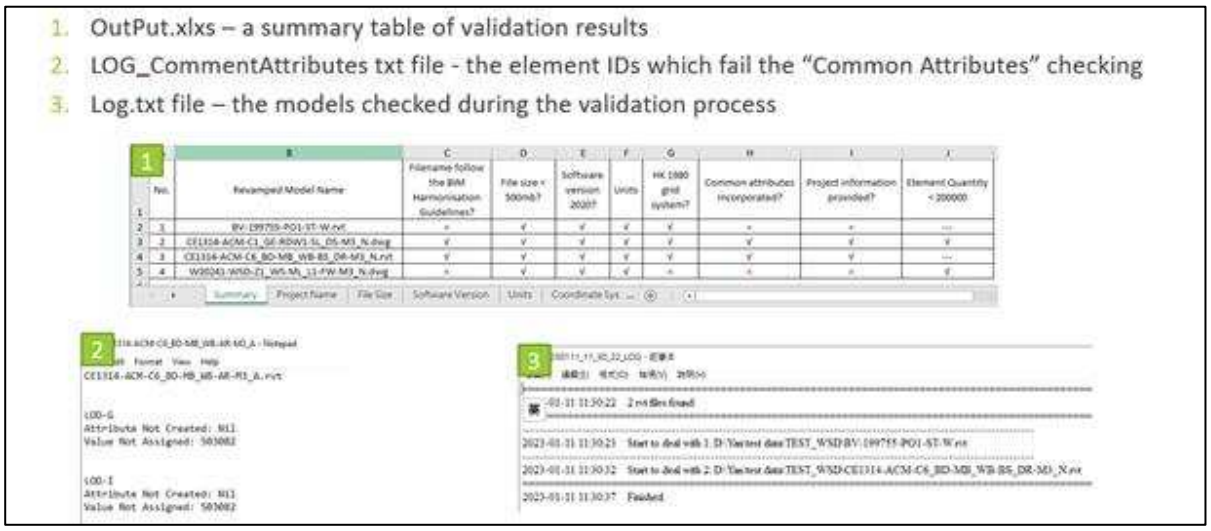

Figure 6 Automatic outputs of BIM Validation Tools

3. INTEGRATION OF BIM AND GIS

The implemented enhancements in data submission, data validation, data conversion and data visualization have paved the way for smart city applications through the GBDR, facilitating the transformation of Hong Kong into a data-driven spatial city. As as a centralized repository, the GBDR provides authorized parties with ready access to BIM models of the entire city for application development. The integration of BIM with various spatial data can provide a comprehensive view of the environment. By using GIS spatial analysis tools, the impact of new developments on the surrounding environment can be assessed, benefitting the design, construction and facility management.

One example of BIM/GIS integration is the use of BIM data to update the 3D Digital Map encompassing building outlook and interior structures. This enables visualization, indoor building applications and city modelling. The CSDI Portal and 3D Digital Map are available for public use for free and have the potential to enhance government services and support the development of applications with smart technology.

Furthermore, the Development Bureau is developing in phases the integrated capital works platform, which will draw BIM data from the GBDR through APIs for conducting analysis of capital works project information. This platform will facilitate the Development Bureau continuous monitoring and review of project performance. More government departments will

start interfacing with GBDR and explore the use of BIM data in various aspects, e.g. site analysis and feasibility studies (DEVB, 2023).

4. BENEFITS OF THE ESTABLISHMENT OF THE GBDR ON BIM DATA SHARING AND SMART CITY APPLICATION DEVELOPMENT

The establishment of the GBDR has brought various benefits to the entire Government. It provides a centralised data platform for BIM and GIS data sharing and visualization, eliminating the need for manual data exchange. This promotes easy and efficient sharing of BIM data among government departments and enhances data interoperability by eliminating the need for multiple BIM databases owned by different government departments.

Moreover, by involving various stakeholders and professionals within the government, such as architects, engineers, land surveyors, and government officials, in the development of the GBDR, better coordination, cooperation, and communication can be achieved in regard to the various aspects of the capital works projects cum decision and policy making. This enhanced collaboration may lead to improved project outcomes and cost savings.

The harmonisation of BIM standards across different government departments ensures data standardisation and consistency across various BIM projects. By establishing common data formats, naming conventions, and classification systems, it becomes easier to integrate and analyse BIM data from various sources. The harmonisation of BIM Guidelines/standards across various government departments reduces the possibility of adopting the wrong BIM Guidelines.

GBDR also allows for the reuse of BIM data from past projects. By extending the lifespan of BIM data beyond completion of the construction project not just fulfilling the operation needs for assets and facilitating management, the external façade of the BIM models can be used for the continuous updating of the territory-wide 3D map and the internal building information can assist the generation of the territory-wide pedestrian network.

5. CONCLUSION

The GBDR was launched in 2022 to serve as a centralised and single source BIM data repository of the Hong Kong SAR Government for storing and navigating territory-wide BIM data while facilitating BIM data exchange. The Lands Department has been playing a leading role in promoting the adoption of OpenBIM and OpenGIS, as well as the development of BIM/GIS integration. Over the past year, the project has made significant contributions to the entire Government, including storing BIM data from capital works projects, upholding BIM data quality, reducing administrative costs through intelligent checking of BIM data submissions, conversion, and publishing, and enabling secure and seamless BIM data sharing through APIs for inter-departmental collaborations. The successful implementation of this

project sets the foundation for more efficient and effective smarter governance in land planning and construction.

Looking ahead, there are opportunities to extend the usage of the GBDR, with more construction-related platforms and common data environments interfacing with the GBDR for improved management and administration. The Lands Department will continue maintaining the BIM validation tools, upholding BIM standard harmonisation, developing new BIM APIs and analytical functions, facilitating BIM/GIS integration and providing secure and seamless connections to the GBDR. These efforts contribute to the development of a data-driven governance and the formulation of better policies supported by sufficient data..

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