ENHANCING VALUE CHAIN COLLABORATION AND EFFICIENCY WITH INTEGRATED DIGITAL DELIVERY

EXECUTIVE SUMMARY

Driven by the escalating demands for improved efficiency, accuracy and collaboration in projects, the Built Environment (BE) sector is undergoing a transformation whereby Integrated Digital Delivery (IDD) is becoming an increasingly essential requirement, rather than a mere choice.

The effective adoption of IDD is dependent on various factors, including thorough upfront planning, effective change management, utilisation of digital solutions and the commitment of stakeholders. Developers play a pivotal role in ensuring the realisation of these factors, which is illustrated in CanningHill, a mixed-use development comprising residential, commercial and hospitality components.

CapitaLand engaged a Building Information Modelling (BIM)/ IDD consultant early in the project to strategise and guide IDD implementation. They had also incorporated relevant BIM and IDD requirements into the project's contracts to align stakeholders on IDD expectations and standards.

Leveraging earlier IDD project experience, CapitaLand identified multiple digital solutions that would best suit the complexities of the CanningHill project.

INTEGRATED COMMON DATA ENVIRONMENT (CDE)	ROBOTIC TOTAL STATION (RTS)	VIRTUAL MOCK-UPs
• Enhanced collaboration and data sharing among stakeholders • Time savings • Improved quality	• Enhanced site safety • Better construction quality with fewer defects • Reduced reworks and minimised delays	• Time and cost savings • Enabled more informed decision-making process.

Key IDD solutions implemented in CanningHill

Together with City Developments Limited, CapitaLand is optimistic about the immense potential of IDD to transform the BE sector, making it a valuable asset in the rapidly evolving technological landscape of today.

Project
CanningHill

Location
1 and 5 Clarke Quay, Singapore

Typology
Mixed Development (Residential, Commercial, Hospitality)

Developers
CapitaLand Development and City Developments Limited

Concept Architect
Bjarke Ingels Group

Project Architect
DP Architects Pte Ltd

Main Contractor
China Construction (South Pacific) Development Co

Civil & Structural Consultant
KTP Consultants Pte Ltd

Mechanical, Electrical and Plumbing Consultant
Beca Carter Hollings & Ferner (S.E. Asia) Pte Ltd

Quantity Surveyor
AECOM Singapore

BIM/ IDD Consultant
BIMAGE Consulting Pte Ltd

Expected Year of Vacant Possession
2027

This case study focuses on the efforts by CapitaLand, as they oversee and manage all BIM/ IDD activities for CanningHill.

MOTIVATIONS FOR IDD ADOPTION

SUCCESS FROM PAST PROJECTS

CapitaLand's IDD adoption journey was shaped by the successful BIM and IDD outcomes achieved in earlier projects such as Jewel Changi Airport and The Star Vista. Through enhanced visualisation and simulation capabilities, they were able to detect and resolve potential clashes, enabling improved efficiency, reduced rework and timely completion of projects. The project teams were also able to address coordination issues and manage stakeholders' expectations from the outset.

These outcomes further reinforced CapitaLand's confidence in the transformative potential of IDD.

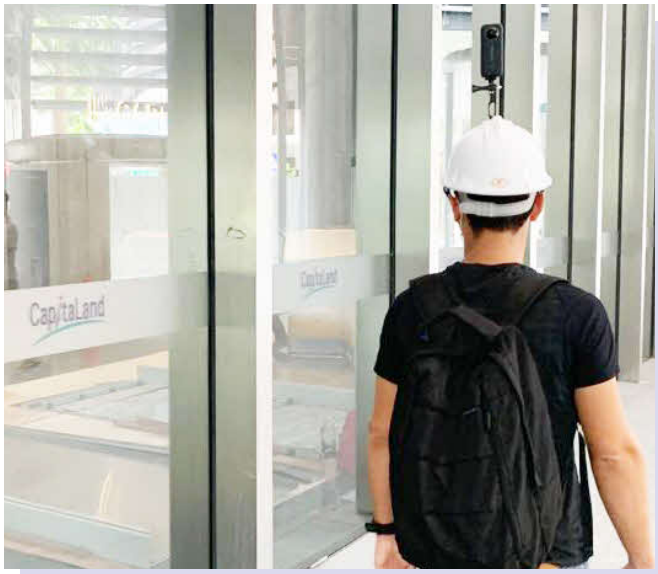
MARKET LEADERSHIP AND OPERATIONAL EFFICIENCY

CapitaLand prides itself on being a leading developer that is committed to maintaining a competitive edge. This drive has spurred the organisation to actively seek out new technologies and digital tools that can streamline processes, improve collaboration, optimise resource allocation and improve project efficiency.

For instance, CapitaLand has piloted advanced technologies such as Artificial Intelligence (AI) for defect management, and electric generators to improve site safety and air quality during projects.

To enhance performance of their assets, CapitaLand also implemented smart tools such as Internet of Things (IoT) sensors to monitor and improve building performance, as well as intelligent building platforms to monitor and automate fault detection through analytics.

Electric generators for improved site safety, air quality, and reduce operational carbon and noise pollution.



Using AI to detect defects in images from videos that were recorded with body-worn cameras during daily site walks.

TOP MANAGEMENT SUPPORT

A key driving force behind CapitaLand's motivation to adopt IDD was the strong support and advocacy from the firm's top management.

An example of such support was the decision to appoint a BIM consultant from the outset to ensure that IDD was implemented effectively in the project.

The project team further reinforced management's belief in IDD by providing bi-monthly updates to all stakeholders. These updates, which included rendered virtual mock-ups and model video walkthroughs, not only demonstrated the progress of IDD implementation, but also reflected the benefits of BIM/ IDD and the importance of robust visualisation tools.

KEY FOCUS AREAS FOR IDD IMPLEMENTATION

The varied components and intricate design of CanningHill posed complex challenges, necessitating extensive coordination and collaboration across the project team to optimise resources, improve efficiency and ensure timely project delivery. The effective utilisation of digital tools and solutions was crucial in achieving these objectives.

The following paragraphs showcase **three** such solutions that were implemented for CanningHill.

Digital Enabler: Common Data Environment

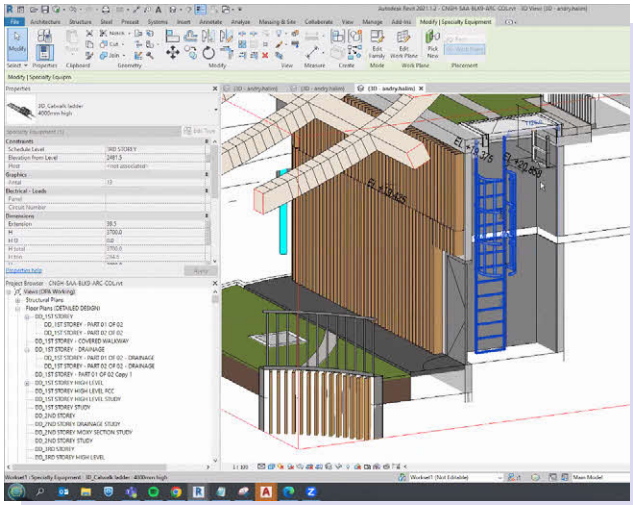
1 EFFICIENT PROJECT INFORMATION MANAGEMENT WITH INTEGRATED COMMON DATA ENVIRONMENT (CDE)

The use of a single CDE is generally recommended for projects. While complex project requirements and diverse stakeholder needs may necessitate the use of multiple data environments, the use of multiple disconnected platforms and data silos could disrupt information flow and hinder collaborations. It is therefore crucial to ensure seamless integration and mutual complementarity among the platforms.

In CanningHill, CapitaLand combined Autodesk's BIM 360 and Oracle's Aconex to enable comprehensive BIM-based collaboration, coordination and efficient document workflow management. BIM 360 was utilised for BIM-related processes and documentation, while Aconex specifically focused on document management, including Requests for Information (RFI) and Requests for Approval (RFA).

The integration of these two interoperable platforms not only reduced the need for time-consuming tasks such as manual documentation and coordination, but also facilitated data integration and efficient information transfer across various stages of the project lifecycle.

Furthermore, BIM 360's BIM capabilities improved the design coordination and visualisation aspects of Aconex, while Aconex's document management features complemented the information exchange and workflow management capabilities of BIM 360.



CDE repository with live model coordination for all BIM modellers and coordinators.

Operating as a digital hub, the integrated CDE served as a collaborative space for exchanging, communicating and coordinating project-related information. This enabled the project team to seamlessly and effectively manage both 3D BIM models and project documents, facilitating coordination through a single source of truth.

Benefits

Time Savings

- **Reduced** manual documentation
- **Faster access** to up-to-date information
- **Faster** decision making
- **Quicker** issue resolution

Improved Quality

- **Fewer** documentation-related errors
- **Enhanced** visibility and tracking of project data
- **Accurate and up-to-date** project information

How It Works

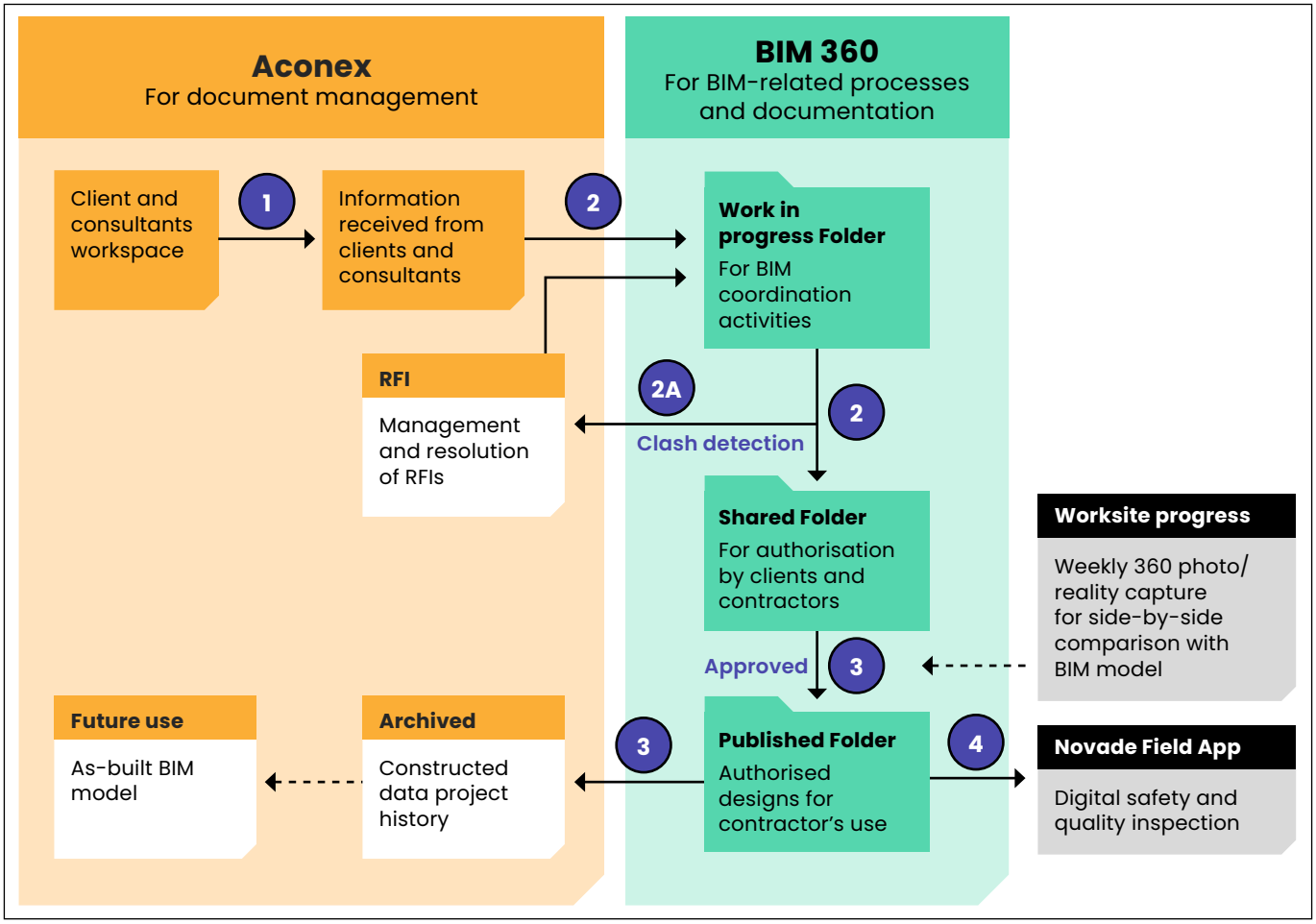


***Figure 1**: Integrated CDE in CanningHill*

Step 1: Information Flow

The project initiated with information from client via Aconex. Contractor received project information from clients and consultants, who maintained separate information sets within the platform.

Step 2: BIM-based Coordination and Collaboration

Information was transferred from Aconex to BIM 360 platform where BIM coordination activities took place in the "Work-in-Progress" folder, before moving to "Shared" folder for authorisation by clients and consultants.

> ***[Parallel Activity]** Worksite progress was tracked using drone overviews and weekly 360 photo documentation at set checkpoints via Airsquire technology. The platform was integrated with BIM 360, allow direct comparisons between current site conditions and the BIM model. The platform also maintained a historical photo record, offering insights into the construction timeline.*

Step 2A: RFI Management

RFIs were generated and managed in Aconex when design clashes or issues were identified during BIM 360 coordination.

Step 3: Transition to Construction

Authorised designs were then transferred to "Published" folder for contractor's use. Following completion, the information was then archived in Aconex's "Archive" folder.

> ***[Parallel Activity]** Appointed contractors were contractually obligated to maintain and update the BIM model, creating an as-built version by incorporating ongoing changes. This ensured the model's relevance for future work, including Addition & Alteration (A&A), Asset Enhancement Initiatives (AEI) and facility management. Facility management teams were also involved in the model updating process.*

Step 4: Digital Safety and Quality Inspection

Novade's safety and quality platform, integrated with BIM 360, was implemented to monitor safety and quality. Issues logged in Novade Field App could be located in the BIM model, enabling quick problem identification. This integration streamlined BIM model updates and allowed time savings.

2 BRIDGING BIM AND FIELD WITH ROBOTIC TOTAL STATION (RTS) TO AVOID COSTLY REWORK

The use of manual total stations usually entails multiple manual processes, from setting up the total station to marking points, verification, validation and installation. The related workflows also lack the use of advanced technological tools and processes required for seamless integration between BIM and field construction activities. As a result, manual total stations often lead to inaccuracies, necessitating reworks or adjustments that may result in additional material usage and wastage.

Due to the inherently complex nature of CanningHill, which includes mixed-use typology and intricate design geometries, it was crucial that all on-site installations were thoroughly checked and verified against the BIM model to avoid costly reworks. This therefore necessitated the employment of RTS for this project.

RTS, which integrates the functions of a manual total station with robotic technology, facilitated the direct transmission of precise BIM information to the construction site. This ensured accuracy and efficiency in project execution.

Additionally, the as-built conditions on-site could also be cross-checked against the BIM model by retrieving site markings from the RTS to identify variations arising from site constraints. This process enabled the update of the BIM model and empowered the project team to make informed decisions.

Use of RTS on site.

Benefits

Improved Safety

Precise alignment of construction elements
Mitigates risk of structural failures and collisions

Earlier detection of deviations
Prompts corrective actions and averts safety hazards

Better Quality

Rigorous comparison of site markings against design intent in BIM model
Ensures that construction elements are positioned according to design intent

Real time verification of on-site installations against BIM model
Reduces likelihood of errors or deviations

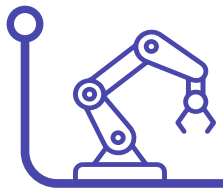
Time and Cost Savings

Precise and efficient field layout based on BIM data
Reduces reworks and minimises delays

Early detection of deviations and discrepancies between the site and BIM model
Facilitates timely corrective measures, eradicating costly reworks

Automates manual tasks
Reduces time and effort for manual processes (e.g. marking and verification, validation, BIM model updates and progress tracking)

How It Works



ROBOTIC TOTAL STATION (RTS)

Conventional Workflow
(Before RTS)

Current Workflow
(With RTS)

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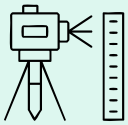


Assessment

Laser scanning technology was employed to capture the existing site conditions. Geographic Information System (GIS) integration was utilised to incorporate adjacent buildings into the project model. Various studies, such as line-of-sight analysis and site risk evaluations, could be conducted.

1

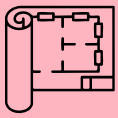
Manual marking and verification of installed points against the BIM model

Required more manpower on-site to carry out tasks.

Setup

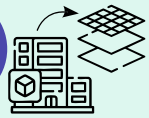
Required the transfer of BIM information from the model to the site using Autodesk Point Layout software to push data to the RTS.

2



Manual validation of installation points against the BIM model

More time consuming as it involved manual verification and comparison of the physical model with the BIM model.



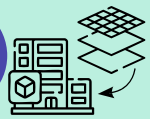
BIM-to-Field Process

RTS was used to accurately mark piles, kingpost, foundations, diaphragm walls and other construction elements on-site based on BIM information.

3

Manual visualisation and coordination between BIM model and field measurements

Subject to inaccurate measurements and misinterpretation of the BIM model.



Field-to-BIM Process (Reverse)

Facilitated retrieval of site markings from RTS and comparisons against the design intent in the BIM model to identify deviations or misalignments.

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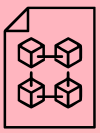
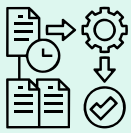


Manual updating of the BIM model based on field deviations

Lack of real-time updates in relation to BIM model, resulting in discrepancies or errors that could only be identified during later stages of construction or installation. This led to rework and additional costs.



Quality Assurance (QA)/ Quality Control (QC) Checks and automated BIM updates

Deviations and misalignments were used to update the BIM model, ensuring accurate alignment between field and BIM data. There was automated exchange of data between RTS and BIM software, facilitating seamless integration.

5

Manual progress tracking and documentation

More time consuming as surveyors needed to manually record and enter data into separate documentation systems or software.

Report Generation

Reports were generated for progress tracking and documentation.

3 DESIGN VISUALISATION AND EVALUATION USING VIRTUAL MOCK-UP TO REDUCE PROJECT COST

Physical mock-ups are commonly used in construction projects to visualise and evaluate different aspects of the design prior to commencement of actual construction or fabrication. There are, however, limitations associated with the use of physical mock-ups.

Recognising the inefficiencies of using physical mock-ups, CapitaLand decided to adopt the use of virtual mock-ups for CanningHill.

With virtual-mock-ups, the project team could leverage 3D modelling software and virtual reality platforms to generate highly realistic and immersive visualisations. These visualisations offered a more precise representation of the designs, allowing stakeholders to navigate and evaluate designs from various perspectives, resulting in a more informed design-making process.

Project stakeholders could also make design modifications directly within the virtual environment, eliminating the need for physical alterations and expediting the update process. Additionally, the digital nature of virtual mock-ups also facilitated real-time collaboration and remote access for the team, eliminating the need for travel, and enabling efficient communication and decision-making. This led to enhanced productivity and expedited project progress.

By leveraging technological advancements, virtual mock-ups effectively mitigated the constraints of physical mock-ups, optimising performance and cost efficiency.

Disadvantages of Using Physical Mock-ups

High costs
Materials, labour and storage costs can be significant, especially when there are multiple iterations or revisions due to design conflicts.

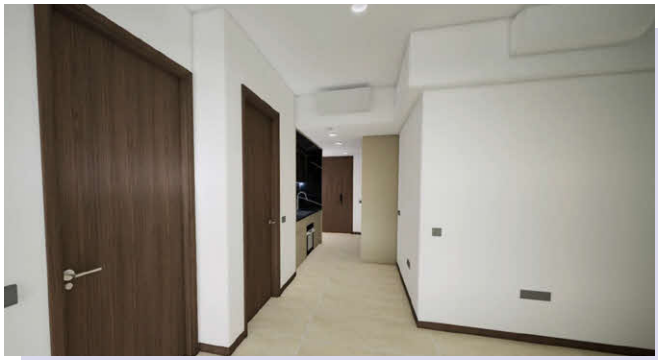
Time consuming
- Coordinating design elements across disciplines can be time consuming, especially if there is a lack of comprehensive visual understanding.
- Takes time to construct scale models, especially for complex projects. This can slow down the overall project progress.

Benefits of Virtual Mock-Ups

More informed decision-making process
Enabled by more realistic and accurate representation of designs.

Time savings
Achieved through real-time collaboration capabilities and the ability to make direct design modifications without having to wait for physical scale models to be constructed.

Reduced project cost
as physical mock-up models are no longer needed.



Virtual mock-ups of CanningHill Piers, the residential component of the CanningHill development.

How It Works

VIRTUAL MOCK-UPs

Conventional Workflow
(Before Virtual Mock-ups)

Current Workflow
(With Virtual Mock-ups)

0 Stakeholders Preparation

Familiarisation:
Training programmes were implemented to familiarise stakeholders (e.g. contractors and sub-contractors) with the virtual design environment and its capabilities. By actively involving stakeholders and encouraging their participation, a more accurate and comprehensive design evaluation process was achieved.

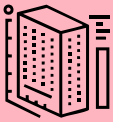
1 Design Conceptualisation

The design team conceptualised the project and created initial sketches and ideas using a modeling software.

Design concept development:
The design team used 3D modeling software to create virtual models based on the design concept.

2 Detailed Model Creation

The team constructed physical scale models of the design to visualise and evaluate its spatial characteristics.



Creating 3D virtual models:
The team created detailed 3D virtual models using BIM-based authoring tools, accurately representing the design elements.

3 VR Model Creation

A dedicated space was prepared to assemble and showcase the physical mock-up. This entailed organising the necessary materials, tools and labour for construction of the mock-up.

Virtual design environment:
The team utilised a virtual design environment, such as a virtual reality platform, to visualise and interact with the virtual mock-up.

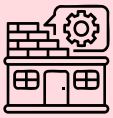
4 Stakeholder Engagement in Design Evaluation

Stakeholders visited the physical mock-up space to assess the design, evaluate spatial arrangements and provide feedback. This involved on-site evaluation, coordination and collaboration among project participants.

Evaluating design in virtual environment:
Stakeholders utilised the virtual design environment to assess the design, evaluate spatial arrangements and provide feedback. Real-time collaboration and design expertise enabled efficient evaluation and decision-making.

5 Update Design Model with Changes

If design changes were required based on the evaluation, the physical mock-up needed to be modified. This involved obtaining additional materials, making adjustments and repeating the construction process.



Making design updates in virtual models:
Design updates and modifications were made directly within the virtual models using the BIM-based software. This allowed for quick and efficient changes without the need for physical alterations.

CHANGE MANAGEMENT STRATEGIES

To ensure the successful implementation of IDD, CapitaLand undertook a series of impactful change management initiatives. These initiatives were designed to prepare the project and its stakeholders, equipping them with the necessary tools to fully harness the potential of IDD.

Early Onboarding of a Competent BIM Consultant as an Adviser

CapitaLand recognised the importance of engaging a proficient BIM/ IDD consultant from the project's inception. BIMAGE Consulting (BIMAGE) was therefore enlisted as an adviser during the project's early phases to provide guidance and expertise. Their responsibilities included:

Creating 3D Design Visuals for Enhanced Visualisation

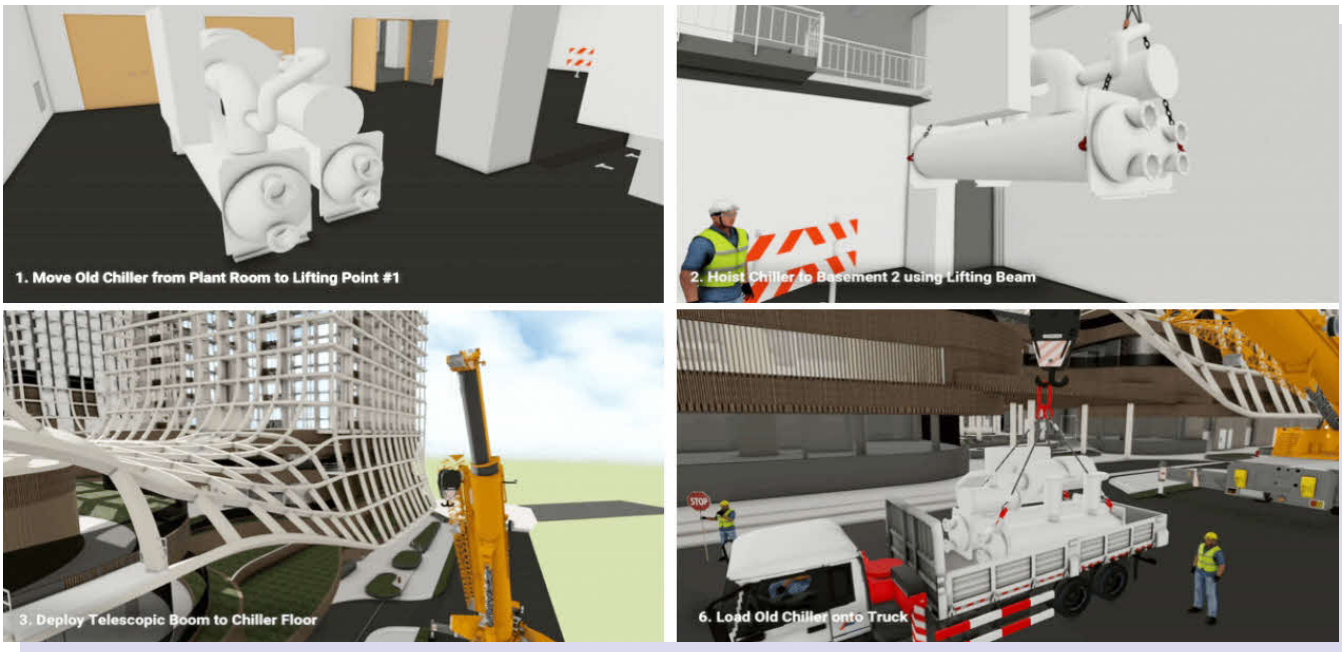
Collaborating closely with the project team, BIMAGE generated 3D design visuals that enhanced the comprehension of spaces and initial maintenance strategies in the early design phases. This included line-of-sight analysis for individual residential units, proposed space allocation for large MEP (Mechanical, Electrical, Plumbing) equipment replacement and overlaying existing site conditions on the proposed design. These visuals aided in informed decision-making and comprehension of the project's design intent.

Stringent QA/ QC Checks on Design Consultants' Models

BIMAGE partook in the QA/ QC checks of the Design Consultants' models to ensure that the models were well-coordinated across the different disciplines. The primary goal was to ensure that the models were fit for use by the Contractor once they were onboarded. As the Contractor would continue to build upon the Design Consultants' models, this helped to improve the overall efficiency and eliminated the need for re-modelling, ultimately saving valuable time for the Contractor to focus on their primary task of construction.

Assessing BIM Competency of Contractors during Tender

BIMAGE conducted a comprehensive assessment of contractors' BIM/ IDD competency during the tender process. This rigorous evaluation ensured that only competent and experienced contractors were selected, thereby contributing to the overall success of the project's IDD implementation.

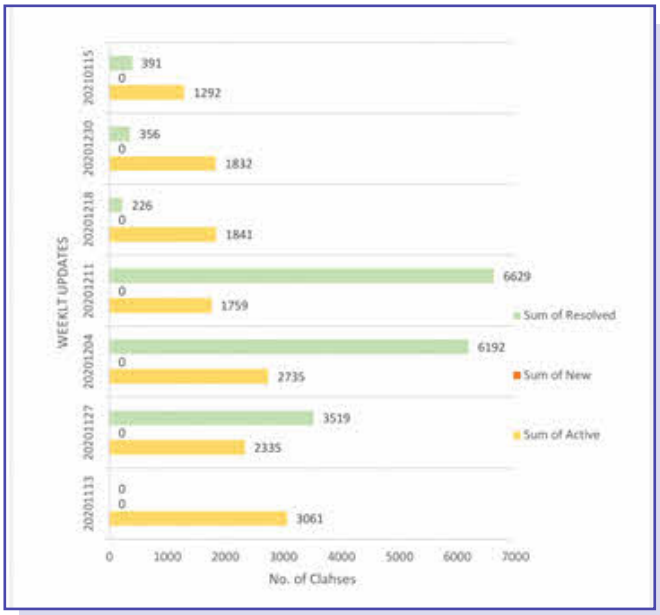


Maintenance simulation showing MEP replacement strategies for feasibility studies emphasizing on logistics and safety.

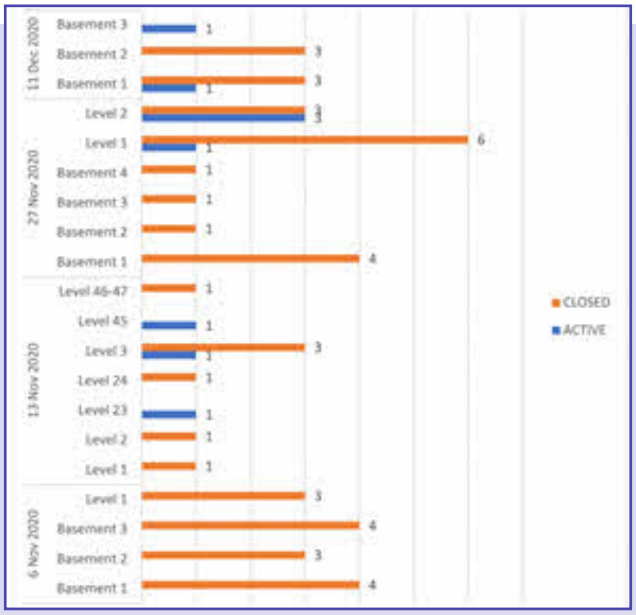
ii Specifying BIM/ IDD Requirements in Contracts

The implementation of BIM and IDD practices in projects was not new to CapitaLand. However, CanningHill marked the first time that CapitaLand incorporated BIM/ IDD specification requirements, including the deliverables and designated digital platforms, into the contract terms for consultants, contractors and sub-contractors. This was done to address the common industry challenge of misaligned expectations and processes within the project team.

BIMAGE helped define the requirements, including standards, deliverables, software licences and other relevant aspects. They also developed a comprehensive BIM Work Plan and Roadmap that outlined project-specific BIM milestones, workflows, responsibilities and deliverables. This ensured compliance with BIM/ IDD standards throughout the project's lifecycle.



Weekly updates showing clashes of active and new issues arising in the design model.



Overall updates per floor showing critical issues of active and closed items during model design review.

Example of BIM/ IDD Requirements in Contracts

CapitaLand mandated that consultants had to hand over the BIM models they developed to the appointed contractor, at no cost. This obligation had been clearly defined in the contracts with consultants, setting clear expectations for information sharing.

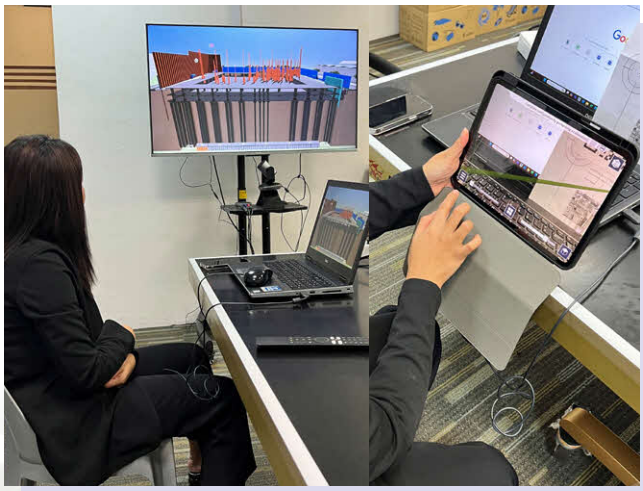
Similarly, contractors were required to share the BIM models with all sub-contractors, including the nominated sub-contractors. Careful consideration was given to ensure that proprietary codes or software in consultants' sheets were properly addressed to avoid any gaps in the handover process. The establishment of consensus and active engagement between consultants and contractors played a crucial role in preventing potential issues.

iii Providing Regular Updates on BIM/ IDD Activities

CapitaLand conducted regular briefings and discussions with the project team as they believed that it was important for project stakeholders to be kept updated about ongoing BIM/ IDD activities.

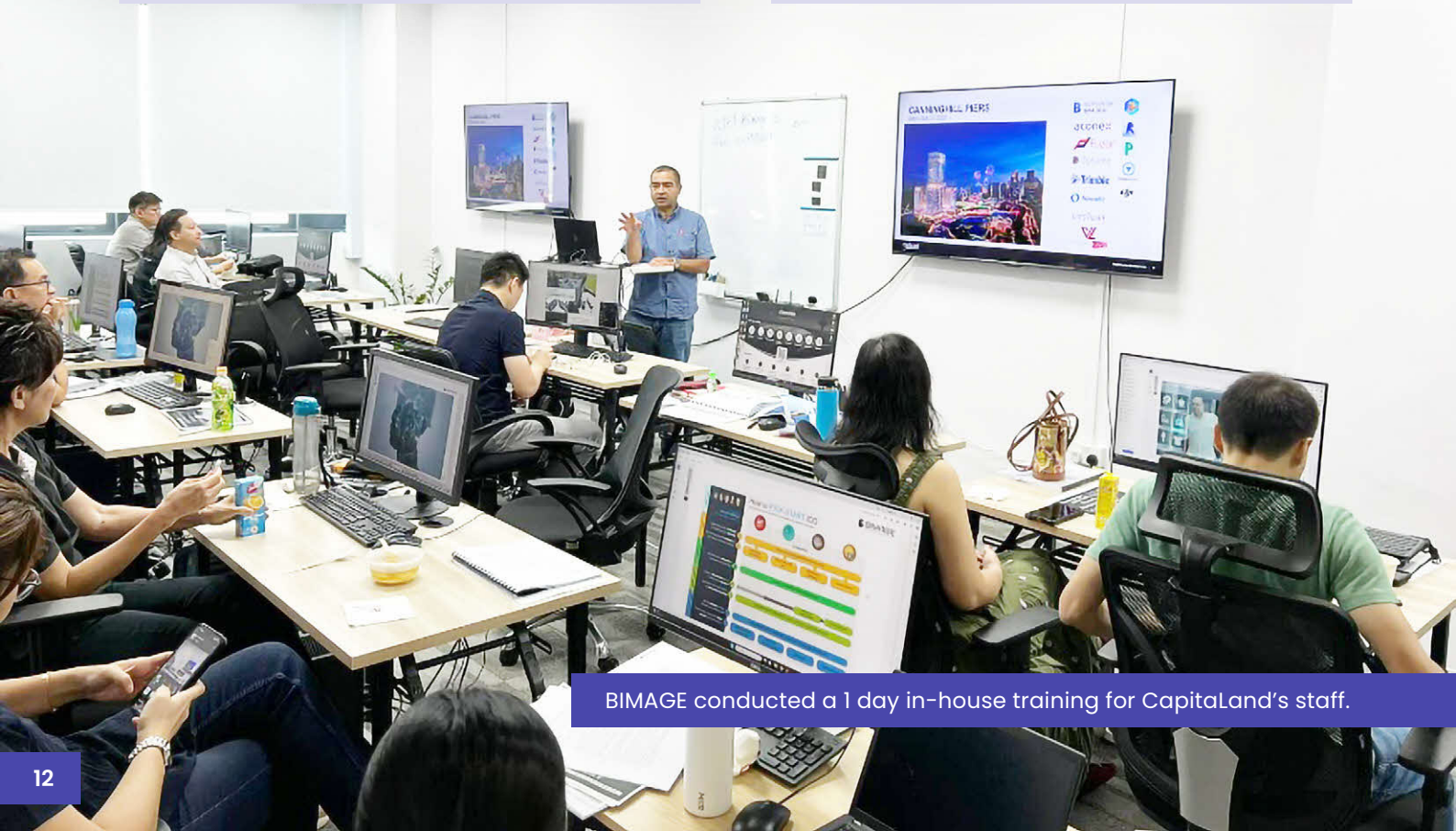
Visualisation tools, such as immersive 3D models and interactive presentations, were used during the briefings to facilitate stakeholders' understanding of the project's progress and deliverables. Discussions were also held to ensure that the project team was aligned on the project roadmaps at various phases, and that stakeholders were clear on the expected deliverables and specific digital use cases to be implemented, via the identified platforms. This helped to reduce the risk of contractors failing to meet the requirements specified in the contracts.

Other than providing updates and ensuring alignment on the project, the briefings also provided CapitaLand a platform to highlight the potential benefits that BIM/ IDD could bring to the project. These include improved coordination, enhanced collaboration, early clash detection and streamlined construction processes. Stakeholders were able to gain greater insights into how BIM/ IDD could contribute to project success, thus empowering them to make well-informed decisions.



IDD activities and internal meeting between BIMAGE and main contractor.

Bi-weekly meetings with all relevant project members – CapitaLand's project manager, consultants, main contractor and sub-contractors.



BIMAGE conducted a 1 day in-house training for CapitaLand's staff.

iv Utilising BIM Models in Project Technical Coordination Meetings (TCM)

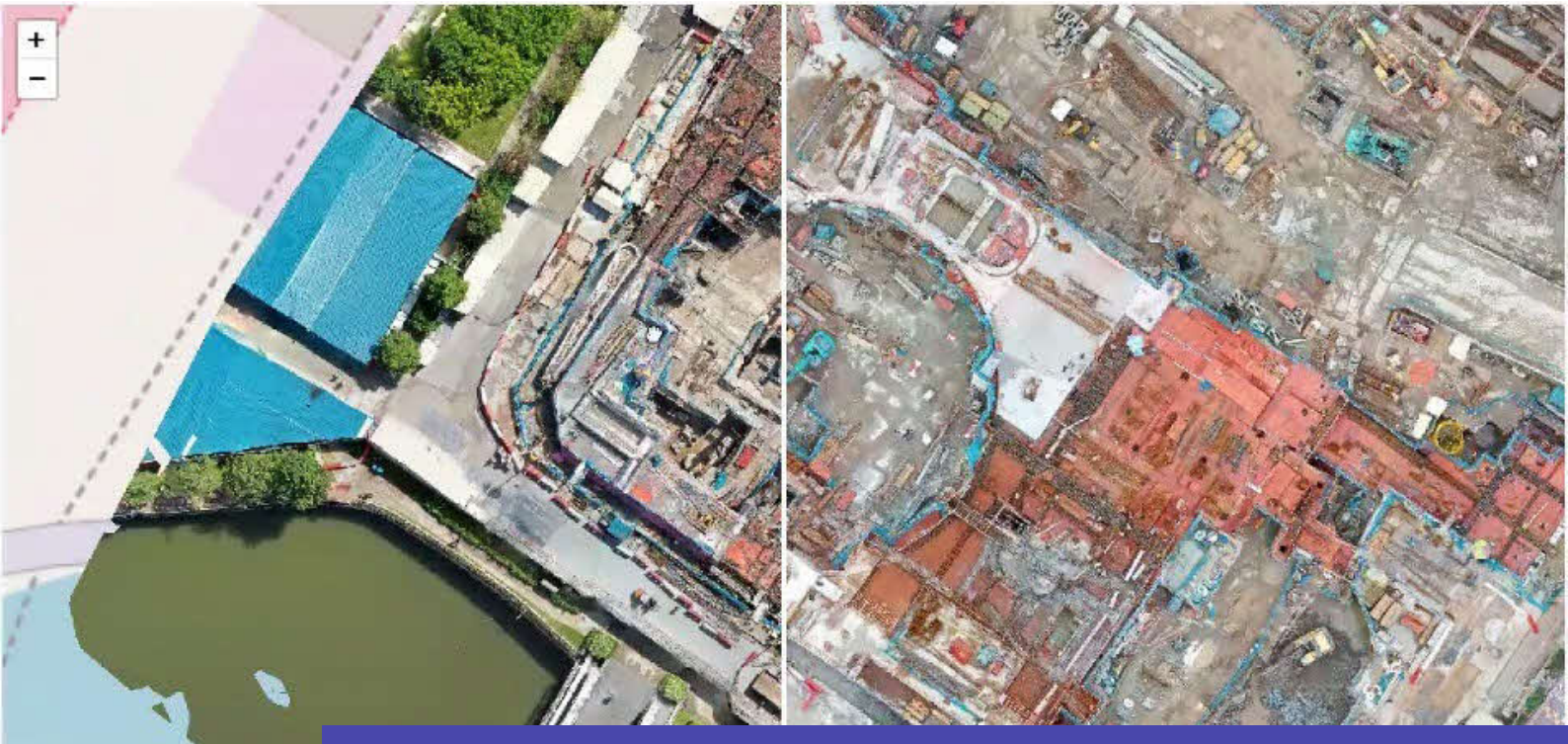
The team leveraged Virtual Design and Construction (VDC) tools during Technical Coordination Meetings (TCM) to identify and address design or coordination challenges proactively. These sessions brought together key stakeholders – such as the main contractor, sub-contractors, consultants, and project management team – to ensure alignment with critical project requirements, timelines, and design intent.

TCMs serve as a collaborative platform where project team could address issues systematically, promoting early problem resolution and mitigating downstream risks. The use of VDC tools, especially BIM models, bolstered communication by providing a dynamic, real-time visual reference that simplified complex technical discussions.

For example, when conflicts arose – be it conflicts between structural, mechanical and electrical, or architectural elements; insufficient headroom; or obstructed sightlines – the relevant parties could promptly access the BIM model to examine the problem in 3D. This visual representation enabled clearer comprehension amongst team members, expediting the decision-making process. It also allowed the team to jointly and effectively explore solutions.

Drone flight showing aerial view of the site, conducted bi-weekly for site progress.

Leveraging the BIM model's layers and data-rich environment, all parties could also swiftly identify problem sources, assess potential cross-disciplinary impacts, and propose coordinated design adjustments in real time. This streamlined process promoted accountability, as each member's role was well-defined within the BIM workflow, allowing easier tracking and completion of assigned tasks. Consequently, the improved coordination facilitated by TCMs led to smoother project delivery, enhanced quality, and better alignment with the overall project objectives.



Side-by-side comparison of site progress using smart date tracker from drone application.

v Appointing a Dedicated Person-in-Charge of BIM/ IDD

One of the strategies that CapitaLand undertook to drive IDD implementation in CanningHill was to appoint a dedicated person-in-charge to manage all digitalisation efforts, with an emphasis on BIM/ IDD, in particular. The person-in-charge, also known as the Digital Lead, collaborated closely with BIMAGE to ensure that all BIM/ IDD criteria were met.

KEY ROLES OF THE DIGITAL LEAD

Coordinating with Project Stakeholders:

As the primary liaison for consultants, contractors and sub-contractors, the Digital Lead was able to promote effective communication, coordination and cooperation among all parties, fostering a collaborative environment. The Digital Lead also chaired the weekly Virtual Design and Construction sessions and the fortnightly BIM/ IDD progress meetings. These sessions ensured that the project stakeholders saw the importance of BIM/ IDD implementation.

Enforcing BIM/ IDD Requirements:

The Digital Lead ensured that project stakeholders adhered to the terms of the contract and the BIM/ IDD requirements outlined in the BIM Execution Plan. The Digital Lead also effectively coordinated BIM activities and monitored the delivery of the associated deliverables.

vi Developing Workforce to be IDD Competent

CapitaLand recognised that successful IDD implementation relied on the competencies of its workforce. Hence, the organisation prioritised training and upskilling initiatives to equip employees with the necessary knowledge and skills.

A culture of continuous learning and innovation was fostered, encouraging employees to embrace IDD methodologies and adapt to digital transformation. Through workshops, seminars and industry conferences focused on IDD and industry-wide digital best practices, CapitaLand ensured that its workforce stayed ahead of IDD advancements, fostering a collaborative environment that propelled IDD implementation across projects.

CapitaLand is also collaborating with BIM professionals to conduct in-house workshops to better equip its workforce on relevant BIM/ IDD training. The trainings will focus on topics in relation to project management, such as the relevant authority guides and Code of Practices in Singapore, drafting of BIM clauses, BIM handover, common gaps in BIM coordination, scheduling and running IDD meetings, working with CDE and data standards.

In-house workshops to enhance digital competencies of staff.

VDC tools were used during weekly technical design meetings to improve project visualisation, support technical discussions, and foster collaboration.

The BIM/IDD initiatives implemented at CanningHill, along with their benefits and challenges, were shared internally with all project managers at CapitaLand Development.

BIMAGE conducted a 1 day in-house training for CapitaLand's staff.