The adoption and future of bim construction essay

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research identified the uses of Building Information Modeling in the industry. Then, the project examined the essential characteristics of future's building information models. Finally, the project concluded with the agenda for the next generation of building information models. Chapter 1 - IntroductionBefore discussing the adoption and future of BIM, Building Information Model and Building Information Modeling are defined as follow: Building Information Modeling is the development and use of a computer software model to simulate the construction and operation of a facility. The resulting model, a Building Information Model, is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users�� needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility.(AGC Contractors�� Guide to BIM, 2007)Building Information Model and Building information Modeling are both referred as BIM in this research. In the conventional 2D CAD, it can only show a building by some independent view such as 2D plans, section and elevation. The disadvantage of it is when we edit one of the mentioned views, detailed check and update on all other views separately are required since there is no links between those view and it is the major causes of poor drawings and discrepancies nowadays. It is the major difference between BIM and 2D CAD. Moreover, the 2D CAD is only some graphical entities but in BIM models the object can be defined as individual building element such as beams, columns, slab, etc with the size or thickness stored in the BIM models. The follow key generic attributes of BIM are defined by CRC Construction Innovation (2007) and it forms a guideline of what BIM can do currently in this research: 1. robust geometry2. comprehensive and extensible object properties that expand the meaning of the object3. semantic richness4. integrated information5. lifecycle support(CRC Construction Innovation, 2007)It is noticed that although studies have been conducted for the benefits of adopting existing BIM, the future development of BIM is seldom addressed. This research aims at finding out the functionality and coverage of the existing building information models in the architecture, engineering and construction (AEC) industry based on the current adoption of design tools. More importantly, to identify the essential characteristics of future's building information models. Lastly, the agenda for the next generation of building information models will be forecasted according to the results of case study or interview. Chapter 2 �V Literature ReviewAs the research aims at studying the coverage of the existing and future development of BIM, extensive studies had been conducted in the current uptake of BIM in Hong Kong and oversea and also the benefits of BIM in the current models. The following sections will review and summarize the literature for this research. 2. 1 Review in International BIM Activity and Current uptake of BIM in Hong KongInternational BIM ActivityUnited KingdomThe UK Government has set out a goal for their government project and adopting ��Push Pull�� strategy on the use of BIM. The government is in the role of ��Pull�� to pull the industry to adopt BIM by buying assets from the industry while the industry act as a role of ��Push�� by providing training and defining method and documentation in BIM. It is very good to have the government to take the initiative to promote the use and adoption of BIM in the construction industry. The UK Government has also defined 4 levels of BIM as a guideline on the deliverable at the end of the project. The United Kingdom��s BIM Maturity Levels are set out below:�ELevel 0: Unmanaged CAD probably 2D with paper (or electronic paper) as the most likely data exchange mechanism.�ELevel 1: Managed CAD in 2 or 3D format using BS1192: 2007 with collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data management by stand-alone finance and cost management packages with no integration.�ELevel 2: Managed 3D environment held in separate discipline building information modelling tools with attached data. Commercial data managed by enterprise resource planning software. Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as ��pBIM�� (proprietary). The approach may utilise 4D program data and 5D cost elements as well as feed operational systems.�ELevel 3: Fully open process and data integration enabled by ��web services�� compliant with the emerging IFC/IFD standards, managed by a collaborative model server. (Could be regarded as integrated BIM potentially employing concurrent engineering processes.)(UK Government BIM Strategy, 2011)SingaporeA Construction Productivity and Capability Fund (CPCF) was set up by the Singapore government and the government understand that BIM is a very important component on the enhancement of construction industry. The Construction and Real Estate Network (CORENET) program was set up by the Singapore government to drive the change in the construction industry. It provides the platform to exchange information among all parties in the industry as well as government authorities. An e-Plan Check system is also provided to encourage the use of BIM in Singapore. It is fully funded by the government and is designed to drive the industry from 2D plans to BIM that can used throughout the life cycle of the building, i. e. from design stage to construction stage or even demolition. This system also allows architects or engineers to check their BIM for regulatory compliance on the internet. It can be seen that this system is very useful and really encouraging the use of BIM in the industry especially in the statutory submission. United States of AmericaThe General Services Administration (GSA) in USA has committed to a strategic and incremental adoption of 3D, 4D, and BIM technologies. They are now exploring the use of BIM technology throughout a project��s lifecycle in the following areas including spatial program validation, 4D phasing, energy and sustainability, circulation and security validation, etc. Spatial program BIMs are now required by GSA as the minimum requirement for the submission to Office of Chief Architect (OCA) for final approvals. This means the concept design from the architects and engineers working on these projects must be submitted to the GSA in both the native format of the BIM authoring application and as a digital file. More advance BIM technology is always encouraged by GSA in their projects. GSA is now focusing on the development of capability to store BIM model as an asset. It can be seen that holding and managing building asset data could becoming the base for more pro-active and evidence based strategic management of built facilities. It can be seen from the above International BIM activity that the government is taking the leading role or the initiative on the development of BIM, promoting and encourage the use of BIM to enhance the whole construction industry. Current uptake of BIM in Hong KongThe Construction Industry Review Committee (CIRC) is appointed by the Hong Kong SAR Chief Executive in 2000 to review comprehensively the current state of the construction industry and to recommend some improvement measures. Application of information technology was recommended by the CIRC which they think that construction efficiency will be improved through new development of software. It has led to the introduction of Building Information Modeling technology in Hong Kong since 2004. It is widely understand that BIM is one of the key components to the future success of the Hong Kong architecture, engineering and construction (AEC) industry. Some of the key players in the industry are already successfully applying BIM in different local projects and it is well known that the benefit of using BIM is huge. The followings are several of the well known industry leaders and project that adopting BIM:�EProject: Community College City University Building (CCCUB)Location: Hong KongType: InstitutionalDescription: Community College City University Building is a BIM Project that Aedas adopted BIM technology to its full extent. The project involves the design of a 7 storeys, 40, 000 sq. m teaching facilities at the existing hilly campus site.�EProject: Prince RitzLocation: 448 Prince Edward Road West, Hong KongType: Residential / CommercialDescription: Prince Ritz is a BIM project that New World Development Company Limited adopted BIM technology. The site area of Approx. 1070m2, Domestic Area of Approx: 8040m2, Non-Domestic Area of Approx: 1600m2, Building Height of 119m.�EProject: Building 20Location: Hong Kong Science Park, New Territories, Hong KongType: R&D office buildingDescription: The new building �V referred to as ��Building 20�� during design stages �V is to enhance Hong Kong Science Park's role as a hub for innovation and technology development. Although energy saving technology had already been adopted in the park, Building 20 is designed to embrace green and sustainable technologies �V and demonstrate these can be viable in commercial buildings.�EProject: Cathay Pacific Cargo TerminalLocation: Hong Kong International AirportType:

Air Cargo Terminal BuildingDescription: The Cathay Pacific Cargo Terminal is designed to maximize usage of the site area of approximately 10 hectares. With a floor area of 260, 000 square metres �V exceeding the floor area of Two International Finance Centre �V it will be the largest cargo terminal in the world based on cargo through-put per square metre.�EProject: Goodman Interlink Logistics CentreLocation: Tsing YiType: Industrial ConstructionDescription: The building is relatively simple, with logistics facilities on the first 16 levels, warehousing at upper levels, and offices at the top. BIM is chiefly being employed to ensure that construction proceeds smoothly, and the BIM model was used to develop the 4D simulation showing the construction process.�EProject: One Island EastLocation: Taikoo Place, Hong KongType: CommercialDescription: One Island East is a 300m high office building with a total GFA of 145, 000m2. Special structural engineering design approaches were adopted such as prestressed concrete steel composite slab due to the 27m long span at the uppermost floors, outrigger trusses, etc. The design also considered environmental issues by extensive use of grade 100 concrete and the application of building information modelling (BIM). Similar to the countries mentioned above, The Housing Authority (HA) of the Hong Kong Government started piloting the use of BIM in the public rental housing projects since 2006. They have set up their own in-house standard, guidelines and component families for effective model building, electronic file management and communication between BIM users. There are several public rental housing projects using BIM at different project stage ranging from feasibility study to construction stage or even demolition. The projects such as So Uk Demolition, So Uk Redevelopment, Kwai Chung and Kai Tak development show encouraging results on the BIM applications.

It is a good start for the Hong Kong Government to adopt BIM in their project and this is encouraging the use of BIM to the AEC industry. Having a basic understanding of the adoption of BIM in both Hong Kong and oversea, the next section will go through the review of the benefits of the existing BIM models. 2. 2 Review in benefits of the existing BIM modelsBefore go into the details on the review of benefits of the existing BIM models, the functionality and coverage of the existing BIM will be gone through in the next section. The functionality of existing building information modelsIn the past decades, scholars have been making great effort in investigating the function and usage of BIM that facilitate the production of the best possible project performance. Salman Azhar et al. (2008) identified eight categories of BIM usage and they include Visualization, Fabrication/shop drawings, Code reviews, Forensic analysis, Facilities management, Cost estimating, Construction sequencing and Conflict, interference and collision detection. In addition, Hergunsel (2011) suggested the similar usage and they are Visualization, 3D Coordination, Prefabrication, Construction Planning and Monitoring, Cost Estimation and Record Model. It can be seen that the major usage can be summarized into: Visualization, 3D Coordination, Prefabrication/Fabrication, Facilities management, Cost Estimation, Construction sequencing and monitoring. Benefits of the existing BIM modelsThe following paragraphs will review the benefits of the existing BIM models from the function and usage commonly adopted in the Hong Kong and oversea projects. CRC Construction Innovation (2007) identified that accurate geometrical representation of the parts of a building is the key benefit of the BIM. They summarized the related benefits into nine categories as follows: 1. faster and more effective processes2. better design3. controlled whole-life costs and environmental data4. better production quality5. automated assembly6. better customer service7. lifecycle data8. integration of planning and implementation processes9. ultimately, a more effective and competitive industryIn addition, AGC (2005) identified the following benefits to the contractor using BIM:�EThe ability to identify collisions�EThe ability to visualize what is to be built in a simulated environment�EFewer errors and corrections in the field�EHigher reliability of expected field conditions, allowing for opportunity to do more prefabrication of materials offsite, which is usually a higher quality at a lower cost�EThe ability to do more ��what if�� scenarios, such as looking at various sequencing options, site logistics, hoisting alternatives, cost, etc.�EThe ability for non-technical people (clients, users, etc.) to visualize the end product�EFewer callbacks and thus, lower warranty costsAlthough there are many benefits of using BIM currently, it should not be limited to the current uptake of it and more characteristics are necessary to enhance the use of BIM in more different discipline in the future to produce a better project performance. It will be further discussed in this research. Chapter 3 - Research MethodologyIn order to study the essential characteristics of future's building information models, case studies will be conducted for several building projects to examine the functionality and coverage of the existing building information models first. With reference to the literature review and the case study conducted, the essential characteristics of future's building information models will be uncovered and the agenda for the next generation of building information models can be forecasted. In summary, the methodology for this project is summarized in the following schematic diagram: Chapter 4 �V Functionality and Coverage of Existing BIMCase studies and interview were conducted to examine the functionality and coverage of the existing building information models and three recent remarkable building projects in Hong Kong were selected. The following paragraphs will describe the selected case studies in detail. 4. 1 Case Study 1: One Island East �V Hong KongProject BackgroundThe project is a Grade-A office located on the Hong Kong Island. The building consists of 70-storey of commercial tower with 308m high from ground. It is enclosed by the external curtain wall. The total Gross Floor Area (GFA) of the project is about 145, 000 m2 and the average GFA of a typical office floor is about 2, 300m2. The superstructure construction commenced on March 2006 and the whole project is completed in 2008. The image of the building is shown in Figure 1. Figure 1 Rendered Image of One Island East (left) and cross section (right)Detail AnalysisCentralized project design office was set up to facilitate a better collaborative environment among Architects and Consultants. Representatives of the design consultants were stayed in one single office and therefore the coordination among architecture, structure and building services design was effective and efficient by adopting this arrangement. They can solve the coordination problems immediately in front of the digital model instead of making phone calls and sending request for information by email. The 3D model was built with reference to the 2D CAD drawings for each consultant in the centralized design office. The sub-models from each disciplines were then merged to form a 3D model consist of architecture, structure and MEP. Each sub-model which is based on the floor levels was further dissected into different zones for coordination. Different discipline can base on the 3D model to coordinate any clash in 3D view. The flowchart of Implementation for Superstructure Construction is shown in Figure 2. The images for project-wide multi-discipline design coordination and Automatic Clash Identification are shown on Figure 3 and Figure 4 respectively. Figure 2 Flowchart of Implementation for Superstructure ConstructionFigure 3 Project-wide multi-discipline design coordinationFigure 4 Automatic clash identification and ManagementIn the main structural frame construction, two critical processes, which would affect the overall programme are 4-day typical floor cycle and outrigger construction. In this project, Virtual Prototyping (4D Model) was adopted to simulate the construction sequence of there two processes. It allows the engineers and contractor to construct and review the complicated details many times in the computer, prior to actual construction. The typical 4-day cycle construction sequences are shown in Figure 5 to Figure 8. Figure 5 Four Day Cycle (Day 1)Figure 6 Four Day Cycle (Day 2)Figure 7 Four Day Cycle (Day 3)Figure 8 Four Day Cycle (Day 4)Virtual Prototyping can also identify potential problems such as arrangement of heavy core wall reinforcement, shear studs and couplers that are welded on the outrigger elements and allow resolution prior to the actual installation. The steel outrigger elements encased in corewall is shown in Figure 9. With the aid of the 3D model, several improvements on the connection details, construction methods and sequences have been achieved which has streamlined construction to gain time without affecting the overall structural performance of the building. Figure 9 steel outrigger elements encased in corewallUpon completion of the project, the 3-D model can be used as a maintenance manual with the technical information and physical location of all plant, equipment and services routing built-in. Searching and updating of as-built information will be much more efficient and systematic. Observation and Interpretation from the Case StudyCase

Study 1 is a traditional building project with different discipline (Architect, structural engineer, MEP engineer, etc) involved. It is observed that the centralized project design office is a very effective and efficient way to get all the discipline to work and coordinate together. It is noticed from the case study that one of the key function of BIM is the clash detection. Once any clash is detected from the BIM model, all related discipline can quickly resolved in the project office. Another key function of BIM observed is the Virtual Prototyping. It can simulate the complicated details to allow resolution before actually installed on site. It can also simulate the construction sequence to allow contractor to have a better planning and can streamline the construction. Last but not least, the function of facilities management is also observed in this case study. All as-built information including the technical information of plant and equipment is stored in the BIM model to facilitate the future management of all facilities. 4. 2 Case Study 2: Sludge Treatment Facility �V Hong KongProject BackgroundThis project will help to relieve that disposal problem. The sludge treatmentplant will process 2, 000 tonnes of waste water sludge per day and will be commissioned in 2013. The waste water sludge, mainly collected from Stonecutters Island Sewage Treatment Works, the largest treatment facilityin Hong Kong, will be incinerated by fluidized bed incinerators. It will evaporate all of the water content in the sludge and burn 90% of the remaining solid component leaving only about 60 tonnes per day of ash for disposal, thus the capacity required in landfills for sludge disposal will be greatly reduced. The image of the treatment plant is shown in Figure 10. Figure 10 Rendered Image of Sludge Treatment FacilityDetail AnalysisBIM is used to facilitate the design and coordination process, as well as the quantity for fabrication material ordering in this project. The objective of using BIM in this project is to produce a highly organized and coordinated model where it can be utilized by all in the design and construction teams for planning. In terms of MEP, the information for pipe work production, procurement, fabrication, installation and commissioning were highly detailed in the 3D design models to produce piping system drawings for procurement and pre-fabrication. Moreover, the BIM used can demonstrate whether the means of escape, maintenance access and vehicular ingress zones is clash free or not as it is very critical to show to local authorities for their acceptance and certification. Observation and Interpretation from the Case StudyFrom case study 2, it is observed that one of the functions of BIM is to estimate the quantity of material to be ordered. It is also noticed that clash detection is another major function not only on detecting clash between MEP and structure but also the clash between means of escape and maintenance access, etc to comply with building ordinance. 4. 3 Case Study 3: HKIA Midfield Concourse �V Hong KongProject BackgroundThe proposed Midfield development includes the construction of the Midfield Concourse building (MFC) to a standard at least commensurate with that of Terminal 1. This 5-level building features a large clear open span steel truss roof, high standard internal finishes and a full range of building services and airport systems. The MFC is designed to provide an ultimate floor area of approximately 110, 000m2 with 20 bridged stands. The image of MFC is shown in Figure 11. Figure 11 Rendered image for HKIA Midfield ConcourseDetail AnalysisSince it is a Joint Venture project, multiple BIM software platforms are used to deliver the optimum solution. With the application of BIM, clash analysis, interactive room data sheet and BIM management was provided. The objective is not to inhibit the JV team��s ability to use already seemingly disparate software to work in a coordinated manner outside the base originating software packages. The output from the design team in this project would be CAD drawings and Revit modules. The client would then pass the model to the contractors who would continue to develop the model and return the as-built model for facility management. Observation and Interpretation from the Case StudyIn case study 3, it can be seen that the major function is the clash detection which is similar to previous two case studies. Another major function is the facility management after the building has been built. It is similar to case study 1 which is discussed in previous section. 4. 4 InterviewIn order to have a clear picture regarding the function and coverage of BIM in the previous section, interview is conducted to the related engineer as they play an important role in the design coordination and project management. Findings from the interviewCase Study 1It can be seen that the adoption of BIM in case study 1 is the highest among all cases. The interviewee said the use of BIM in the project can first of all gave them a 3D visualization of the whole building instead of just looking on the 2D plans and sections. It is mentioned that the BIM model is an integrated model with the size of beam stored and so less discrepancy was found compare to the 2D drawings in which section need to be checked and revised due to the changes on plan. It is also mentioned that the advantage of using BIM is having the function of clash detection. It solved many clash between MEP and structure before it is actually find on site to avoid any late change to design. The interviewee also said the Virtual Prototyping (4D Model) is very useful for them to identify the complex detailing and critical area before the problems are found on site. It allows time for them to resolve it prior actually installed on site. As mentioned by the interviewee, Virtual Prototyping (4D Model) can also model the construction sequence planning and these techniques allowed construction progress of the 1, 500 tonne steel outrigger trusses to be greatly improved. 10 working days were saved for the internal outrigger core wall and 16 working days for external core wall comparing to contractor��s original programme as mentioned by the interviewee. The function of quantities estimation and scheduling is also mentioned by the interviewee. The interviewee said all structural elements are well defined with grade and size in the BIM model and therefore with this powerful feature, quantity measurement can be very efficiently and accurately carried out using the model, without the need of manual calculation. It is obvious that the quantity surveyor gain benefits from this function. Last but not least, the interviewee mentioned that BIM can also manage the facilities after the building have been built. It is mentioned that BIM can be used in the whole life cycle of the building from design development to physical construction and finally to property management and even demolition. Case Study 2The interviewee said it was essential to delivering the project efficiently and effectively by utilizing BIM. The interviewee said it is never been used on such complex project that fully integrates structural, civil, building services and process engineering in a single model. It is mentioned that all team members had access to the updated master model and they could visualize every area of the overall layout. Barriers between the standard of 2D drawings from different disciplines were eliminated. The interviewee also said all meeting and discussions were conducted using this powerful tool to visualize delivery routes for major equipment and positioning of the plant during construction on site. The model also facilitated the design process, especially in congested area where the risk of clashes between pipes, pipes and equipment, equipment and structures are high. It also saved time and paper without printing numerous 2D layouts and sections for meetings. Case Study 3The interviewee said the client required a significant 3D process from the Joint Venture team to deliver a coordinated model approach. A robust workflow was implemented taking into account every step of the software integration, exchange, review, clash analysis and return of models to the client. It is mentioned that with the application of BIM, clash analysis was provided. A virtual rehearsal of the construction process was conducted prior to ��real�� construction, i. e. the fourth dimension (4D) BIM. By the use of BIM, there is potential to reduce errors, site requests for information (RFI), improve build-ability, have the ability to create fast and impressive visualizations and animations, have the ability to demonstrate integration and coordination with the engineering design team and reduce the contractor��s potential pricing risk by greater understanding of overall project thus minimizing traditional contingencies for the ��unknowns��. 4. 5 SummaryOverall, the common functionality and coverage of the existing BIM model from the case studies and interview can be interpreted and summarized as follows: 1. 3D visualization �V it gives the 3D view of the whole building instead of just 2D plans and sections2. clash detection �V it facilitate the design process and clash can be solved before actually found on site3. construction planning (4D) �V it can optimize the construction period with good planning before actually constructed on site4. Quantities Estimates and Scheduling �V it can efficiently and accurately measure quantity of elements in the model directly5. Facilities Management �V it can be used for renovations, space planning, and maintenance operationsChapter 5 �V Essential Characteristics of Future��s BIMIn this chapter, the possible characteristics of future��s BIM will be identified by literature review and the essential characteristics will be uncovered. Below are some of the possible characteristics that will be discussed in this chapter: 1. sustainability/energy2. construction safety3. Artificially intelligent BIM5. 1 Sustainability/EnergyNowadays, more and more people in the construction industry concerning about the sustainability of the building. In particular, energy efficiency becomes a major measure of building performance. Leadership in Energy and Environmental Design (LEED) is known as one of the programme adopted to certify the building in terms of sustainability. CO2 emission is also another key in measuring the sustainability of the building. In traditional building design, target for CO2 emission and energy saving is set as a measure of sustainability. It can be achieved by so call more sustainable design and more efficient use of energy. BIM can actually model the energy usage and other sustainability measures to achieve a more sustainable design of building but not many companies are doing this nowadays. Currently, the traditional sustainable design, are based on CAD tool to model the building. It needs some energy simulation tool to simulate the performance of the building. The set of data required for the simulation is quite complex and not easy to handle. However, the development of Green BIM tools seems can solve this data handling problem. Azhar et al. (2011) claimed that the Green BIM tools can integrates the design model and the simulation can analyze multi-disciplinary information in a single model which improves the analysis and eliminates errors of data handling. This can provide the designer a direct feedback on now to improve the performance of the building over life cycle of the building. However, there are still some problems in using BIM for sustainable design. The energy analysis is now current rely on the estimated values for air flow, etc which may lead to unreliable result. Therefore, Ibrahim et al. (2013) suggested using real data gathered from the building and the problem can be overcome. Data flow between BIM models and energy analysis tools is also a problem. Further development on the data transition is still required to make the use of BIM. In summary, BIM technology is already used to monitor the building performance and for sustainable design. It can also be seen that sustainable design is a major component on the building performance in the future and therefore it forms an essential characteristics in the future��s BIM. Future development of importing energy analysis tools into BIM model is necessary. 5. 2 Construction SafetyConstruction safety is a worldwide issue. It is critical to identify the potential safety hazards in the safety planning process. BIM potentially can be provided for safety design and planning as suggested by Sijie Zhang et al. (2013). In tradition, construction site safety is always the sole responsibility of the contractor. It is seldom to think of the site safety in the building design stage. Design engineer did not aware their design would give great impact on the site safety due to different construction method and schedule. Traditionally, safety analysis and control are based on experience and historical statistics. It provides valuable but general information for safety planning. It can be seen that it is not sufficient for some special or unique project to predict the occurrence of accidents. It led to the other approach such as virtual design or BIM to simulate the real situation. Safety rules can be set and it would be checked automatically in the BIM as proposed by Sijie Zhang et al. (2013). However, Sijie Zhang et al. (2013) found the following limitations on the implementation in BIM: 1. BIM can��t model in real-time basis, 2. manual effort still required in rule interpretation. On the other hand, Kamardeen, I (2010) suggested the use of Accident Prevention through Design (PtD) to various phase of the design process to identify risk and hazards that workers may be encountered on site. Mitigating design solutions can then be introduced to meet the design requirement and safe working environment for the works. 8D modeling tool for PtD is introduced and Kamardeen, I (2010) concluded that the tool would be able to perform hazard audits on BIM models and provide suggestions for design revision for critical elements and suggestions for on-site hazard control for non-critical elements. In summary, it can be seen that it is feasible to implement construction safety into BIM models and it is well known that construction safety is very important to the construction industry. This also considered as an essential characteristics in the future��s BIM. 5. 3Artificially intelligent BIMNBS (2012) suggested that artificially intelligent BIM (Ai-BIM) could be one of the developments in the future BIM. The BIM models will contains information and guidance such as code, client requirements, etc related to the project and the BIM itself will actually design for the designers. It is known that it is still in very early stages but high potential in the future. At the moment, it is not considered as the essential characteristics since this feature is not necessary to the designer. It is just a helping tool and it still needs decision and judgment from the designer. 5. 4 InterviewSeveral engineers were interviewed and they agreed that sustainability and construction safety would be the coming hot topic in the industry and those are the coming essential characteristic of the future��s BIM. 5. 5 SummaryIn conclusion, sustainability/energy (7D) and construction safety (8D) are the essential characteristic of the future��s BIM based on the above studies. These are recommended to be integrated into future��s BIM. The future��s BIM is not limited to the above two characteristic. It should be further developed to nD in the future based on the industry��s needs. Chapter 6 - Agenda for the Next Generation of BIMHaving a long discussion regarding the functionality and coverage of existing BIM and essential characteristics of future��s BIM, sustainability/energy (7D) and construction safety (8D) are recommended to be the characteristics of future��s BIM. This section will then discuss and set the agenda for the next generation of the BIM. 6. 1 Discussion on Current uptake of BIM in Hong KongAs mentioned in the literature review, The Housing Authority (HA) of the Hong Kong Government started piloting the use of BIM in the public rental housing projects since 2006. This move can encourage the construction industry to the adoption of BIM. However, in Hong Kong, the adoption of BIM is mainly driven by the clients nowadays. It is very hard to say when BIM can be fully adopted in the whole construction industry. Policy in Singapore can be referred. Having an e-plan checking system would really pull the industry on the adoption of BIM. Policy in UK can also be referred. More importantly, a set of guideline or standard like UK should be defined particular for Hong Kong. Without any government policy and guideline, there will be no motivation for the industry to move forward on the adoption of BIM. There are also some constraints when implement the policy on the full adoption of BIM. Apparently, the major issue would be the resources especially for those small firm and contractor in the industry. Those small firm and contractor may not have enough resource and thus they are not willing to adopt BIM. Therefore, the whole construction industry should be consulted to give their opinion on the adoption of BIM. 6. 2

Proposed agenda for the next generation of BIMIn summary, agenda for the next generation of BIM is summarized in the following schematic diagram: Chapter 7 - Conclusion and Way ForwardThe research aim of investigating the future development of building information models has been fulfilled through conducting a comprehensive literature review and case studies. The functionality and coverage of the existing building information models were found through case studies and interviews. It is found that 3D visualization, clash detection, construction planning, quantities estimates and scheduling and facilities management are five common functions in the existing BIM. It is also found from various literatures and interviews that sustainability/energy (7D) and construction safety (8D) are the upcoming essential characteristics in the future��s BIM. Discussion was made on the current uptake of BIM in Hong Kong. With reference to the literature and international BIM activity, agenda for the next generation of building information models was proposed. Although BIM has been widely adopted in overseas building project with the demonstration of its effectiveness, limited local experience can be retrieved owing to a limited number of building projects adopting BIM in Hong Kong. Even though two essential characteristics were uncovered, it is suggested to further investigate the possible characteristics in the nearly future based on the industry��s needs as the way forward after this research. Further investigation on the timeline of the agenda is also needed as the way forward after this research. To conclude, the research studies have been carried out satisfactorily and the researcher believes this research will be beneficial to the whole construction industry.