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BIM Annex C – Trackwork (TWK) CCSM BIM Requirements	**Yes**
BIM Annex D – 4D BIM Simulation Requirements	**Yes**
BIM Annex E – 5D BIM Quantity Take-Off (QTO) and Costing Requirements	**Yes**
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21 BUILDING INFORMATION MODELLING (BIM) REQUIREMENTS

21.1 Objectives

21.1.1 This Project Information Requirements (PIR) document defines the Authority's minimum Building Information Modelling (BIM) requirements for the project and to ensure compliance to the latest version of BS EN ISO 19650.

21.1.2 This document is defined to support the Asset Management framework of the Authority.

21.1.3 This document shall be used in conjunction with the latest version of BS EN ISO 19650, BS PAS 1192 part 6, Singapore BIM Guide, Code of Practice for Building Information Modelling (BIM) E-Submission and Singapore VDC Guide, as a guidance for the Contractor to develop the BIM processes and procedures (i.e. BIM implementation) in the production of the required BIM Deliverables, Virtual Design and Construction (VDC), and Integrated Digital Delivery (IDD) implementation throughout the Contract to achieve explicit project goals. In the event where there are discrepancies between this document and the above-mentioned documents, this document shall prevail unless otherwise specified by the Authority.

21.2 Definitions

21.2.1 **As-Built Model (ABM)** shall refer to a Project Information Model (PIM) to be developed and updated by the Contractor, recording the actual constructed assemblies, installation elements and components with accurate size, shape, location, quantities and orientation of the project.

21.2.2 **Asset Information Model (AIM)** shall refer to a separate ABM to be further developed and updated by the Contractor, recording all the asset information such as Operation and Maintenance (O&M) user manual reference, equipment specifications, warranty details, manufacturers' data, asset codes, etc. The asset information shall be in accordance with the Authority's Asset Information Standards (AIS) and asset-related information requirements documented in the agreed BIM Execution Plan (BEP).

21.2.3 **Asset Information Requirements (AIR)** shall refer to the Authority's Asset Information Standards (AIS) on asset-related information requirements, which is to be adhered and incorporated in the AIM. The details of the AIS will be issued by the Engineer upon Contract award.

21.2.4 **BIM Deliverables** shall refer to PIM and AIM in native and IFC formats, BIM Elements, Drawing Sheets, BEP, BIM related reports/ schedules/ templates/ simulations/ analysis/ videos/ rendition, and other associated file formats to be developed, updated and delivered by the Contractor.

21.2.5 **BIM Elements** are also known as BIM objects or object families, which comprise of digital representation of the physical and functional characteristics of an actual object or a component. BIM Elements required for the project shall be developed and updated by the Contractor. It shall consist of Level of Information Need (LOIN) represented by geometry and non-geometry attributes of the elements including the space clearances for systems and services related' performance, maintenance and installation coverages.

21.2.6 **BIM Execution Plan (BEP)** shall refer to a project specific BIM implementation plan to be established and implemented by the Contractor's Project BIM Manager (PBM), demonstrating the Contractor's proposed approaches, resources, capability, capacity and competency to accomplish the BIM/ VDC/ IDD related objectives and outcomes, BIM Deliverables and LTAEIR requirements specified in the Contract.

21.2.7 **BIM Software** shall refer to all software and plug-ins used by the Contractor for the purpose of designing, modelling, reviewing, analysing, visualisation, communication, coordination and collaboration for the Contract.

21.2.8 **Common Data Environment (CDE)** shall refer to an agreed designated digital solution to be provided, used and managed by the Contractor, for communication, collaboration and information exchange amongst the stakeholders within the Contract and with the Interfacing Parties (InfP).

21.2.9 **Construction Models** shall refer to the PIM to be developed and updated by the Contractor during the construction stage, for design and construction coordination; shop drawing approval, Design for Manufacturing and Assembly (DfMA) (where applicable); and the Drawing Sheets production for manufacturing, fabrication, installation and assembly.

21.2.10 **Coordinated Combined Services Model (CCSM)** shall refer to the PIM to be developed and updated by the Civil and/ or Trackwork (TWK) Contractors during the design and/ or construction phase development; for the purpose of coordination checks across all disciplines to form a complete project.

21.2.11 **Delivery Team** shall refer to the Contractor's team who is responsible for the creation of information for the project. The team shall comprise of the Contractor and his appointed designers, sub-contractors, and suppliers for the project. The number of teams and its size and structure shall be in response to the scale and complexity of project delivery activities and information/ asset information management requirements to be delivered for this project.

21.2.12 **Design Models** shall refer to the PIM to be developed, updated and delivered during the design stage such as Concept Design, Preliminary Design, Pre-Final Design and Final Design.

21.2.13 **Drawing Sheets** shall refer to two-dimensional representative documentations such as layout plans, sections, elevations, detailing, schematic diagrams, schedules, single line diagrams, notes and legend and other perspective views or graphical outputs generated directly from the PIM and AIM by the Contractor.

21.2.14 **Integrated Concurrent Engineering (ICE) Meetings** shall refer to designated discussions to be facilitated by the Contractor, to align all stakeholders within the Contract and InfP to work collectively and in parallel to resolve identified issues in a conducive environment or room.

21.2.15 **Integrated Digital Delivery (IDD)** shall refer to the streamlining of work processes and connecting stakeholders across the entire value chain, to leverage on digital innovations, technologies and solutions to deliver better project outcomes across the various project lifecycle. (i.e., digital design, digital fabrication, digital construction, and digital asset delivery and management).

21.2.16 **Industry Foundation Class (IFC)** shall refer to a neutral and non-proprietary open file format developed by buildingSMART. The Contractor shall export the IFC files from PIM and AIM, as part of submission requirements with the Authority/ the Engineer and information exchange with the InfP.

21.2.17 **Integrated System for Information & GrapHical Techno-environment (InSIGHT)** shall refer to the Authority's platform for information exchange between the Engineer, the Contractor and InfP; BIM Deliverables submissions; make correspondences, communication and collaboration amongst the Engineer's project stakeholders and the Contractor.

21.2.18 **Interfacing Parties (InfP)** as specified in this document, shall refer to the Engineer's project stakeholders and his appointed parties, and the lead appointed party of the adjacent contracts or interfacing contracts whom the Contractor shall liaise with, for coordination and/ or interface works to form a complete project.

21.2.19 **Level of Geometry (LOG)** shall refer to BIM Elements to be included in the PIM and AIM at each project phase, for each room/ area/ space/ zone specified in this Contract.

21.2.20 **Level of Information (LOI)** shall refer to the information to be embedded in all geometric and non-geometric attributes or parameters of BIM Elements to be included in PIM and AIM at each project phase specified in this Contract.

21.2.21 **Level of Information Need (LOIN)** shall comprise of LOI and LOG related information for each room/ area/ space/ zone. This information shall be included in PIM and AIM at each project stage of the development throughout the project lifecycle.

21.2.22 **LTA Exchange Information Requirements (LTAEIR)** shall refer to the Authority's digitalisation standard requirements, for producing all BIM Deliverables specified in the Contract.

21.2.23 **Model Author** as specified in **Clause 21.4**, shall refer to an appointed party responsible for creating and developing the LOIN for the PIM, AIM and other BIM Deliverables specified in the Contract.

21.2.24 **Model User** as specified in **Clause 21.4**, shall refer to the Engineer's authorised party to obtain and use the PIM, AIM and other BIM Deliverables for carrying out their scope of work specified in the Contract.

21.2.25 **Project BIM Coordinator (PBC)** shall refer to the appointed party of the Contractor's Delivery Team, who is responsible for creating and delivering discipline specific BIM Deliverables for the project.

21.2.26 **Project Information Model (PIM)** shall refer BIM models developed during the design and construction phase of the project in response to requirements stipulated in the latest version of LTAEIR and as specified in the Contract. The PIM consists of Design Models, Construction Models including DfMA, CCSM, and ABM.

21.2.27 **Project BIM Manager (PBM)** shall refer to the Contractor's appointed lead who is overseeing all BIM Deliverables and BIM related matters. The PBM shall be responsible for establishing all essential BIM related set up; orchestrate and manage the PBC; coordinate with the Contractor's Task Team and Delivery Team on BIM/ VDC/ IDD related tasks and delivery; rectify all BIM related issues and matters; and accountable for the quality of the BIM Deliverables.

21.2.28 **Task Team** shall refer to a team within the Delivery Team, the parties shall be the Contractor's sub-contractors and suppliers who are responsible and accountable for performing a specific task appointed by the Contractor, for all the scope of work specified in the Contract.

21.2.29 **UniClass** shall refer to an international unified classification led by National Building Specification (NBS), for all construction projects. All BIM Elements and BIM Deliverables to be submitted by the Contractor, shall be identified with an appropriate UniClass code.

21.2.30 **Virtual Design and Construction (VDC)** is a management process combining the technologies (BIM/ IDD) with a designed work process management scheme (PPM - Process and Production Management) to be established by the Contractor, to support project stakeholders working together on a project in an integrated and simultaneous way (ICE Meetings) to achieve explicit project goals.

21.2.31 **3D Coordination** shall refer to all disciplines' PIM being federated into a combined PIM by the PBM, to identify and resolve collectively on the design and/ or construction conflicts prior to manufacturing, fabrication, procurement, construction and installation.

21.3 General

21.3.1 The Contractor shall make all submissions to the Engineer via InSIGHT.

21.3.2 The Contractor shall be responsible and accountable for developing, updating and delivering all BIM Deliverables, including the proposed LOIN, quality control and quality assurance management, strategy and process for information management and collaboration, asset information management, and information exchange management, etc. as specified in this document and their agreed BEP.

21.3.3 The Contractor shall coordinate with all parties within the Contract and InfP on all necessary BIM/ VDC/ IDD related delivery tasks, LOIN requirements, the compatibilities of the BIM Deliverables and BIM Software, design and space clearances of installation, inspection, and maintenance requirements, and penetration openings, etc.; to form a complete project prescribed in the Engineer's requirements.

21.3.4 The Contractor shall leverage on BIM/ VDC/ IDD technology and methodology, to improve design and construction processes, minimise lean construction wastes, optimise the resources and achieve best productivity and buildability outcomes.

21.3.4.1 The Contractor shall arrange a workshop with the Engineer, to identify and establish performance objectives, controllable factors, quantitative KPIs, and targeted outcomes to be achieved for the project. The Contractor shall propose the enhancement workflow and processes with BIM/ VDC/ IDD methodology that will be implemented in the project. The accepted implementation details shall be documented in the BEP.

21.3.4.2 The Contractor shall collect and track all the data and project progresses to facilitate the production metrics measurement. The Contractor shall submit these metrics results for verification and justification on the performance optimisation, process improvement and productivity gains through the implementation of BIM/ VDC/ IDD in the project.

21.3.5 The Contractor shall be responsible for delivering all BIM Deliverables to the satisfactory of the Engineer. The BIM Deliverables shall comply with the BIM requirements of the Authority and regulatory compliance requirements of the relevant authorities/ agencies.

21.3.6 All BIM Deliverables shall fulfil all BIM/ VDC/ IDD related requirements. The Contractor shall leverage on 3D Coordination and collaboration processes to identify, rectify, verify and resolve all design and construction conflicts with all parties within the Contract and the InfP in advance, prior to making submissions to the Engineer for acceptance. The Contractor shall ensure no impact to the project progress and the BIM Deliverables submission timeline. All remedial works arising from failure to do so shall be carried out at Contractor's own cost.

21.3.7 The Contractor shall coordinate with the InfP to acquire/ provide all necessary information and share the PIM with the InfP for 3D Coordination and for the development of their BIM Deliverables. The Contractor shall ensure no impact to the interfacing contracts' BIM Deliverables submission deadlines. All remedial works arising from failure to do so shall be carried out at Contractor's own cost.

21.3.8 The Contractor shall be responsible and accountable for the accuracy and consistency in the production of BIM Deliverables, including the associated LOIN for the PIM, AIM, and Drawing Sheets. The Contractor shall verify and ensure that the BIM Deliverables are complying with the latest version of LTAEIR prior to making submissions to the Engineer and information exchange with the InfP. All remedial works arising from failure to do so shall be carried out at Contractor's own cost.

21.3.9 The Contractor shall provide all necessary BIM Deliverables at no cost to the InfP as part of the information exchange requirements. The details of information exchange schedule and requirements agreed between the Contractor and InfP shall be documented in both parties' BEP.

21.3.10 The Contractor shall provide all necessary BIM Deliverables to the Engineer as part of the design review and project management requirements upon request by the Engineer.

21.3.11 The boundaries of the Contractor's PIM and AIM shall include the extent of the Contractor's architectural, engineering design and construction scope of work, including all LOG and LOI that are adjacent to or interfacing with, as specified in the Contract.

21.3.12 The Contractor's PIM and AIM shall comply to the Authority and the relevant regulatory compliance requirements of the respective authorities/ agencies. The Contractor shall be responsible for all regulatory BIM native e-submissions. The Contractor shall ensure not to cause any impact to the application for Temporary Occupant Permit (TOP), Temporary Fire Permit (TFP) and Certificate of Statutory Completion (CSC) clearances.

21.3.12.1 The Contractor shall submit all approved regulatory related PIM, Drawing Sheets and other associated documentations submitted to and received from the respective regulatory authorities/ agencies to the Engineer as part of the Authority's record.

21.3.13 The Contractor shall establish and perform quality control checks to ensure the file format compatibility, quality, LOIN related accuracy and consistency of their BIM Deliverables prior to submissions to the Engineer and use as information exchange with InfP. All remedial works arising from failure to do so shall be carried out at Contractor's own cost.

21.3.14 The Contractor shall facilitate regular ICE Meetings with all parties within the Contract and InfP including their PBM and/ or PBC, to identify and resolve collaboratively on all identified design and construction conflicts found in PIM between the Contract and interfacing contracts.

21.3.14.1 To reduce latencies in response time, where necessary, the design Qualified Person (QP) of the Contractor and/ or the InfP shall attend the ICE Meetings to minimise potential impacts to the BIM Deliverables' timeline.

21.3.14.2 Where necessary, the Contractor shall participate in the ICE Meetings requested by the InfP to collaboratively discuss and resolve all identified design and construction conflicts found in the PIM between the Contract and interfacing contracts.

21.3.14.3 The Contractor shall establish pre-planning for ICE Meetings for the Contract, and with their interfacing contracts. The meeting plan shall define the purpose, meeting agenda, expected outcomes, identified key participants, decision making methodology and meeting frequency; to arrange the essential resources, venue and logistic required for ICE Meetings. The details of agreed ICE Meetings and meeting schedules with the InfP shall be documented in both parties' BEP.

21.3.14.4 In the event where there is a dispute between the Contractor and InfP, the Engineer's decision shall prevail.

21.3.15 The Contractor shall propose and obtain the Engineer's acceptance on the use of a suitable CDE within one month upon contract award. The Contractor's CDE shall be used for their communication, collaboration, and coordination of BIM Deliverables under the Work-In-Progress (WIP) status and shared status within the Contractor's Task Team and Delivery Team.

21.3.15.1 The Contractor shall ensure that the data and information stored at the Contractor's CDE, are comply to ISO 19650 Part 5.

21.3.15.2 The Contractor shall be responsible and accountable for implementing protective measures to safeguard the risk of data and information loss, misuse or modification that cause impact on the safety, security and resilience of the assets, products, the built environment, or the services provided by, from or through the Contractor.

21.3.15.3 The Contractor shall liaise with the Engineer, to appropriately classify the information (Official Open/ Official Closed/ Restricted/ Confidential) and sensitivity (Non-Sensitive/ Sensitive Normal/ Sensitive High) and prescribe the proper handling of information in accordance with the LTA's ICT and IM8 guidelines.

21.3.15.4 The Contractor shall propose the appropriate security strategy, security management plan and preventive/ corrective/ mitigation measures to be established and implemented on their CDE for the Engineer's acceptance. The proposed measures shall mitigate potential risks of data and information loss due to discourse of classified information to, and/ or stolen, modified, or misused by unauthorised parties.

21.3.16 The Contractor shall refer to **BIM Annex D** for 4D BIM Deliverables requirements.

21.3.17 The Contractor shall refer to **BIM Annex E** for 5D BIM Deliverables requirements.

21.4 Ownership and Rights to BIM Deliverables

21.4.1 Upon Contract award, all BIM Deliverables developed for the Contract shall become the property of the Authority. The Authority shall have the ownership and exclusive rights to all BIM Deliverables of the Contract unless agreed otherwise.

21.4.2 The Engineer shall have the rights and full discretion to grant its appointed parties the access and/ or full use of the BIM Deliverables.

21.4.3 Where required or applicable, the Engineer reserves the rights to request the Contractor to enforce modifications to their respective PIM and AIM for the design and installation coordination with the InfP.

21.4.4 The Authority shall not be liable for any infringement of copyright due to unlicensed use of third-party contents by the Contractor.

21.4.5 In contributing contents to the PIM and AIM, the Contractor does not convey any ownership rights to the contents provided and the software used to generate the contents. These contents shall solely be for the use of the Contract.

21.4.6 The Model User shall use third-party model at their own risk, with no liability to the Model Author for any use of, and / or reliance on, the contents of PIM and AIM that exceeds the requirements specified in the Contract and in the agreed BEP. Model User shall indemnify and defend the Model Author from and against all claims arising out of, or in relation to, any unauthorised modifications and/ or use of Model Author's contents by the Model User.

21.4.7 All parties within the Contract shall perform their best efforts to minimise the risk on claims and liability arising out of, or in relation to, the use and/ or access to their respective BIM Deliverables.

21.5 BIM Deliverables Requirements

21.5.1 The Contractor shall submit all BIM Deliverables developed for the Contract to the Engineer at each project milestone as specified in the **Appendix B of the Particular Specification**. All BIM Deliverables submission dates including relevant InfP's Civil CCSM and trackwork CCSM (if any) submission dates, shall be documented in the BEP.

21.5.2 All BIM Deliverables associated to the PIM and AIM developed within the Contract shall include as part of the submissions to the Engineer. All BIM Deliverables and digital assets produced or facilitate the production of the project's PIM and AIM are wholly owned and are the property of the Authority.

21.5.3 All PIM, AIM and Drawing Sheets shall be endorsed by the respective design Qualified Person (QP) prior to submitting to the Engineer for acceptance.

21.5.4 The PIM and AIM shall meet the Authority's obligation to Smart Nation & Digital Government Office's (SNDGO) requirements, where applicable.

21.5.5 All PIM and AIM shall be set up in accordance with Survey21 (SVY21) and Singapore Height Datum (SHD) or the latest statutory requirements from Building Construction Authority (BCA) and Singapore Land Authority (SLA), including the Project Base and Survey Points and/ or default False Easting and Northing.

21.5.6 In the production of BIM Deliverables for the Contract, the Contractor shall adhere to the exchange information requirements stipulated in the Authority's latest version of LTAEIR. The details of LTAEIR will be issued only to the awarded Contractor upon Contract award.

21.5.6.1 The Authority's Drawing and CAD Standard requirements shall not be used to produce any BIM Deliverables in this Contract unless otherwise agreed by the Engineer. This document shall only be used as an aid in referencing the existing As-Built drawings and other relevant information received from the Authority and/ or the Engineer.

21.5.6.2 All remedial works relating to **Clause 21.5.6 and 21.5.6.1**, arising from failure to do so shall be carried out at Contractor's own cost.

21.5.7 The Contractor shall submit their proposed BIM/ VDC/ IDD implementation strategy including workflows and procedures, Contractor's internal CDE related security protection measures, and any other BIM related date and information that are not listed in this document or the reference documents specified in **Clause 21.1.3,** for the Engineer's acceptance. The details of accepted proposals shall be documented in the BEP.

21.5.7.1 The Contractor shall develop PIM and AIM that are usable with the intended BIM authoring tool and review software. This shall not cause latency to the Engineer during the submission review processes.

21.5.7.2 Upon commencement of work, the Contractor shall carry out detailed study to identify the suitable model file size or project scale to be adopted to avoid producing huge unusable PIM under normal conditions. The Contractor shall discuss with respective InfP to adhere to similar model breakdown structure strategy prior to any model creation. The agreed model breakdown structure shall be documented in both parties' BEP.

21.5.8 The Contractor shall be responsible and accountable for developing and updating PIM and AIM with all LOIN requirements specified in the Contract. It shall include all required space clearances of the equipment and services installation and maintenance requirements within the Contract and interfacing contracts for 3D Coordination and information exchange.

21.5.8.1 The Contractor shall be responsible and accountable for developing and perform regular updates to both site and terrain models with all existing, proposed data and information that are adjacent to and interfacing with the scope of work as specified in the Contract. The existing data and information for developing the PIM shall base on:

a) information received from the Engineer;

b) all necessary site inspections, verifications, surveys, and studies to be carried out by the Contractor; and

c) all necessary procurement and/ or acquiring of the existing and future planning information of the proposed development from relevant authorities/ agencies by the Contractor.

21.5.8.2 The Contractor shall define and propose the LOIN list for the Engineer's acceptance. The accepted LOIN list shall be documented in the BEP, in accordance with the requirements stipulated in the latest version of LTAEIR.

21.5.8.3 The Contractor shall be responsible to obtain the necessary PIM from respective InfP, to develop and update the required data and information to form a complete project, services and systems related federated PIM prior to construction and installation.

21.5.8.4 The Contractor shall propose an appropriate UniClass code to be assigned to the BIM Elements in the PIM and AIM. The Contractor shall submit the proposed UniClass codes for the Engineer's acceptance and document the accepted list in the BEP.

a) The Contractor shall adhere to the following order of the UniClass tables in the selection of suitable UniClass code to be assigned to the BIM Elements:

i. Products (Pr);

ii. Systems (Ss);

iii. Elements and Functions (EF);

iv. Space/ Location (SL); and

v. Entities (En).

To assign a suitable UniClass code for report/ proposal submissions, the Contractor shall select from the Project Management (PM) table.

b) To facilitate the appropriate selection of the best suited UniClass code for the BIM Elements, the Contractor shall follow the order of pair identifier as listed below:

i. combination by group, sub-group and section; and

ii. combination either by group, sub-group or by group, subgroup, section and object.

c) As part of the BIM Deliverables submission requirements, the Contractor shall incorporate the UniClass code to the BIM Elements from Final Design stage onwards.

21.5.8.5 The Contractor shall ensure that all PIM are complying with CORENET X requirements' IFC-SG parameters (when available).

a) The Contractor shall submit the IFC-SG parameters list relating to the project, for the Engineer's acceptance and document the accepted list in the BEP.

b) The Contractor shall ensure no data and information loss in the IFC files exported from the PIM and AIM. The Contractor shall ensure that IFC-SG parameters are in proper order prior to making submission to the Engineer.

21.5.9 Whenever there is a need to update on new/ revised/ omitted/ outstanding information in the BEP, the Contractor shall submit the revised BEP version for the Engineer's acceptance. All changes shall be documented as a change log within the BEP.

21.5.9.1 The Contractor shall comply with and produce the BEP documentation in strict adherence to the BEP format structure and requirements stipulated in the latest version of LTAEIR.

21.5.9.2 The Contractor shall make the first submission of the BEP to the Engineer for acceptance within thirty (30) calendar days upon Contract award or at an agreed date accepted by the Engineer.

21.5.9.3 The BEP is a live document and shall be constantly updated, revised and submitted to the Engineer by the Contractor's PBM.

21.5.9.4 Any modifications to the agreed BEP shall be discussed, agreed and signed-off by the Engineer, all parties within the Contract and relevant InfP. The Contractor shall discuss with the Engineer to arrive at an agreement on the subsequent BEP revision submission dates, the agreed subsequent BEP submission dates shall be documented in the BEP.

21.5.9.5 Prior to BEP submission, the Contractor shall facilitate a series of ICE Meetings with all parties within the Contract, the Engineer, and InfP including the PBM and PBC, to discuss and agree the BEP contents to ensure the accuracy and consistency in coordination and collaboration works, BIM related schedules and information exchange with InfP.

21.5.9.6 The Contractor shall track and document the reasons, purpose and rationale behind the changes made to the BEP and submit to the Engineer for acceptance. The Engineer shall reserve the rights to request modifications to the BEP contents.

21.5.9.7 The Contractor shall ensure that the BEP contents are align with the InfP' BEP. The Contractor shall participate in all necessary BIM related meetings or discussions relating to the production and updating of the InfP' BEP.

21.5.9.8 The Contractor shall ensure the BEP is clearly defined the responsibilities, BIM Deliverables and the tasks to be fulfilled by each identified roles including the PBM and each PBC (based on discipline and scope of work) for the project.

21.5.9.9 The Contractor shall develop BIM Deliverables and responsibility matrix with reference to Singapore BIM Guide as a guide. The details shall be in accordance with the required BIM Deliverables specified in this Contract. The Contractor shall include the following acronyms to identify the responsible parties' role within the Delivery team and their involvement in BIM Deliverables:

a) Responsible (R) – appointed party who is responsible to complete the BIM Deliverables;

b) Accountable (A) – appointed party who is answerable for the requirements in relation to design compliance, accuracy and consistency of the BIM Deliverables;

c) Consulted (C) – appointed party whose opinions are sought or have been discussed with specific stakeholder(s) before undertaking the actions;

d) Informed (I) – appointed party who are made aware of up-to-date progress and completion of the BIM Deliverables; and

e) Use (U) – appointed party who is authorised to obtain and / or use the BIM Deliverables.

21.5.10 The Contractor shall refer to **BIM Annex B** and **BIM Annex C** for Civil CCSM and trackwork CCSM requirements**.**

21.5.11 The Contractor's Construction Models shall be prepared and updated in accordance with the latest final signed-off CCSM for all shop drawings approval.

21.5.11.1 Where necessary, the Contractor shall use the Construction Models to develop DfMA models for shop drawings and detail drawings production relating to manufacturing, fabrication, installation, and assembly.

21.5.11.2 The Contractor's ABM shall be progressively updated from the Construction Models and shall include all updates from the latest approved CCSM.

21.5.12 The Contractor shall submit the shop drawings and the PIM to the Engineer for approval prior to manufacturing, fabrication, procurement, construction, and installation.

21.5.13 The temporary works drawings and PIM (if any) shall be submitted to the Engineer for approval.

21.5.13.1 The temporary works are generally exempted in the ABM except for any underground and above ground BIM Elements that will be left in place after construction and installation. Where necessary and/ or upon request by the Engineer, the Contractor shall develop a PIM for temporary works for site utilisation planning, safety awareness and construction productivity.

21.5.14 The Contractor shall refer to **BIM Annex F** for 6D BIM asset information requirements.

21.5.15 The Contractor shall be accountable for the data and information consistencies between ABM and AIM prior to submitting to the Engineer for acceptance. The submission shall not be a reason or cause any impact to the InfP's As-Built submission key dates.

21.5.15.1 The Contractor shall submit ABM and AIM to the Engineer for review and comments in a timely manner. The Contractor shall establish an ABM and AIM reviews schedule to the Engineer for acceptance and document in the BEP.

21.5.15.2 The ABM shall include all changes made corresponding to Change Request Notice (CRN), Design Changes Request (DCR) and modifications on-site as per submitted to and received from the Engineer

21.5.15.3 The Contractor shall submit an Interim AIM to the Engineer for review six (6) months before the date of completion of works. The interim AIM review dates shall also be included in AIM reviews schedule.

21.5.16 The Contractor shall be responsible and accountable for developing and updating all necessary BIM Elements or components to form a complete project, services and systems.

21.5.16.1 The Contractor shall be responsible and accountable for developing the BIM Elements not listed in the Singapore BIM Guide. The Contractor shall submit the LOG and LOI of all relevant BIM Elements for each project milestone, the BIM Elements shall include the coverage, maintenance and installation clearances (where applicable). The proposed details shall be submitted to the Engineer for acceptance prior to model creation. The accepted proposals shall be documented in the BEP.

21.5.16.2 In the event where any BIM Elements or components cannot be practicably included in the PIM due to BIM Software limitations, prior to model creation. The Contractor shall identify all limitation issues, document the mitigation plans that have been considered with justification and submit to the Engineer for acceptance. The accepted justifications shall be documented in the BEP.

21.5.17 Where applicable and upon request by the Engineer, the Contractor would be required to develop the BIM Elements for interfacing contracts, to form a complete project, services and / or systems as specified in the Contract.

21.5.17.1 The BIM Elements shall be included but not limited to, maintenance equipment, motorised trolleys, etc. The Contractor shall coordinate with the InfP to obtain the following information for the updates of PIM and AIM to form a complete project, services and / or systems.

a) all necessary design and installation detailed drawings

b) data and information of the BIM Elements and components; and

c) other necessary design, installation and maintenance clearances.

21.5.17.2 The Contractor shall review and verify the PIM received from respective InfP, to ensure that the LOG and LOI of all relevant BIM Elements and components are in-placed and accurate.

21.5.18 Where applicable and upon request by the Engineer, the Contractor shall be responsible to federate the PIM and AIM within the Contract and with interfacing contracts as part of the final BIM Deliverables submission to the Engineer.

21.5.18.1 The Contractor shall be accountable for the accuracy of shared coordinates (X, Y and Z axes) and orientation of all PIM and AIM federated in the federated PIM and AIM.

21.5.18.2 The Contractor shall ensure that the federated PIM and AIM are able to federate seamlessly with the federated PIM and AIM developed by interfacing contracts, to form a line-wide federated model.

21.5.18.3 In the event where issues relating to accuracy and consistency found in the federated PIM and AIM, the Contractor shall immediately rectify and verify upon request by the Engineer at no extra cost.

21.5.18.4 In the event where there is a dispute between the Contractor and InfP, the Engineer's decision shall prevail.

21.6 Quality Assurance (QA) & Quality Control (QC)

21.6.1 The Contractor shall discuss with all parties within the Contract and InfP to establish a quality assurance plan including workflows, processes, preventive/ corrective/ mitigation approaches on the management of data and information and the BIM Deliverables residing at the Contractor's CDE.

21.6.2 The Contractor shall establish the appropriate quality control checks and procedures. The Contractor shall be responsible and accountable for validating the accuracy and integrity of the information and data, prior to submitting to the Engineer and model sharing or information exchange with InfP. The types of quality control checks shall include but not limited to:

a) items to be checked;

b) checking procedures and process;

c) the responsible parties who are accountable/ tasked to perform all necessary checks; and

d) the parties to be involved (i.e., parties who are assigned) in checking the BIM Deliverables.

These established details shall be submitted to the Engineer for acceptance and documented in the BEP.

21.6.3 In the event where the conversion of file format is required for information exchange with InfP; 3D Coordination activities for resolving the design and construction issues; or submissions to the Engineer, the Contractor shall be fully accountable for any data and information loss. The Contractor shall submit the details of conversion methodology including workflow process diagram illustration, preventive/ corrective/ mitigation approaches to recover potential data and information loss. The Contractor shall arrange workshop sessions to demonstrate the methodology and processes to the Engineer for acceptance. The details of the accepted plans, including the user guide manual and illustration diagrams shall be documented in the BEP.

21.6.4 The Contractor shall arrange ICE Meetings with all the InfP to align the information exchange file formats and protocols where possible, for:

a) Point of Contact (POC) on BIM related coordination and collaboration matters;

b) Means of communication and collaboration;

c) BIM Software and its version;

d) BIM Software version upgrading schedule;

e) Types of BIM Deliverables, file format and file version to be shared for information exchange;

f) Information exchange schedule dates;

g) Shared coordinates of the PIM to be coordinated; and

h) ICE Meeting schedule (where applicable).

The Contractor shall be responsible and accountable for full integration, inter-operability, and compatibility of their PIM and AIM. The details of the agreed plans shall be documented in both parties' BEP.

21.7 BIM Software Versions and File Formats

21.7.1 The Contractor shall arrange workshop sessions to coordinate with all parties within the Contract and InfP upon their project onboarding, to agree on the use of the same BIM authoring software and the respective software version, and version upgrades schedule between the Contract and interfacing contracts. The agreed plan shall be documented in both parties' BEP.

21.7.2 The Contractor shall establish a plan for version upgrades of the BIM Software including the PIM and AIM for the project and with the InfP. The timeline, activities and checks required for the upgrading plan shall be discussed and agreed with the InfP. The Contractor shall submit the agreed plan to the Engineer for acceptance and document in the BEP. The Contractor shall ensure that all ABM and AIM have been upgraded to the latest software version available at point of Completion of the Whole of the Works (CWW). The Contractor shall share the accepted plan relating to coordination with interfacing contracts, for the InfP to document in their BEP.

21.7.3 The Contractor shall provide the details of the BIM Software and operating systems to be used in the Contract. Details such as vendor, product name, version identifier, patch number and data architecture (64bit), etc. shall be submitted to the Engineer for acceptance prior to model creation and shall be documented in the BEP.

21.7.4 In the event where an upgrade or change of accepted BIM Software and/ or operating system is required, the Contractor shall submit a proposal explaining the purpose and rationale behind the upgrade or changes. Prior to submitting to the Engineer for acceptance, the Contractor shall coordinate with the InfP to agree on the change or upgrade plans. The accepted revised proposal shall be documented in both parties' BEP.

21.7.5 The Contractor's BIM Deliverables submitted shall be in accordance with the file format as documented in the agreed BEP at each project stage submission and upon request by the Engineer. The BIM Deliverables shall include but not limited to the following formats:

a) Native format of PIM and AIM (*.rvt, *.dgn, etc.);

b) BIM review format (*.nwc, *.nwd, *.nwf, *.i.dgn, etc.);

c) 2D and 3D PDF for general viewing and archiving;

d) Industry Foundation Classes 2x3 (IFC2x3) or IFC4 or IFC 4.3 (when required); and

e) Any other open standard file format, as requested by the Engineer.

21.7.6 All BIM Software applications to be used in the Contract shall meet the following requirements:

(a) IFC certified by buildingSMART and IFC-SG developed by GovTech (when available);

(b) Comply to ISO 19650 requirements;

(c) Comply to Code of Practices for BIM e-submission; and

(d) Inter-operable with no information loss and commercially available software suitable for 3D Coordination purpose.

21.8 BIM Roles and Responsibilities

21.8.1 The Contractor shall submit a proposal as part of the tender proposal submission, to demonstrate the approach and implementation strategy to meet the BIM objectives and requirements specified in the Contract. The details of the proposal plan shall include the resources and manpower to be allocated for delivering the BIM related tasks and delivery of the project.

21.8.2 The Contract shall have one (1) PBM and three (3) PBC to be fully responsible and accountable for all BIM Deliverables submit to the Engineer.

21.8.2.1 The Contractor shall submit the Curriculum Vitae (CV) of the PBM and three (3) PBC (Architecture, Civil & Structure, Mechanical or Building Services, one per discipline) for acceptance as part of the tender proposal submission. The proposed BIM personnel shall meet the minimum qualification requirements specified in **Clause 04 of the Particular Specification**.

21.8.2.2 The particulars of the proposed PBM and PBC roles for the CV submission shall include:

a) The BIM role for the past and current project(s);

b) Brief descriptions of the past and current project(s) information and project duration (i.e., the project start date and project end date in MMM-YYYY);

c) The details of BIM related work scopes and deliverables for the project; his/ her involvement duration (i.e., the start date and end date in MMM-YYYY) corresponding to the appointed BIM role involvement for the past and current project(s); and

d) The details of BIM related skills and qualifications such as the course title, where and year of the certification(s) attained. A photocopy of BIM related certifications shall be included in the CV.

21.8.2.3 The Contractor may allocate other BIM personnel to support the PBM and PBC in accomplishing the BIM requirements and BIM Deliverables specified in the Contract. However, this shall not relieve the PBM and PBC from their responsibility and accountability for the quality of all BIM Deliverables submit to the Engineer.

21.8.2.4 The acceptance from the Engineer for the proposed PBM and PBC shall be completed upon Contract award.

21.8.2.5 The accepted PBM and PBC shall not be allowed to change upon Contract award or within eighteen (18) months upon Contract award, unless otherwise accepted by the Engineer. The Contractor shall submit the CV of the replacement candidate within three (3) days upon notifying the Engineer, with the valid justification explaining the rationale behind the change of accepted BIM personnel role. The qualification and experiences of the replacement candidate shall be equivalent to or better than the accepted BIM personnel.

21.8.3 From project start till project completion, the PBM shall be responsible and accountable for the following tasks and deliveries but not limited to:

a) Develop and submit the BEP whenever there is a need to revise and update;

b) Coordinate and collaborate on Contract wide BIM related matters with project stakeholders within the Contract and with interfacing contracts;

c) Regular update and report on all BIM related activities' progress and status to the Engineer;

d) Oversee, coordinate, collaborate and manage PBC within the Contract;

e) Coordinate and collaborate with the PBM and PBC of the interfacing contracts;

f) Verify and rectify all BIM related challenges and issues in the project;

g) Establish and implement the project delivery, proposed digital solutions adoption and innovations for the project;

h) Establish and implement the standard procedures and enhancement approaches for digital delivery processes, timelines and expected outcomes for BIM/ VDC/ IDD implementation in the project;

i) Establish and implement the approaches and mitigation plans for the adoption of best practices, processes and tools of BIM/ VDC/ IDD in the project;

j) Establish, develop and implement approaches to comply the information and exchange information requirements with project stakeholders within the Contracts and with interfacing contracts;

k) Oversee and ensure on the compliance of the contract wide requirements relating to PIR and the latest version of LTAEIR;

l) Establish, implement and manage modelling and information exchange protocols for information sharing amongst project stakeholders within the contract and with interfacing contracts;

m) Establish and provide customised learning needs relating to digital solutions used in the projects, for the ease of the Engineer to facilitate the submission reviews;

n) Oversee and manage all BIM hardware and software to be used in the project, and to rectify issues relating to BIM hardware and software;

o) Establish ICE Meetings' resources, materials and schedules within the Contract and with interfacing contracts, and to facilitate the ICE Meetings to achieve the best outcomes of the meeting's objectives;

p) Participate in all ICE Meetings to contribute and achieve the best outcomes of the meeting's objectives for the Contract and with interfacing contracts;

q) Establish BIM Deliverables checks, procedures and schedule to detect discrepancies; reduce potential design/ construction issues and minimise resolution;

r) Oversee, monitor and facilitate the regular checks to ensure the contents of the PIM and AIM are complying to the requirements of PIR, LTAEIR, LOIN and regulatory related compliances;

s) Ensure no misalignment in coordinates and orientation in all PIM and AIM of the project;

t) Verify and rectify all misalignment issues found from the federation of all PIM and AIM within the Contract and with interfacing contracts;

u) Set up, oversee and update of the Contractor's internal CDE solution, BIM hardware and software, project specific templates and BIM Elements library for the project;

v) Establish and implement preventive and corrective measures, and mitigation plans to cyber secure the data and information residing at the Contractor's CDE platform in accordance to the requirements specified in Clause 21.3.15;

w) Establish and perform the regular clash detection analysis for PIM, AIM and CCSM; and

x) Track, monitor, rectify and verify all design/ construction conflicts found in the CCSM related deliverables.

21.8.4 From project start till project completion, the PBC shall responsible and accountable for the following tasks and deliveries shall be included but not limited to:

a) Be part of the contributors for the BEP whenever there is a need to revise and update;

b) Coordinate and collaborate on discipline specific BIM/ VDC/ IDD related matters with project stakeholders within the Contract and with interfacing contracts;

c) Regular update and report on all discipline specific BIM related activities' progress and status to the PBM;

d) Coordinate and collaborate with other PBC within the Contract and interfacing contracts;

e) Oversee, coordinate, collaborate and manage BIM modellers within his/ her Delivery Team;

f) Verify and rectify all discipline specific BIM related challenges and issues in the project;

g) Execute the project delivery, proposed digital solutions adoption and innovations for the project;

h) Execute the standard procedures and enhancement approaches for digital delivery processes, timelines and expected outcomes for BIM / VDC / IDD implementation in the project;

i) Execute the approaches and mitigation plans for the adoption of best practices, processes and tools of BIM/ VDC/ IDD in the project;

j) Execute the approaches to comply the information and exchange information requirements with project stakeholders within the Contracts and with interfacing contracts;

k) Oversee and ensure on the compliance of the discipline specific requirements relating to PIR and the latest version of LTAEIR;

l) Oversee and manage discipline specific modelling and information exchange protocols for information sharing amongst project stakeholders within the contract and with interfacing contracts;

m) Participate in all ICE Meetings to contribute and achieve the best outcomes of the meeting's objectives for the Contract and with interfacing contracts;

n) Perform discipline specific BIM Deliverables checks to detect discrepancies; reduce potential design/ construction issues; minimise resolution and to comply the requirements of PIR, LTAEIR, LOIN and regulatory related compliances;

o) Ensure no misalignment in coordinates and orientation in all PIM and AIM of the project;

p) Rectify all discipline specific misalignment issues found from the federation of all PIM and AIM within the Contract and with interfacing contracts;

q) Set up, maintain and update of the discipline specific templates and BIM Elements library for the project; and

r) Execute the preventive and corrective measures, and mitigation plans to cyber secure the discipline specific data and information residing at the Contractor's CDE platform in accordance to the requirements specified in Clause 21.3.15.

21.8.5 The Engineer reserves the right to request the Contractor to replace the PBM/ PBC, should the Engineer deem that his performance is unsatisfactory.

21.8.6 In the event where the PBM/ PBC does not perform to the satisfaction of the Engineer or leave his organisation, the Contractor shall resubmit the CV of the replacement BIM personnel to the Engineer for acceptance.

21.8.6.1 Prior to relinquishing his role and responsibilities as PBM/ PBC, the Contractor shall notify the Engineer at least one month in advanced and submit the CV of the replacement BIM personnel within three (3) days upon notifying the Engineer.

21.8.6.2 The PBM/ PBC shall unconditionally transfer to his successor all tangible and intangible properties and information that came into his possession, custody, or control in his capacity as PBM/ PBC at least one (1) month prior to relinquish his role for the project.

21.8.6.3 A proper hand over checklist including outstanding items to be followed up by the successor, and it shall be signed off by the Contractor, the PBM/ PBC who is leaving and his successor. This document shall be submitted to Engineer for record before the PBM/ PBC relinquish his role for the project.

21.8.6.4 The BEP shall be updated with these changes and the rationale of such changes. The Contractor's PBM shall submit the revised BEP to the Engineer for acceptance, within one (1) week upon the onboarding of the replaced PBM/ PBC.

21.9 Hardware and BIM Software

21.9.1 The Contractor shall provide two (2) sets of hardware (one (1) desktop and one (1) laptop) with all necessary BIM Software and its valid license(s) for the Engineer to carry out the reviews of all BIM Deliverables from Contract award to the end of Contract.

21.9.2 The Contractor shall provide two (2) devices of unlimited mobile data transfer allowing wireless internet connectivity to the workstations furnished to the Engineer at no extra cost. All costs for the data subscription and usage shall deem to be included.

21.9.3 The Contractor shall provide technical support for all hardware, software and internet connectivity to ensure that the software is usable throughout the Contract. The issue shall be resolved within two (2) days upon the date of notification by the Engineer.

21.9.4 The Contractor shall install the version of all BIM Software in accordance with the requirements as specified in **Clause 21.7** of this document. The latest operation system shall include any available software patches on the Engineer's hardware in a yearly basis.

21.9.5 The hardware shall be upgraded as necessary to meet user's intended purpose (e.g., reviewing, rendering, commenting, etc.). The hardware and software provided to the Engineer shall be upgraded in accordance with the requirements as specified in the **Clause 21.9** of this document.

21.9.6 In the event when the hardware is faulty or damaged, the Contractor shall replace the affected hardware components with new parts of equivalent performance or better, as specified previously at no additional cost. These works shall include but not limited to troubleshooting, installation and testing to ensure that the system is functional for purpose. These replacement works shall be completed within two (2) weeks upon date of notification by the Engineer.

21.9.7 The ownership of all BIM Software license(s) shall reside with the Engineer. In the event where BIM Software subscription is required, the Contractor shall subscribe for all BIM Software for the duration of the Contract or a duration accepted by the Engineer.

21.9.8 At least two (2) months prior to the first BIM Deliverables submission, the hardware and BIM Software shall be delivered, configured and functional within the reviewers' premises.

21.9.9 The specifications for the hardware and software shall be submitted to the Engineer for acceptance and shall meet the minimal requirements as specified below:

Desktop Hardware and Software	Requirements
Operating System	Windows 11 Professional, English, 64 bit or higher
CPU	Either 12th Generation Intel® Core™ i9-12900K (16-Cores, 30MB Cache, 5.2GHz), AMD RYZEN 9 5950X or better
Memory	128GB, DDR5, 4800MHz or better
Storage	Primary: 2TB M.2 PCIe NVME SSD with Secondary Storage: 2TB SATA 6Gb/s
Desktop Monitor	27-inch 4K IPS (of similar make and model) monitor or higher; Capable of supporting a minimum resolution of 2,560 X 1,440 or better with VGA, Digital Visual Interface (DVI), High Definition Multimedia Interface (HDMI), Display Port (DP) and USB connectivity complete with all the necessary cables (VGA, HDMI, DP, USB and power)
Graphic Card	NVIDIA® GeForce® RTX 3080Ti with 12GB GDDR6X or higher
Network Card	Integrated 10/ 100/ 1000 Network Interface Card (NIC)/ Ethernet port; + WIFI adapter
Accessories	Keyboard, Mouse, DVD Drive
Security	Software to protect from the latest threats (e.g., ransomware, viruses, malware, spyware, etc.) Software shall be updated on a monthly basis
Office Productivity	Microsoft Office 365 or newer; Adobe Acrobat Reader

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Laptop Hardware and Software	Requirements
Operating System	Windows 11 Professional, English, 64 bit or higher
CPU	Either 12th Generation Intel® Core™ 12900H (14-Core), AMD RYZEN 9 5900HX (8-Core Processor) or higher
Memory	32GB DDR5-4800MHz or higher
Storage	Primary storage: 2TB M.2 or PCIe NVME SSD or higher with Secondary storage: 1TB M.2 or PCIe NVME SSD or higher
Laptop Display	Minimally 17.3-inch FHD (1920 x 1080) 144Hz IPS Anti-Glare 300-nits NVIDIA G-SYNC Enabled
Desktop Monitor	27-inch 4K IPS (of similar make and model) monitor or higher. Capable of supporting a minimum resolution of 2,560 X 1,440 or better with VGA, Digital Visual Interface (DVI), High Definition Multimedia Interface (HDMI), Display Port (DP) and USB connectivity complete with all the necessary cables (VGA, HDMI, DP, USB and power)
Graphic Card	NVIDIA® GeForce® RTX 3080Ti with 16GB GDDR6X or higher
Network Card	Integrated 10/ 100/ 1000 Network Interface Card (NIC)/ Ethernet port; + WIFI
Accessories	Docking Station, Mouse, DVD Drive, Laptop Bag
Security	Software to protect from the latest threats (e.g., ransomware, viruses, malware, spyware, etc.) Software shall be updated on a monthly basis
Office Productivity	Microsoft Office 365 or newer; Adobe Acrobat Reader

21.10 User Support for BIM Tools

21.10.1 The required user support for BIM tools shall be facilitated by the Contractor's PBM or his organisation's in-house BIM trainer. The Contractor shall provide the customised user support:

a) at least two (2) months prior to first BIM Deliverables submission;

b) with the agenda, curriculum and materials corresponding to the project specific BIM Deliverables submissions for the Engineer's acceptance in advance; and

c) as and when required to assist the Engineer in using the proposed BIM Software and to address any issues the Engineer may face during the use of the BIM Software. This hands-on support shall preferably be facilitated at the Engineer's premise.

21.10.2 The Contractor shall provide training for ten (10) staffs appointed by the Engineer. The training shall be carried out in two (2) batches and each training session shall be of a minimum period of two (2) days, tailored in accordance to BIM Software proposed by the Contractor. The training objectives are on the use of all BIM software proposed by the Contractor for the Contract and to allow sufficient proficiency for the appointed staffs to carry out review of the Contractor's BIM Deliverables. The Contractor shall provide the training agenda, venue, syllabus and training materials customised for the project, for the Engineer's acceptance one (1) month prior to training