Building and Construction Authority

BIM Essential Guide

For Land Surveyors

BCA acknowledges the leadership provided by the BIM Steering Committee in support of the production of the BIM Essential Guides

The BIM Essential Guides have been drafted by SISV (Land Surveying Division), HDB, SLA and endorsed by the Centre for Construction IT on behalf of BCA and the BIM Steering Committee.

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Contents

CEO's Message 2

ACKNOWLEDGEMENTS 3

OBJECTIVES 5

Land Survey Site Models for BIM Design 6

- Pre-Construction Planning and Design 6

Strata Surveys for Buildings 9

- BIM Models and Cadastral Strata Surveys 9

As-built BIM Models and Laser Scanning 12

- Use of Laser Scanning 12
- Clash Checks during Construction 16

Surveys for Asset Documentation for Existing Buildings (A&A) 17

- As-Built BIM Models 18
- BIM to field during Construction 19

BIM-GIS Integration for Facilities Management and Smart City 20

Surveys for Roads and Rails (BIM for Infrastructure) 22

CEO's Message

Dear readers,

Under the 1st Construction Productivity Roadmap introduced in 2010, BCA had introduced Building Information Modelling (BIM) as a key enabler of productivity in Singapore's construction industry. Today in 2015, more than 60% of the larger contractors and 80% of the larger consultants have adopted BIM. Moving forward, we have drawn up the 2nd Construction Productivity Roadmap where we would like to advance beyond BIM adoption by individual firms, and leverage on BIM technology for greater integration and collaboration among all firms across the value chain.

Together with the industry, we will continue to explore the unchartered areas of BIM software integration, machine automation and process re-engineering to achieve a quantum leap in the adoption of BIM technology and methodologies that are aligned with our local practices.

We would like to encourage the industry to continue our partnership in improving and expanding the BIM Essential Guides Series, to plug the gaps as more stakeholders play a part in the input and sharing of information and benefits generated from BIM.

We would like to thank the valuable time and efforts of the BIM Managers Forum and the leadership of the BIM Steering Committee, chaired by Er Lee Chuan Seng, Emeritus Chairman, Beca Carter, that enabled the release of this document.

Dr John Keung

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Tang Tuck Kim Registered Surveyor

OBJECTIVES

The objective of this Essential Guide is to assist Registered Land Surveyors to understand their role in BIM projects, including New Construction and A&A Projects. The guide serves as a code of practice for surveyors to understand their critical role and value proposition to BIM and the 3D community by looking into survey workflows and practice within the context of BIM requirements and coordination with other building professionals. The guide also shows the possible use-cases of BIM and land survey deliverables for BIM at the various stages of the project.

Following the Step by Step Land Surveying BIM guide for HDB Housing Projects, we have received feedback and requests from a number of registered surveyors and architects, to develop a similar guide applicable for the surveying industry. Hence this essential guide was developed to provide more information on survey deliverables across the construction lifecycle and situations where other building professionals may replace BIM models in lieu of hardcopy or CAD reference drawings to the surveyors. Appropriate references to existing survey standards are included in the guide. This guide aims to be as comprehensive as possible by incorporating both the use of traditional and newer surveying methods and workflows. With exciting developments in 3D surveying technology and software applications, this guide would need to be reviewed periodically to keep it current with technology advances, standards and requirements.

The role of the surveyor is to certify the correctness and accuracy of survey measurements under the Land Surveyors Acts (Cap.156). Hence it is worthwhile to point out that geo-referenced survey measurements can only be certified correct by a registered land surveyor.

This is a general document that draws some experiences from pilot projects and real life projects. It is not an extensive document intended to cover all scenarios that might arise based on specific projects. Users shall adopt and adjust according to their needs.

This Essential Guide is not intended to base on any particular BIM software and does not cover any explanation or steps on its usage. For help and guide for your specific BIM software, please refer to your software user manual.

Based on the project requirements, do adopt the software recommended for use and implementation in the individual project.

Land Survey Site Models for BIM Design

Pre-Construction Planning and Design

For Field to BIM, it is useful to distinguish between the different types of topographic surveys – The general/preliminary site plans, the detailed topographic plans for construction and the as-built surveys. The general/preliminary site plans are pre-development topographic surveys carried out for designing and planning of development. As-built surveys are surveys that are carried out after the construction is completed. In more complex developments where conservation of building or integration to existing buildings are involved, measured building surveys and a “recreated” BIM model may be required.

The land surveyor surveys existing site condition, terrain and features to create the surface model. This model includes the model orientation and site configuration. It is also geo-referenced with reference to the national grid system. As only the surveyor is able to ensure that the geo-referencing process is authoritative, it is important for the surveyor to generate the geo-referenced BIM site model to facilitate the consultant’s downstream works (add on, design, etc). An Integrated workflow for Site Development and BIM models is essential for the surveyor for such pre-construction topographical surveys.

The Step by Step Land Surveying BIM guide for HDB Housing Projects (Annex A) serves as a user guide to achieve this goal. In the development of this guide, the requirements on the data capture and data format of topographical surveys to support BIM formats were studied. The CAD drawing standard to organize and name the map layers have to be consistent. This is specified in the Standard and Specifications for 3D Topographic Mapping in Singapore (www.sla.gov.sg). This standard requires a new map layer (DTM layer) containing only surface spot levels was added to facilitate the importing the points to create the site surface in the BIM model.

In the 2D topographic plan, the z value or level of the features is not important. This means that it does not matter whether the field surveyor pick the x,y,z position of the top or bottom of the lamp post or anywhere in between the top and bottom of the lamp post. For the 3D topographic survey, it is important to read only the bottom of the lamp post for the point to be copied to the DTM layer. Only points of 3D features on the surface are to be copied to the DTM layer for creation of the surface.

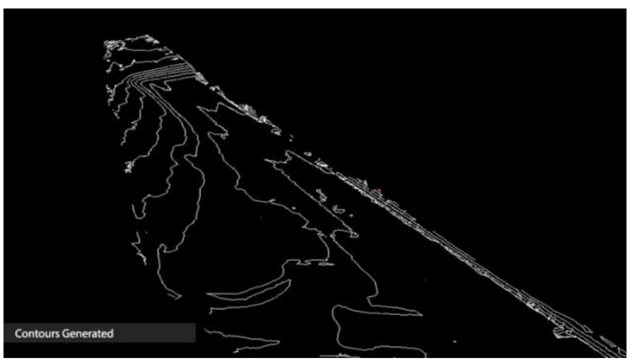
It is possible to have 3D topographic survey plans with 3D lines but 2D symbols for features like trees and lamp posts. If the 3D features are to be shown as accurate 3D models, then both the top and bottom of the lamp post shall need to be captured in order to scale the 3D symbols of the feature. This implies that additional map layers for the top of the 3D features will need to be added and specified in the Standard and Specifications for 3D Topographic Mapping.

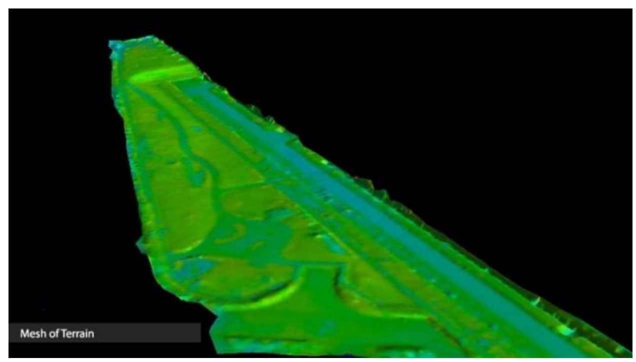
The above guide adapts the traditional surveying methods using total station for BIM compatibility. BIM software can process the field surveys data in both CAD and BIM format for use by the other building and construction professionals. The surveyor needs to be familiar with importing survey data from survey equipment into BIM software or exporting data from BIM models for reference. It does not preclude the use of GPS, 3D Lidar or photogrammetric tools for such use cases.

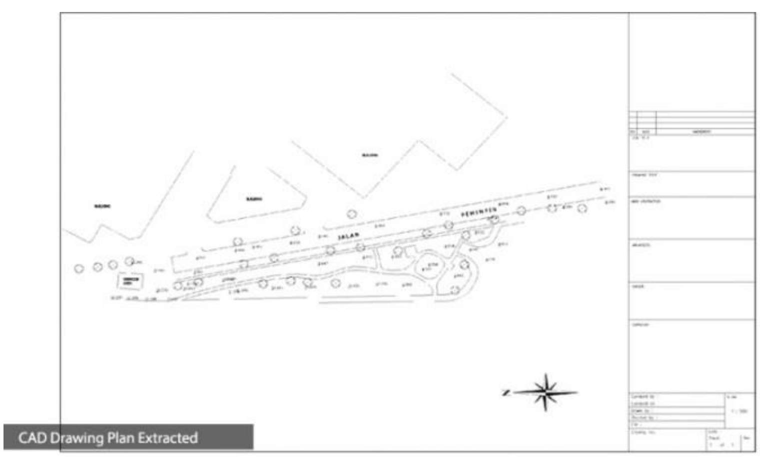
In integration of BIM with other formats of information, an understanding of differences between BIM, 2D CAD, 3D CAD and GIS is important. The surveyor must integrate BIM models, 3D models and 3D survey/GIS data such as TIN and DTM. It is not just the ability to perform basic BIM tools and functions or manage the user interface, setting preferences and reviewing projects. It is the ability to adapt and integrate data from different data sources with an appreciation and the intrinsic grasp of data accuracy and precision that only the surveyor can possess. It is also the ability to assess the appropriate level of information and data quality requirements (fitness of use) for the application or task at hand.

Producing the Surface Model from Topographical Survey

Acknowledgement: Mr Gerry Ong (GPSLANDS)







Strata Surveys for Buildings

BIM Models and Cadastral Strata Surveys

A cadastral land survey delineates the land ownership boundary of a unique land lot. The proposed site boundary or cadastral boundary of the land lot will be incorporated into BIM site model to allow for designers to plan and design the building layout and orientation. Strata surveys depict the final boundaries of a strata lot in a Strata Certified Plan (CPST). As BIM models are rich data source for buildings, there is huge potential for BIM applications to be applied to surveys and geospatial databases which involve buildings.

In the pre-construction stage, the architect would design the strata units in a BIM model and then the surveyor is required to compute and certify the proposed strata area to facilitate the sale of the strata units. This strata area is subject to final survey by the surveyor after construction is completed. The surveyor should be familiar with extracting relevant information from reference BIM model for strata surveys. A BIM model allows for the collaboration and communication of architect and surveyor to be improved. The BIM model is used to coordinate and communicate the proposed strata areas for various unit layouts before the construction of the strata units.

The following use case is one of a public housing project where the architect designs the respective unit types in BIM format. Here, the strata boundary of each unit type is being incorporated in the design to determine the strata area. The architect would then proceed with the design of the whole project based on this information. The unit type file is then sent to the surveyor for computation and endorsement.

The surveyor would verify and comment, if any, for the architect to revise on the BIM model and the architect would revise before returning it to the surveyor. After a final check, the surveyor would endorse on the plans for the architect's use. This ensures a smoother coordination between the architect and surveyor.

By incorporating the strata boundary upfront during the design stage, the architect is able to factor in the strata area and how it would affect the overall design and yield of the blocks within the project. This minimises unnecessary drastic amendments needed to the design to meet targeted yield arising from minor differences in unit type area. A standard guide on the definition of strata boundary for HDB projects also help to enhance a common understanding of the strata area interpretation between the architect and surveyor.

Sample of a Unit Type Plan Extracted From a BIM Model

Acknowledgement: Housing & Development Board

Replacing many reference CAD plans with a single BIM model is an advantage for the surveyor. A single highly structured data format from the architect providing complete, consistent and clear information on the strata unit will benefit the surveyor. The 3D nature of the BIM model allows the surveyor to examine relevant information and visualize much better, especially when the unit designs becomes more innovative and less regular in configurations. The capability of BIM to generate plans easily with standard template for items such as surveyor's certification, north point and auto-generation of information such as strata unit areas can help avoid drafting or editing errors such as wrongly computed strata unit areas or wrong north points.

Calculations can be obtained and verified easily for GFA calculation of the whole building after the GFA has been defined in the BIM model. The native BIM file is submitted by the architects to the authority to support their GSA calculations. In parallel with the GFA verification, in time, it may be possible that more automatic verification of strata areas become feasible for strata units with more uniform and standard designs.

Currently there is a review of the existing cadastral system in Singapore to become a true 3D cadastre. BIM models, with its rich information, may serve as a source of information for the building models with the 3D cadastral framework. This may be a potential use case of BIM models for further research and development.

As-built BIM Models and Laser Scanning

Use of Laser Scanning

Laser scanning technology is a powerful tool for capturing as-built information. Common applications like as-built documentation, BIM modeling, creating 2D plans, building inspection and verification can be done faster with 3D scanning data.

New buildings are being built with interesting and complex architecture design for the purpose of aesthetics, energy efficiency and space optimisation. There are existing old buildings with historical value and they need preservation. Surveyors are involved in the as-built survey of both new and old buildings. Conventionally, the as-built survey captures the geometry such as angles and distances to produce building facade drawings and floor plans in 2-dimensional (2D).

Today, 3D Laser scanning technology, particularly the Terrestrial Laser Scanner (TLS), is a faster and more effective tool to capture 3D points (X,Y,Z) in the form of point cloud. Capturing large amount of 3D coordinates using the conventional survey equipment will be slow and costly. 3D as-built point cloud data combined with photo images can be used for many purposes, namely, verification of the construction, subdivision of buildings, conservation of heritage buildings and monuments, facilities management etc.

The principal of TLS scanning is not unlike the conventional radial surveys using total stations. When taking measurement, scanner emits laser pulse to the object and the time for laser to travel to the object and reflects back to scanner is measured to determine the distance. Together with the measured horizontal and vertical angles and having some known survey control points, the three dimensional coordinates of every each laser point on the object can be determined.

Generally the TLS workflow can be categorized into planning, control and target establishment, equipment setup and scanning, and data processing.

Planning is to be carried out prior to the commencement of a project. Planning involves understanding of project requirements and site reconnaissance to identify any obstructions that may introduce voids or shadows in the data. Knowledge of project requirements and site condition helps to determine which type of equipment to use and to identify the optimal set of setup locations. Number of station setups can be planned according to overlap requirements without compromising the allocated time frame. Areas that are difficult to scan should be identified and overcome by introducing additional setups or complementing the survey with other methods of data collection.

A control network consists of a collection of identifiable points with integrity of their positional accuracy. The purpose of the control network is to control the data quality, registration, verification of the position of an instrument. The control network may be tied to a coordinate frame used by the local jurisdiction. Target placement is also equally important as they are used to register scans taken from different scan positions. There is wide variety of target types: retro-reflective targets, spherical targets, paper targets, prism targets, etc.

Some registration software are able to recognise natural targets and able to use them for registration. Easily recognizable object corners, cracks, markings and wall planes are promising natural targets. One basic and important principle to bear in mind when using targets, is that they need to be widely spread out, not only in X and Y direction but also in the Z direction. Apart from that, scans data of building interior and exterior can be combined through the use of common targets, control network or overlapping point clouds.

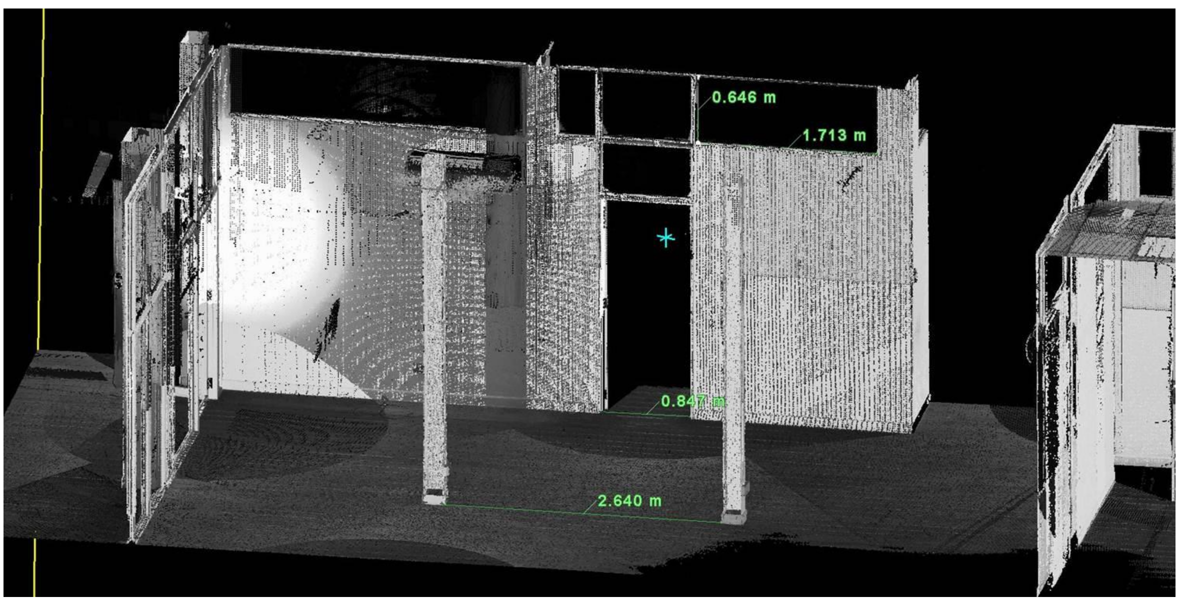
Terrestrial scanner is usually setup on top of a tripod on stable ground and levelled. Setting the scanner at higher position provides better inclination angle and will capture more of the data on the floor, if there is a need to scan the floor. One of the key considerations in a scanning project is the selection of an appropriate resolution. Resolution is the distance between two subsequent measured points and it determines the density of points in the point cloud. The resolution is selected based on the smallest detail of the surface structure that needs to be recognizable. A higher resolution means the more points need to be scanned and thus taking a longer surveying time. Besides the time taken, the dataset storage size increases as well. It is good practice to re-check the required targets and objects of interest are within the scanner's line of sight before starting any scan.

Data processing requires the scanned data to be transferred from the scanner to a computer. Some of data cleaning processes are done during the import of point cloud into the software, such as filtering of noise and points that are further from the effective distance. In most cases, there are multiple scans required to ensure a complete coverage, instead of just scanning from one single position. Each of these scans has their own scanner coordinate system.

Registration is the process to align and orientate these scanner coordinate systems into a global site coordinate system. There are several methods of registration. The most common one is by identifying and fitting the common artificial or natural targets. Another way is by identifying and fitting the common point cloud features between the scanned data. There is also the registration method by identifying fitting the common planes of point cloud in three dimensions between the scan data. The next step is to translate the registered point cloud into desired output format which it may be in standard point cloud formats, GIS and CAD line format, meshes and 3D models.

Extraction of Measurements from a BIM Model

Acknowledgement: Singapore Land Authority



Clash Checks during Construction

The following use case of point clouds is in the clash detection for the purpose of BIM integrity checks. It is an application where 3D point clouds are used for asset inspections.

BIM Integrity Checks for CleanTech

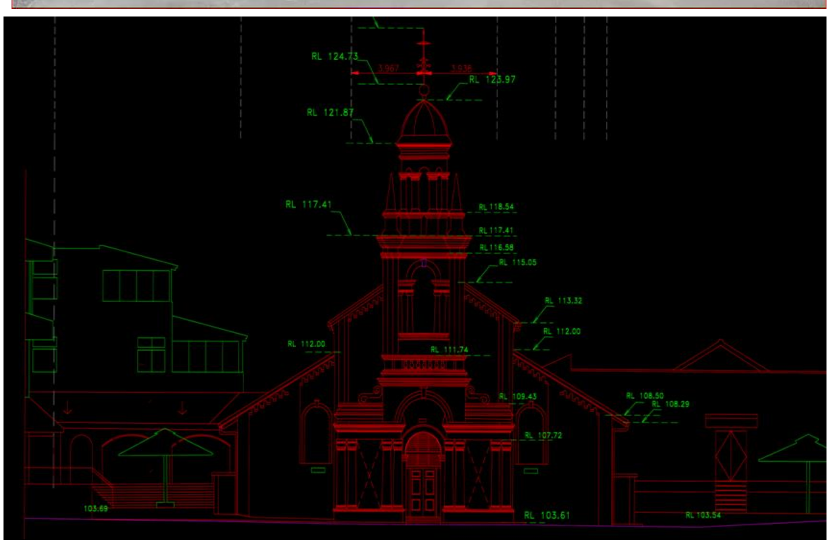
Acknowledgement to BIMage Pte Ltd

Surveys for Asset Documentation for Existing Buildings (A&A)

Some projects involved heritage buildings that need to be preserved and maintained. Such older buildings may not have documentation in the form of engineering or architectural drawings. By constructing the models of the building or asset facilitates, architects, engineers and consultants are able build a catalogue of objects with full traceability.

Extraction of Line Geometry for Model Creation Directly from Source Data (High Integrity)

Acknowledgement to Tang Tuck Kim Registered Surveyor

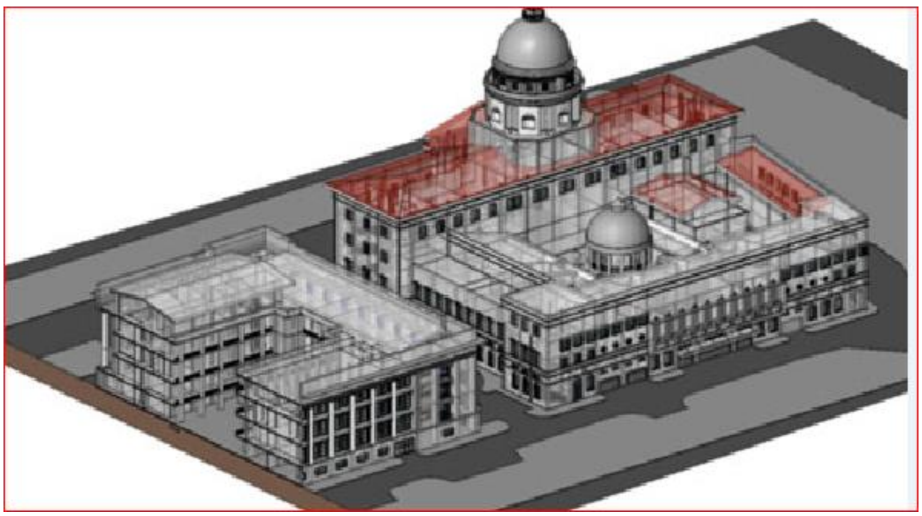


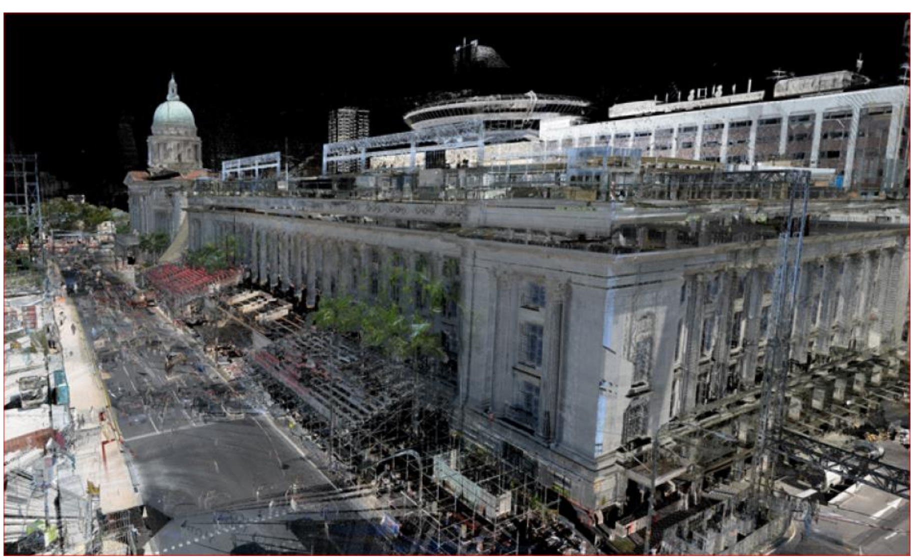
As-Built BIM Models

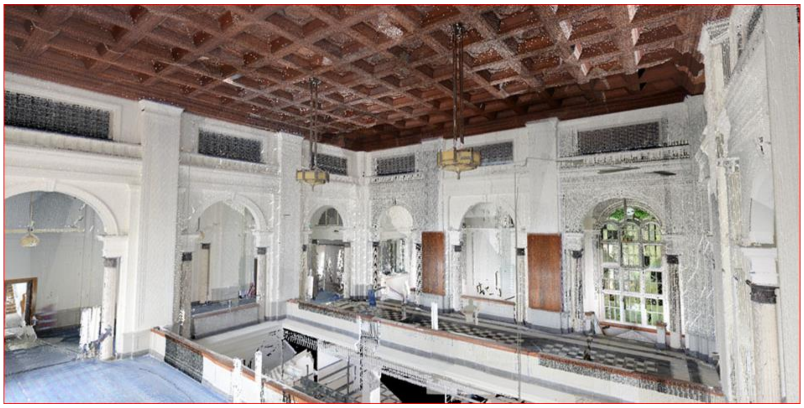
The as-built BIM model involves the technique of Scan to BIM. 3D Points are the building block of anything and everything natural and/or built environment that is represented on a plan. The below use case is the creation of as-built BIM model from 3D point clouds for the National Art Gallery.

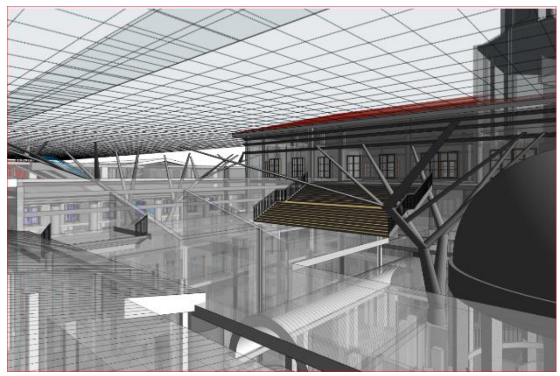
National Art Gallery Models

Acknowledgement to Di-HUB Pte Ltd









BIM to field during Construction

BIM to field refers to the extraction of relevant BIM information and exporting it into survey instruments for setting out of land boundary and buildings during construction. This is also applicable to A&A works. Various survey instruments now have the capability to view, examine and extract relevant information from the BIM model. In place of using 2D plans and a set of pre-determined coordinates, a BIM model is being used for setting out. This feature is increasingly common in survey equipment as BIM models may eventually replace more CAD drawings as reference information.

BIM-GIS Integration for Facilities Management and Smart City

Facilities management (FM) is probably the last frontier for BIM application in the as-built environment. The facilities management sector relies very much on the monitoring of facilities for operations and maintenance of buildings. In order to track, monitor and plan pre-emptive maintenance regimes, a comprehensive system that manages massive information of the facilities, their status and location is an absolute necessity.

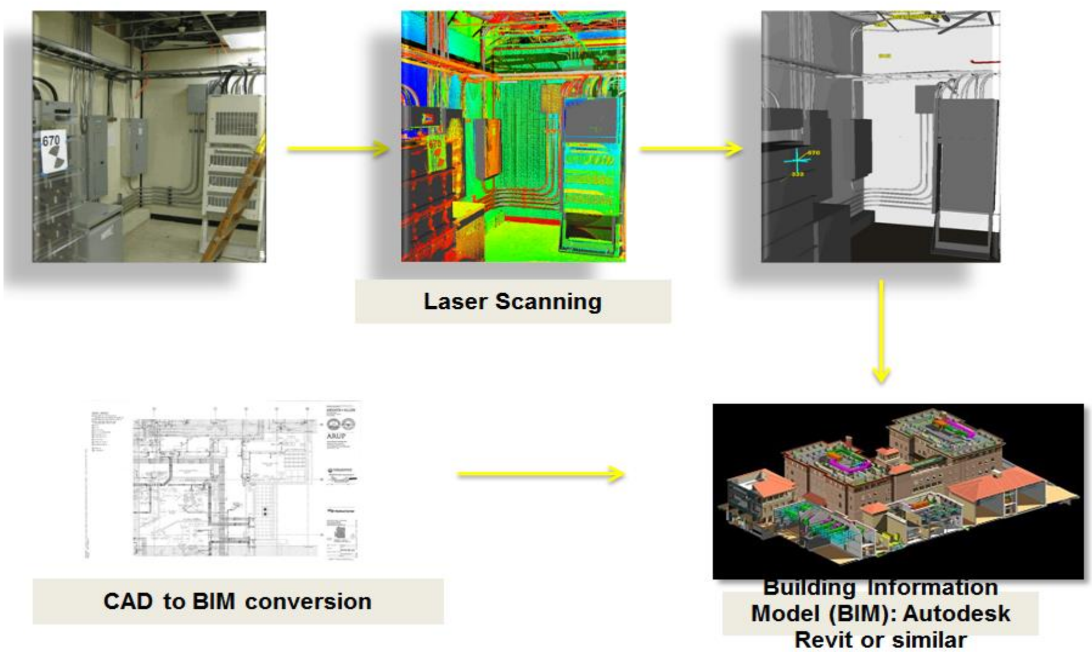
The primary challenge for FM as an industry is go beyond hardcopy plans – that is the need to go digital and manage it digitally. Initiatives like Go Green initiatives encourage digital management of data as building information will enable the analysis and simulation. BIM offers the solution of being a good data source and BIM for FM enables relevant information to be collected and populated in a standard format before construction. The as-built BIM model will enable FM managers to manage and integrate data with FM systems and GIS. The surveyor can play a role in verifying the location of facilities in the verified as-built BIM during and after construction.

The buzzword “IOT” or Internet of Things connects sensors back to central systems with internet connectivity for smart city initiatives. Developing smart city technologies and practices for infrastructure, municipal services and green initiatives will enhance service delivery to people living and working in the urban environment. Managing complex and big data collected requires significant investment, deep skills and knowledge. As the original geospatial data collectors, the surveyor may consider adding value in their role as the data specialist to understand, integrate, manage and apply data while retaining data integrity.

The following use case applies to Data audit and as-built BIM for AM/FM.

Data Audit for As-Built BIM for AM-FM

Acknowledgement: Mr Ajith Menon (BIMage Pte Ltd)

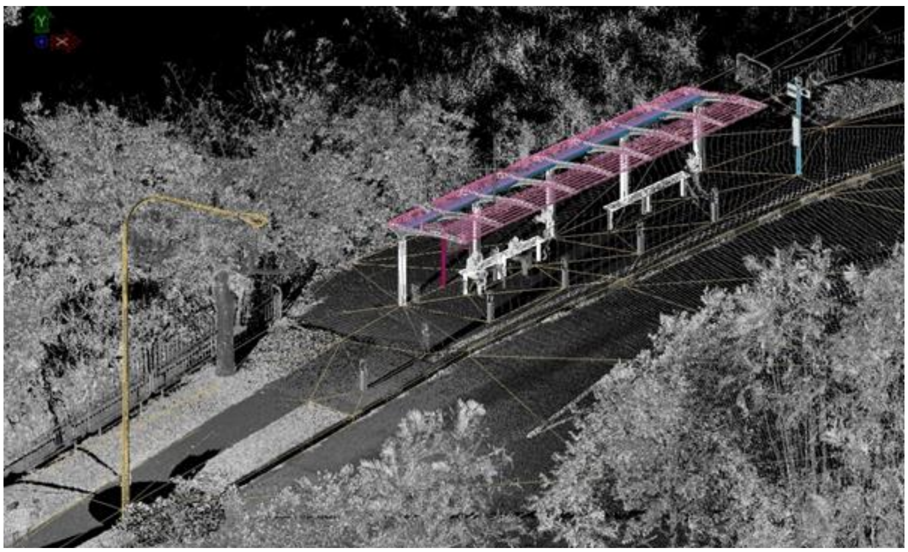


Surveys for Roads and Rails (BIM for Infrastructure)

In the same way that Scan to BIM applies to buildings, it also applies to infrastructure. The following use case shows how line geometry may be extracted from point clouds.

Point Clouds and Line Geometry

Acknowledgement: Mr Leong Kin Weng (Surbana International Consultants Pte Ltd)



Exporting 3D model to CityGML LoD2

Acknowledgement: Mr Leong Kin Weng (Surbana International Consultants Pte Ltd)

This guide is part of the BIM Essential Guide Series

BIM Essential Guide	FOR EACH BIM PROJECT		FOR EACH ORGANIZATION
	WITHIN EACH DISCIPLINE	ACROSS MULTIPLE DISCIPLINES	ALL DISCIPLINES
For Architectural Consultants	●		
For C&S Consultants	●		
For MEP Consultants	●		
For Contractor	●		
For Land Surveyors	●		
For BIM Execution Plan		●	
For BIM Adoption in an Organization			●
For Transfer of BIM Data into Building Performance Analysis (BPA)		●	
For Construction Collaboration		●	
For BIM for Design for Manufacturing and Assembly (DfMA)		●	

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