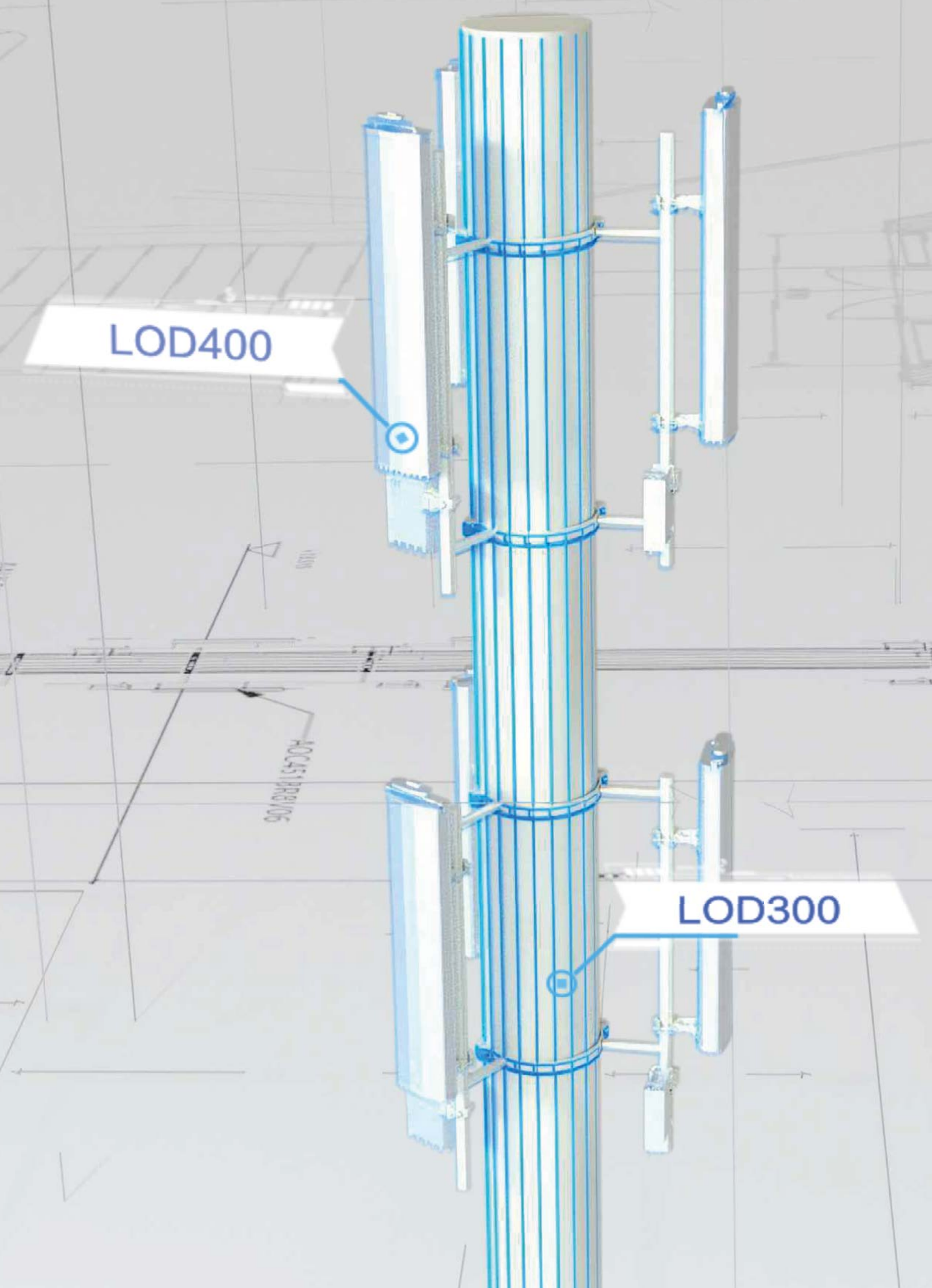
T-BIM Technical White Paper

T-BIM: Telecom-Building Information Modeling



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Introduction

The digital wave sweeping across the globe has seen information, network, and intelligent technologies play an increasingly prominent role in the strategic development of enterprises and governments. Telecom carriers possess fundamental network capabilities and information communications infrastructure, putting them in prime position to play a precursory role in the digital economy system. Similarly, communications service providers and equipment vendors are expected to help boost digital service provisioning.

Telecom carriers are gradually deepening their digital transformation, placing more focus on service improvement, network upgrade, innovative operations, and marketing optimization. Network construction and O&M represent major areas for network upgrade. In this context, Huawei proposes a digital site solution to help telecom carriers build digital twins for telecom sites, enhance production and O&M management, and stimulate the economic value of site infrastructure. This will be paramount in helping them unlock their potential and move upstream on the value chain.

Huawei's leading telecom-building information modeling (T-BIM) is based on the building information modeling (BIM) practice in construction industry and leads the way for digitalizing site operations. T-BIM is service-driven to aggregate seven categories of site asset information about communications, temperature control, lightning protection and grounding, electrical, infrastructure, equipment room, and tower systems. It ensures information integrity and effectiveness in cross-system and cross-domain collaboration, helps standardize engineering construction, and improves the efficiency of asset operation management.

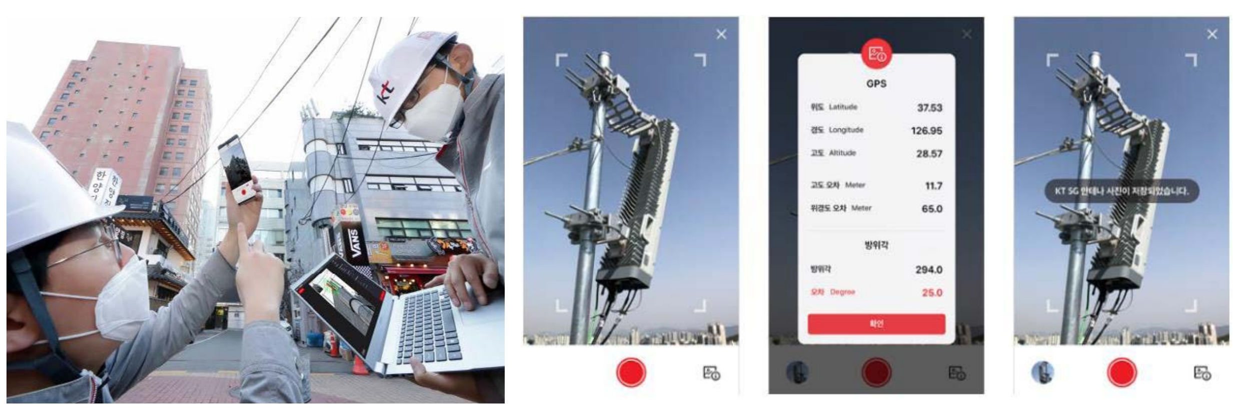
Contents

1 Overview and Implications of Telecom Digital Transformation

Leading carriers have been drawing on successful technologies from other industries in an effort to explore digital site operations, based on the operation and data collection requirements of telecom sites.

AR-Based Data Collection for Antenna Installation

Collaboration between KT, a South Korean telecom carrier, and VIRNECT, an industrial AR solution provider, has seen the development of an AR application that is capable of obtaining information about the azimuths, downtilts, and heights of 5G antennas[1]. The collected information is then sent to the server in real time where it is organized and stored. This protects the health and safety of engineers and improves the efficiency of antenna information collection during wireless network optimization and inspection.



(1) Electronics] 5G antenna maintenance using AR technology, KT Base Station Twin

UAV-Based Tower and Site Survey and Inspection

SmartSky Networks, an in-flight connectivity provider, and TIM Brasil have realized a simple tower and site survey solution that utilizes unmanned aerial vehicles (UAVs) to help the digitalization of site information. This solution helps standardize site management and verification and streamlines the settlement between telecom carriers and tower vendors, facilitating access to traditional sites. Furthermore, by combining UAVs with panoramic and tilt-shift photography, it also simplifies environment survey and distance measuring for base stations, enabling engineers to inspect sites without climbing towers. All information about the tower and device installation can be easily structured for storage. Esri, a global supplier of geographic information system software, and Aerodyne SML, a global drone based managed solutions provider, have provided a similar UAV solution to an Indonesian carrier Telkomsel.

High-Precision Data Collection Based on UAVs and Laser Scanners

TDC NET, a Danish telecom service provider, has developed a smart site engineering solution for future 5G networks in partnership with Ericsson. This solution aims to leverage the latest UAVs, 3D modelling, artificial intelligence (AI), and machine learning to collect high-precision site data and digitally implement site restoration to facilitate 5G engineering installation.

Simple, quick, and effective site information collection has become a carrier-wide priority for pursuing network O&M transformation. As data collection technologies are introduced from other industries, carriers must set up clear digital operation standards to check data compliance, redundancy, and scenario suitability, and determine whether additional digital technologies are needed to support full-lifecycle site upgrade. This will guarantee the economic value of digital transformation solutions. Carriers also need digital platforms to store, query, edit, share, and convert new data. Therefore, a set of data standards and management methods conforming to engineering construction and asset operation will be essential for achieving digitalization.

2 BIM Disrupts the Construction Industry with Digital Technology

The construction industry has undergone radical transformations in the way construction projects are envisaged, from hand-drawn blueprints, to computer aided design (CAD), and now building information modeling (BIM). BIM is an intelligent 3D modelling technology that constructs a parameterized 3D geometric model of buildings to carry building or engineering information. It comprehensively covers all stages of the construction process to facilitate collaboration among all involved parties.

The tram line project for the Huawei Songshan Lake Campus is a prime example of this[(2)]. The design team first integrated the GIS data into the BIM platform to help simulate the site's environment. In the simulation process, the route design, plane and vertical attributes, as well as cross-section usage plans were all completed using the BIM platform. Then, the data was exported from the BIM software for review and optimization. Each design element referenced the data in other design systems to ensure consistency and synchronization between phases. Based on the GIS data, the design was shared with the general team to smoothen communication and decision-making. Meanwhile, project reporting was directly carried out over the BIM platform, cutting the need for repetitive work while also improving labor efficiency by approximately 50%.

This example of BIM in practice can inspire tower vendors and telecom carriers to achieve site digitalization and innovation.

(2) BIM + GIS: BIM Application in the Design of Huawei Smart Campus Tramways

3 Growing Investment and Desire for Site O&M Innovation

According to the latest forecast of the Global System for Mobile Communications Association (GSMA), telecom carriers worldwide will invest more than US$1.1 trillion in network construction in the next five years, of which 80% will be used for 5G infrastructure networks. In 2020, Vodafone established a mobile tower business unit, Vantage Towers, to operate 82,000 sites in 10 countries and with a vision to build 1,200 sites in the next five years. It has included site digitalization as one of its six strategies to shorten the time to market (TTM) and reduce O&M costs. As the world's largest tower vendor, China Tower has constructed more sites in the six years (until 2019) after its establishment than the industry's aggregate number of the past 30 years, with a growth rate of 125%. In 2020, China Tower proposed a new strategy oriented to towers and distributed indoor services, focusing on resource sharing between telecom sites and public utilities as well as specialized public power backup services. This strategy strives to reduce overall costs, strengthen resource coordination and service optimization, and improve asset operation.

A strategic priority for telecom carriers is digitalizing network construction and O&M to ensure the robust development of site infrastructure. Based on database technology, BIM will enable various communication systems to be integrated into a centralized platform and allow the production processes and asset resource statuses to be reviewed by design, construction, contracting, maintenance, and operation teams from their specialized perspectives. Standardized, online, and transparent network construction is conducive to visualized and interactive asset management within the entire lifecycle and ensures consistency between design and operation. As a result, lean production and asset value management can be achieved for telecom sites.

4 Major Challenges of Digital Network Construction and O&M

Founded in 2014, China Tower has become the world's largest tower company, possessing a total of 2.015 million sites in China (by mid-2020), with a market share of 96.3%. Despite its success, the company suffers from a number of operation problems, of which some are recurring while some are caused by management. These include:

· Inaccurate basic data, affecting revenue

· Large number of site visits, driving up costs

· Difficult asset monetization, information asymmetry, and repetitive communication

These challenges are industry-wide issues, which, based on the analysis and surveys by China Tower, mainly fall into three categories:

Dumb resource management: In addition to main equipment, base stations require a number of dumb resources, such as antenna poles, equipment rooms, and batteries. The forms, locations, and statuses of these resources are difficult to manage, making it impossible to directly learn site status based on site completion blueprints.

Information inconsistency: Platforms for managing site information are different among design, planning, engineering, and O&M, hampering information sharing and update efficiency. This results in information inconsistency and burdening verification.

Low efficiency: Traditional site survey is a tool-based process of manual data collection. Site sketches must be input into specialized design and drawing software, which is costly and time-consuming.

Huawei's digital site solution resolves these issues, which incorporates digital collection and data processing, 3D component and site modeling, BIM platform solution design and integration, and value application development. It aims to transform traditional form-based data management to increase efficiency and facilitate scaled 5G rollout, cross-industry resource sharing, and proactive market expansion. By establishing the T-BIM specifications, digital site operation involves site asset object model and data standards as well as the data management that is based on the standards. It offers an alternative to traditional form-based data management and enables operation elements to be connected. This facilitates structured storage for eight data categories related to site and production asset operations, staffing, managed service resources, O&M investment, and customer service quality. This solution provides the following advantages:

Efficient management based on site information modeling

· Data management with assets as the minimum unit

· Construction and operation management with sites as the minimum unit

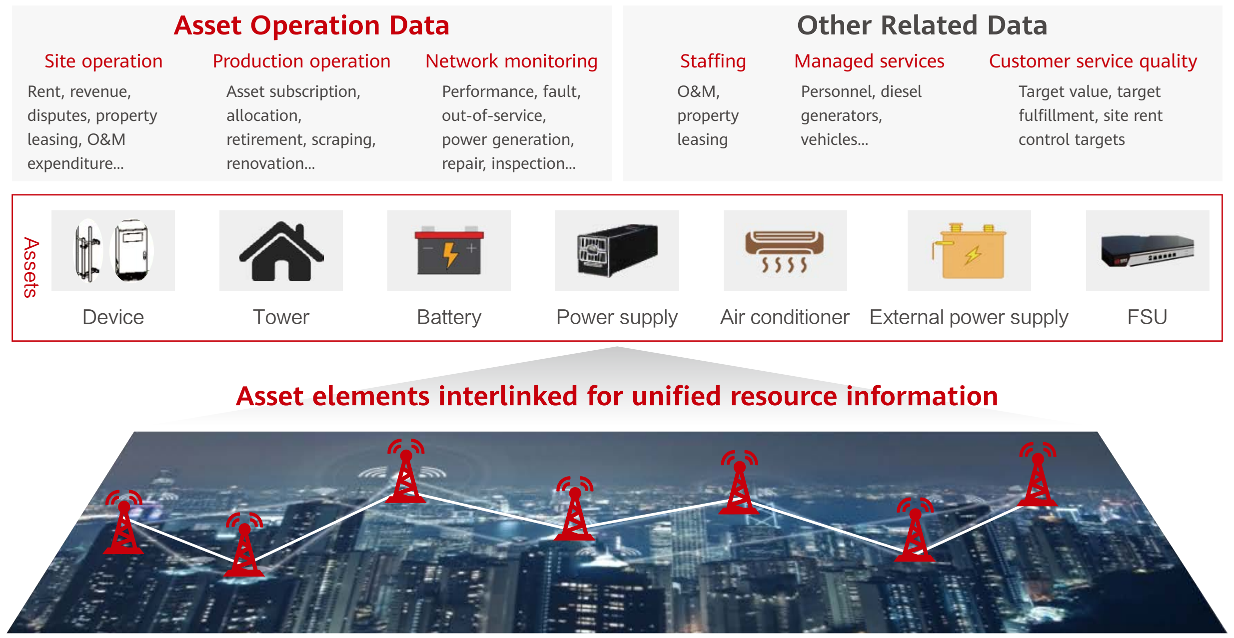
· Asset association with site and operation data

Complete data standards and specifications

· Standardized asset elements

· Smooth data flows between domains and systems

· Data modeling based on service applications



Site information modeling emphasizes space-based data management and association, enabling flexible analysis and solution formulation to assist scientific decision-making.

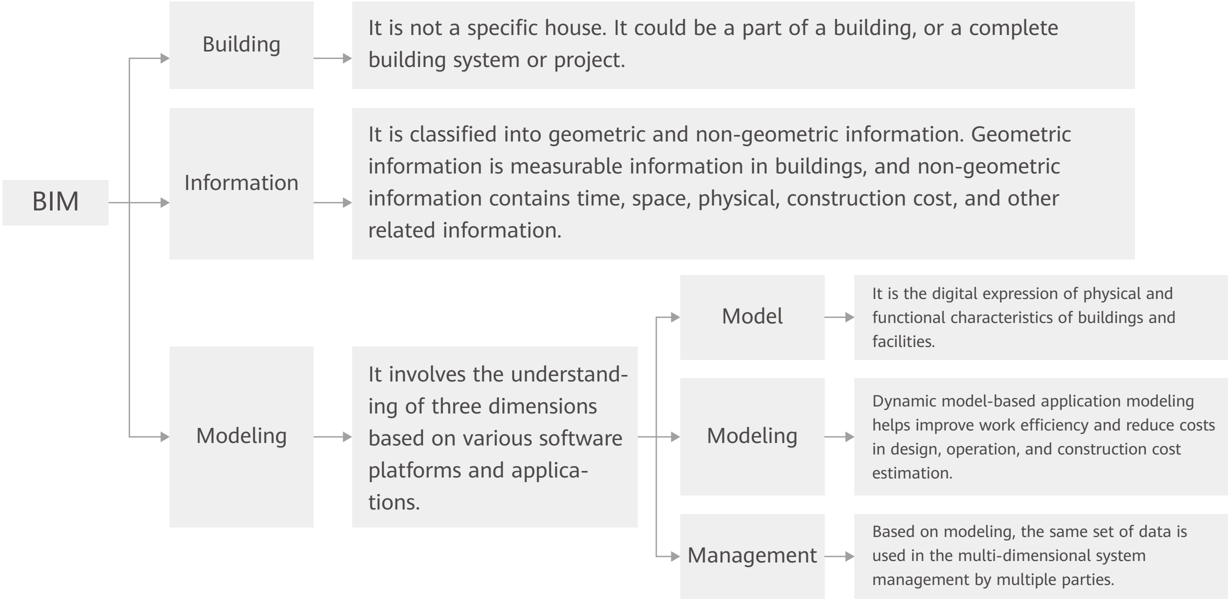
5 Specifications of Huawei T-BIM

5.1 Huawei Digital Site Information Modeling System

5.1.1 Relationship with BIM

Building information modeling (BIM) creates and manages building information throughout the lifecycle of construction engineering, including planning, design, construction, and O&M. Real-time, dynamic 3D modeling covers geometric, spatial, and geographic information as well as information about the properties and material of various building components. The concept of BIM was proposed by Autodesk in 2002 and soon applied in the construction engineering industry. China is also formulating related standards and specifications.

BIM defines the building modeling as a general infrastructure modeling that can also be applied to other industries.



Based on its deep understanding of the communications industry, Huawei proposed the concept of Telecom-BIM (T-BIM) in 2019. This concept is the theoretical basis of Huawei's digital site information modeling. Based on wireless base station projects and experience in 3D GIS spatiotemporal data management and multi-scale modeling, Huawei proposed the concept of T-BIM to construct the telecom site information modeling. This model comprehensively combines geometric entities and attribute and relationship information in the planning, design, construction, operation, and maintenance of telecom sites, making it the first standard information modeling system in the communications industry.

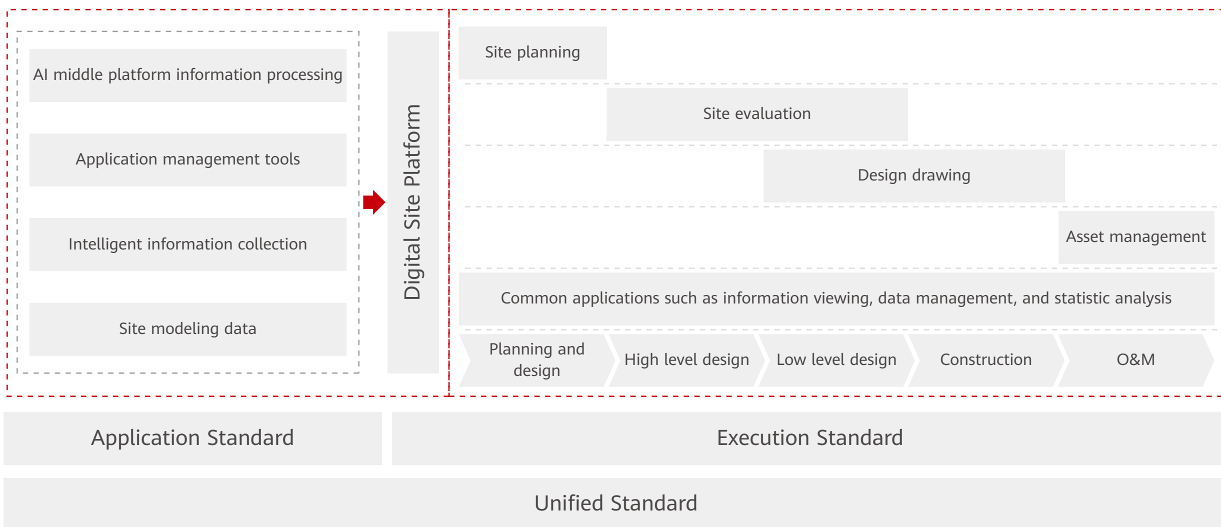
5.1.2 Structure of the Digital Site Information Modeling System

With reference to industry standards, Huawei divides the digital site information modeling into three layers of standards: unified, application, and execution standards.

Unified standards: As the bottom layer, the application standard of the digital site information modeling (that is, the T-BIM data standard) can form a complete set of information modeling system specifications after the application and execution standards are developed at the upper layer. T-BIM presents the geometric, attribute, and relationship features of the entity objects in the wireless base station engineering and displays them on a computer screen. In addition, it records the geometry (including shape and texture) and attributes of the entity objects in the physical world and shows their connection, installation, combination, and space affiliation.

Application standards: Align with data structure, classification, storage, and management requirements; establish a digital platform based on data management specifications; unify modeling data and platform standards by using specifications; and implement data flow and information sharing based on the same data source and format.

Execution standards: Top-level standards are used for model delivery and platform application. These standards focus on the service nodes in the customer's process and can be directly operated and executed. This helps customers implement process- and platform-based services, improve service processes and management capabilities, and reduce costs.



5.2 Specifications of Huawei T-BIM

Based on China's Unified Standard for the Application of Building Engineering Information Modeling, the characteristics of applications in the communications industry, and Huawei's years of experience in the telecom market, T-BIM Specifications (T-BIM for short) has been formulated.

As a standard for guidance, T-BIM defines the modeling objects, divides the level of development, and formulates modeling specifications to improve the application level of T-BIM, standardize the use of the building information modeling in wireless communications base stations, and implement standardized application of T-BIM. T-BIM is applicable to the end-to-end operation process of wireless base station engineering, including site selection and planning, survey design, infrastructure construction, equipment installation, and engineering maintenance.

T-BIM mainly includes the following technical information:

· Basic specifications on the site information modeling

· Granularity and hierarchy of modeling objects

· Composition of telecom site objects

· Geometric, attribute, and relationship objects

· Definition of the level of development

· Modeling application scenarios

5.2.1 T-BIM Basic Specifications

· Wireless base station engineering covers the lifecycle of planning and design, including high- and low-level design, construction, and O&M. The modeling deliverables of T-BIM in each lifecycle must meet the application requirements of the next lifecycle.

· T-BIM consists of modeling objects. The modeling objects are used as information carriers during the entire process of delivery.

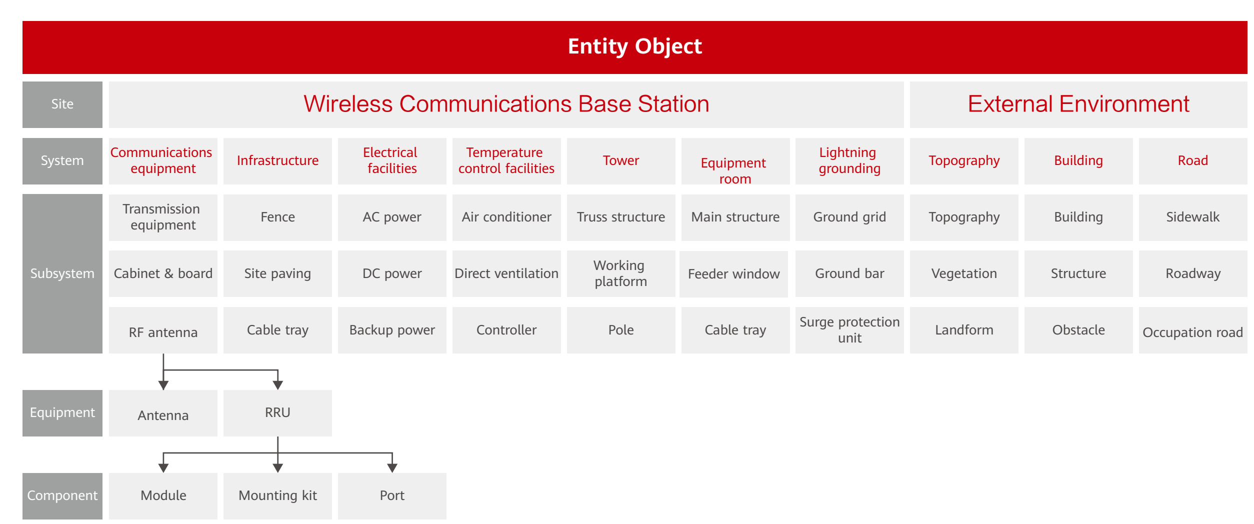
· During the delivery preparation of T-BIM, determine the modeling object granularity and select an appropriate level of development based on the delivery requirements, deliverable forms, and requirements of delivery collaboration.

· T-BIM objects are described by geometric, attribute, and relationship information, which can be supplemented by two-dimensional figures, text, documents, and multimedia.

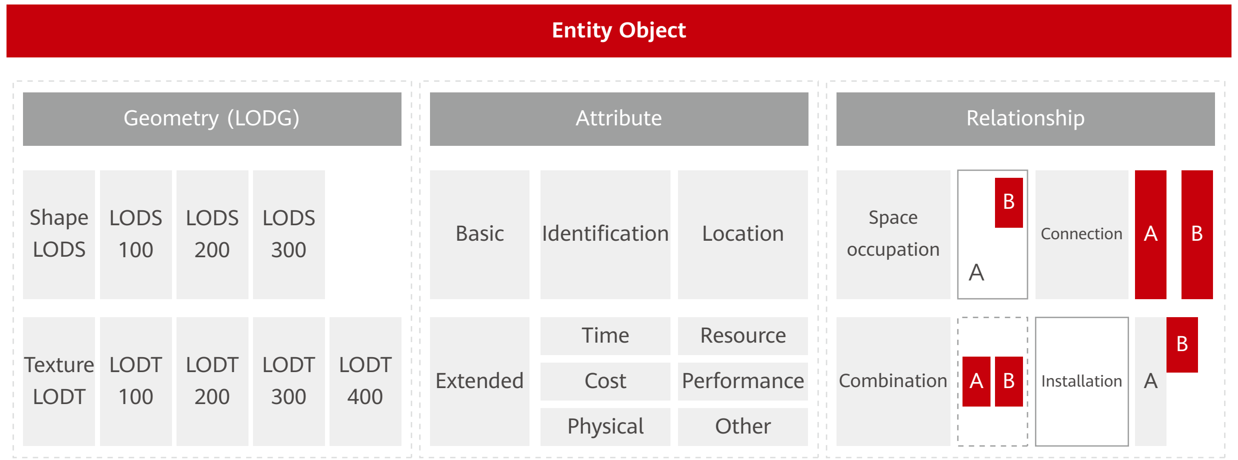
· If the level of development of the geometric information about T-BIM objects is inconsistent with that in the attribute information, the attribute information is preferentially used.

5.2.2 Composition of Telecom Site Objects

In T-BIM, Huawei has established a system at the entity object modeling level and organized the structure list of entity objects. A set of site objects and elements is displayed in a tree structure starting from the site level. Objects at different levels have different granularities. Entity objects at different levels are managed in either inclusion or nesting mode. This modeling structure not only facilitates the indexing of objects, but also the display of object levels and relationships.



Geometric, attribute, and relationship objects are basic features of the modeling. The site information modeling is directly defined by these features as data. Upper-layer structures such as modeling data structures, information processing logics, and platform applications are based on partial definitions. Huawei's T-BIM defines and explains this in detail.



5.2.3 Geometric, Attribute, and Relationship Objects

Geometric Objects of T-BIM

· Geometric objects in T-BIM are used to describe the unstructured information of the modeling objects. It includes the shape and texture and must comply with the specifications described in Table 5.2.3.1.

Table 5.2.3.1 Geometric information of T-BIM

Name	Type	Description
Geometric object	Shape	Describes the outline of modeling objects, which is the visual reconstruction of the space occupation information of physical objects.
	Texture	Describes the material of modeling objects, which is the visual reconstruction of visual effects and material feature information of physical objects.

· The shape describes the angles, lines, surfaces, and volumes in the three-dimensional space.

· The texture describes colors and images and has two types, which must comply with the specifications described in Table 5.2.3.2.

Table 5.2.3.2 Texture material classification

Name	Type	Description
Texture	Classification texture	Used to replace the texture of real images and distinguish the type and status of an entity.
	Actual texture	Used to restore the colors of the facade of a physical entity.

Attribute Objects of T-BIM

· Attribute objects of T-BIM are used to present the structured semantic information carried by modeling objects.

· It consists of both basic and extended attributes. Basic attributes are basic information about modeling objects and remain unchanged throughout the lifecycle of the modeling. Extended attributes are a collection of additional information based on the particular requirements of different application phases of a project.

· An attribute dimension measures the range of attribute information contained in a modeling object. In accordance with basic and extended attributes, attribute sets are decomposed into different attribute dimensions according to different features of attribute semantics. The attribute dimensions must comply with the specifications described in Table 5.2.3.3 and Table 5.2.3.4.

· The attribute set contained in basic attributes must comply with the specifications described in Table 5.3.4.

Table 5.2.3.3 Basic attribute set of wireless base station engineering

Type of Attribute Set		Description
Identification	Entity	A number that uniquely identifies an object.
	Type	Identifies a type.

Location and position	Geographical location	Describes the position or point of an object in physical space. The attribute elements should include the longitude, latitude, altitude, GPS position, WGS84, direction, and local coordinate system position.
	Production location	Describes the production and distribution location of an object or a resource. The attribute elements should include the geographic coordinates of where it is produced, assembled, and warehoused.
	Administrative location	Describes the administrative divisions of a country. The attribute elements should include the street, county, state or province, region, and country.
	Installation position	Describes the spatial location where an entity object is installed. The attribute elements should include the spatial affiliation attribute.

· The attribute set contained in the extended attributes must comply with the specifications in Table 5.2.3.4.

Table 5.2.3.4 Extended attribute set of wireless base station engineering

Type of Attribute Set		Description
Time and cost	Time and scheduling	Describes the sequence, delivery and cost activities, lifespan, time period, and other time-related values. The attribute elements should include the dates for production, purchase, installation (start and end), site inspection, acceptance, commissioning, expiration, dismantling and recycling as well as the project phase, depreciation timetable, and maintenance schedule.
	Time and scheduling	Describes the monetary value of a product or material. The attribute elements should include the currency type, unit price, wholesale price, cost of retail and installation, and purchase terms.
Resource	Manufacturer	Describes the attributes related to the creator or issuer of an object (mainly products). The attribute elements should include the manufacturer name and production capacity as well as details of the manufacturing process.
	Product	Describes the attributes of commodities and materials related to harvesting/mining, manufacturing, and design. The attribute elements should include the product name, model, inventory, accessory, function, factory setting, structure, color, and coating type.
	Warranty	Describes warranty-related information. The attribute elements should include the manufacturer's warranty type, terms, and period.
	Installation	Describes attributes related to the use of a product in the installation and creation. The attribute elements should include the installation configuration, surface treatment, method of installation and fixing, and fastener type.
Physical	Single size	An attribute used to quantify a specific one-dimensional distance. The attribute elements should include the standard or customized size, length, width, distance, depth, thickness, radius, and spacing.
	Area	An attribute used to quantify a spatial range with a two-dimensional boundary. The attribute elements should include an angle, area, and spatial area.
	Volume	An attribute used to quantify a spatial range with a three-dimensional boundary. The attribute elements should include the volume, specific volume, and volume flow.
	Relative attribute	An attribute that quantifies a metric relative to another, and varies according to the value of other variables. The attribute elements should include the frequency, speed, power, acceleration, and relative value.

Physical	Temperature	An attribute applicable to the temperature. The attribute elements should include the temperature itself and the temperature type.
	Structural load	An attribute related to the external force applied to a part. The attribute elements should include the constant and live load.
	Quality	An attribute applicable to the weight and quantity of a substance. The attribute elements should include mass and density.
	Force	An attribute that causes the mass to change its speed or direction. The attribute elements should include force, torque, and moment of inertia.
	Electrical attribute	Describes electrical information relating to an entity object. The attribute elements should include the voltage, current, power supply, and power distribution panel.
Performance	Function and use	Defines the functions and features of a specific service or object. The attribute elements should include function efficiency, limitation and capability, as well as the applicability and processability.
	Configuration	Describes the attributes of an object after the internal configuration affects its appearance, functions, and performance. The attribute elements should be selected from the lower-layer object attributes and mapped.
	Connection	Describes the external connection feature of an object. The attribute elements should include the local port type, peer port requirement, cable type, and interface.
Others	Others	Extension of the attribute set

· According to the specific lifecycles, some basic and extended attributes are combined to form an attribute set for a specific application in order to facilitate the evaluation, analysis, and application of a specific project.

· The basic and extended attribute elements should be extended without changing the related attribute set types. In addition, the attribute elements that compose the attribute dimension should be consistent with the definition of the attribute element table.

Relationship Objects of T-BIM

· A relationship object is used to express the association between a model and other modeling objects. The relationship types of T-BIM include connection, combination, installation, and spatial affiliation.

· The content contained in the relationship objects of T-BIM must comply with the specifications in Table 5.2.3.5. For details about the examples of each type of relationship objects, see Appendix B.

Table 5.2.3.5 Relationship objects of T-BIM

Name	Item	Description
Relationship object	Type	Type of a relationship object.
	Implementation medium	Element that implements the relationships between entity objects.
	Associated object	Records a group of associated objects.
	Relationship type attribute set	Relationship type attribute set

· A connection relationship defines two objects within a site or between two sites. A connection is a physical channel established between two objects based on their physical features.

· The connection relationships between modeling objects must be set based on the content granularity of the entity objects corresponding to both parties.

· If the content granularities of the entity objects on both sides of a connection are the same, the connection relationships are classified into one of five types.

· If the content granularities of the entity objects corresponding to the two parties of a connection are different, the connection relationship type must comply with the lower specifications.

· A combination relationship defines the relationship between multiple entity objects at the same level. A higher-level entity object can have some of the same attributes of a lower-level entity object.

· After the combination relationship is defined, the attribute overlay of the entity object must comply with the following rules:

(1)The attributes of a higher-level entity object must be obtained based on those belonging to a lower-level entity object. In addition, the attributes of the entity objects must be the same.

(2) A lower-level entity object must define whether its attributes can be overlaid with those of a higher-level entity object.

· An installation relationship defines the relationship between one object and another in a fixed position through the installation medium. In addition, the installation relationship forms a fastening mode between the two objects, not a new object, and indicates the position and interface type of an object installed on another object. In this way, the relative positions of different objects at a site can be determined, and a stable structure can be formed.

· A spatial affiliation relationship defines a dependent spatial relationship between an entity and other affiliated entities through behaviors such as placement and installation. When the spatial position of the attached entity changes, a spatial affiliation relationship is formed between the two entities if the spatial position of the entity can be affected. The spatial affiliation relationship is recorded using a spatial affiliation attribute in the basic attribute element set.

5.2.4 Level of Development

Level of development (LOD) refers to the development stages of model objects in T-BIM. T-BIM requires that content granularity and an appropriate level of development be determined based on project lifecycle and application scenarios. LOD includes level of development geometry (LODG) and level of development relationship (LODR).

LODG consists of level of detail shape (LODS) and level of detail texture (LODT), which express a level of detail for model shape and texture, respectively, for a given stage in the development lifecycle. LODR expresses the level in which relationships between entities are expressed for a given stage.

Level of development geometry

· Rules of geometric object:

(1)Select an appropriate LODG to present the geometric information of model objects;

(2) Select a lower LODG so long as the design and application requirements can be satisfied;

(3) Select different LODGs for various model objects.

· Table 5.2.4.1 shows the classification for the LODS.

Table 5.2.4.1 Classification for the LODS

Requirement	Code	Requirement
Level of Detail Shape 100	LODS 100	It is a white model, which uses a simple geometric object (such as a sphere, cuboid, cylinder, prism, pyramid, and cone) to signify an object's coordinate information.
Level of Detail Shape 200	LODS 200	It is a simple model that combines multiple simple geometric objects (such as the sphere, cuboid, cylinder, prism, pyramid, and cone). This model reflects the positioning and key features of the objects they are modeling.
Level of Detail Shape 300	LODS 300	It is a precise model, which reflects the features of a facade by precisely defining the exact dimensions of its main structure.

· Table 5.2.4.2 shows the classification for the LODT.

Table 5.2.4.2 Classification for the LODT

Level	Code	Requirement
Level of Detail Texture 100	LODT 100	Classified textures: Different colors are used to represent system-level objects.
Level of Detail Texture 200	LODT 200	Classified textures: Different colors are used to represent subsystem-level objects.
Level of Detail Texture 300	LODT 300	Classified textures: Different colors are used to represent device-level objects.
Level of Detail Texture 400	LODT 400	Real textures: Real photos are used to represent objects.

· Table 5.2.4.3 shows the classification for the LODG.

Table 5.2.4.3 Classification for the LODG

Level	Code	Requirement
Level of Development Geometry 100	LODG 100	LODS 100 does not show textures or materials and only meets the requirements to serve as placeholders.
Level of Development Geometry 200	LODG 200	LODS 200 + LODT 100 meet the requirements for design and layout processes.
Level of Development Geometry 300	LODG 300	LODS 200 + LODT 200 meet the requirements for preliminary installation, construction, and processing.
Level of Development Geometry 400	LODG 400	LODS 300 + LODT 300 meet the requirements for high-precision identification throughout installation and construction.
Level of Development Geometry 500	LODG 500	LODS 300 + LODT 400 meet all O&M requirements and reflect the actual level of development geometry.

Level of development relationship

· Level of development relationship

(1)Select an appropriate LODR to present relationships between modeling objects;

(2) Select a lower LODR so long as the design and application requirements can be satisfied;

(3) Levels of development relationship are distinguished by relationship types and expression modes.

· Connections are classified into logical and physical connections.

Table 5.2.4.4 Classification for the LODR

Form	Description
Logical connection	It only indicates logical connections between connected entities. The line entities that implement the connection relationship are not expressed.
Physical connection	It indicates the direction of the line entities that are connected, such as the cabling facilities, feeder window, and cable outlet.

· How installation and combination relationships are expressed is not classified by LOD. Instead, LODR only indicates at what levels they exist.

· Table 5.2.4.5 shows the classification for the LODR

Table 5.2.4.5 Classification for the LODR

Level	Code	Requirement
Level of Development Relationship 100	LODR 100	Combination relationship and the logical connection CREL1 (connections between sites)
Level of Development Relationship 200	LODR 200	LODR 100, combination relationship, and physical connection CREL2 (connections between systems)
Level of Development Relationship 300	LODR 300	LODR 200 and physical connection CREL3 (connections between subsystems)
Level of Development Relationship 400	LODR 400	LODR 300, installation relationships, and physical connection CREL4 (connections between devices)
Level of Development Relationship 500	LODR 500	LODR 400 and physical connections CREL5 (connections between spare parts)

5.2.5 Application Scenarios

· The lifecycle of a wireless base station consists of the planning and design, high-level design, low-level design, construction, and O&M.

· The application scenarios of T-BIM can be classified into new site construction and equipment installation projects.

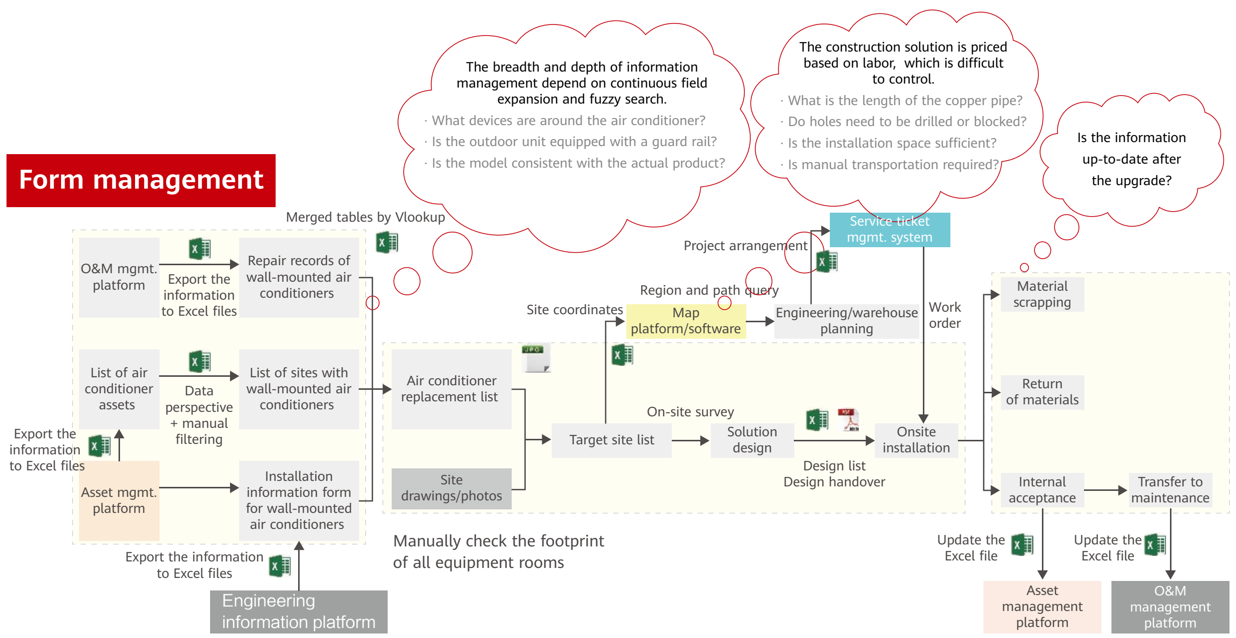
· A new site project includes site selection, planning and design, civil work construction, and equipment installation and commissioning.

· An equipment installation project refers to the installation, upgrade, reconstruction, capacity expansion, and replacement of the communications equipment and auxiliary devices based on the existing site infrastructure.

· In practice, users can select different content granularities, levels of development, and attribute dimensions for each model object to suit the specific modeling application and requirements.

5.3 Service Process Changes Brought by T-BIM

T-BIM emphasizes space-based data management and associations between data to flexibly analyze and formulate solutions in the design phase. One such example is the replacement of air conditioners in equipment rooms. If a wall-mounted air conditioner has been used for over five years, it can be replaced with a cabinet-mounted air conditioner. These legacy air conditioners have to be scrapped by the installer if they have repair records, and the remaining air conditioners need to be returned to the warehouse. Due to limitations in form management, the existing data is insufficient for decision-making unless a special site survey is conducted for each site. As a result, the onsite construction party has to make decisions to control costs. In addition, the data regarding completion of this replacement is also restricted by the form and cannot be extended to support subsequent improvement of operations.

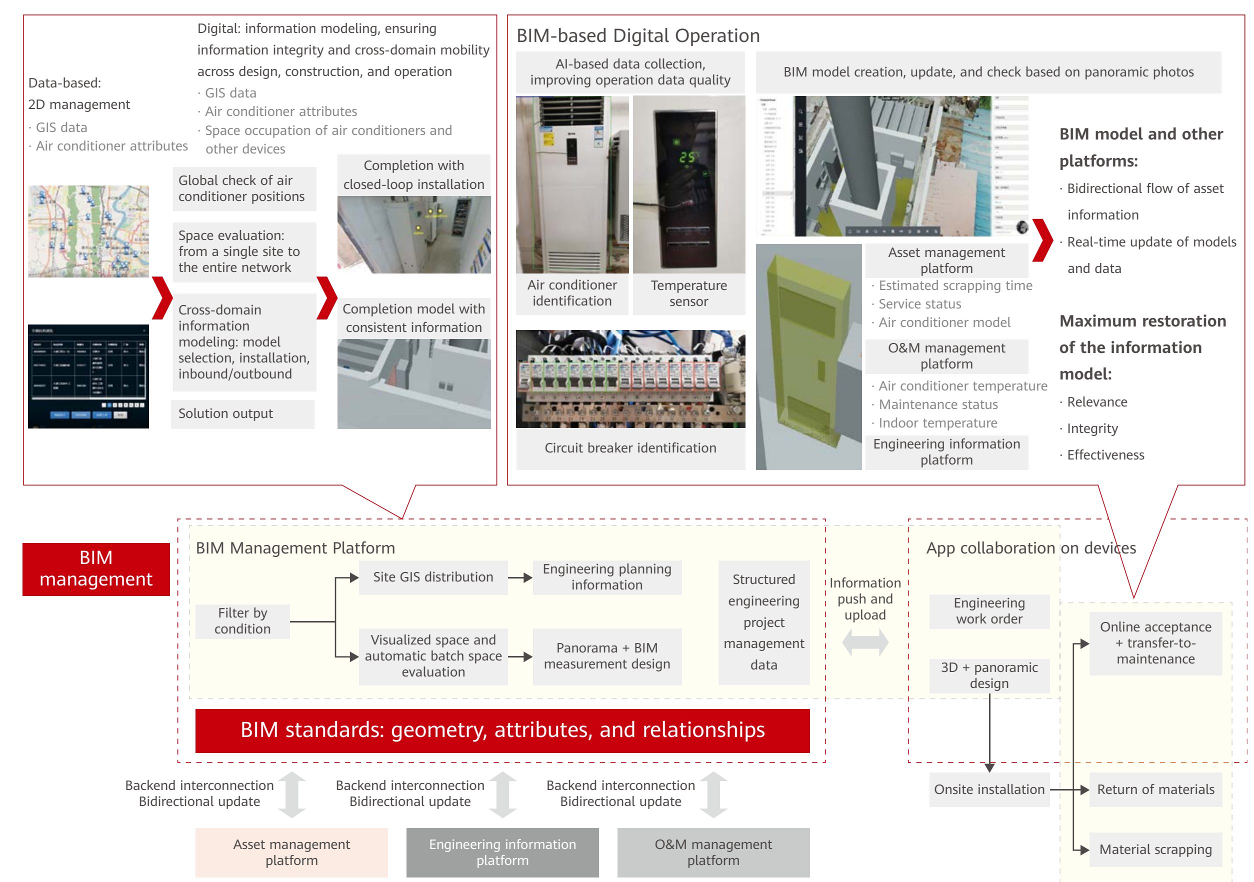


Through the association computation of T-BIM, three scenarios for air conditioner reconstruction can be specified.

Search-based Data Analysis with Information Association and BIM Space Management Capability

Air conditioner	+	Devices below Devices within 1 m Installation height Direct ventilation unit installed ...	+	Battery string Power cabinet > 1.8 m In 2016 ...

The site information model for design updates will be used for implementation and required to be accepted by the model in the completion phase. This ensures the integrity and validity of data, reduces errors during data transfer, and achieves consistency between design and operation.



From Form-Based to Visualized Management

With the specifications defined in T-BIM, original form-based management is modeled for dumb assets. In this way, the 3D model of a site is displayed on a platform or in software with related information, such as the site structure, size, attributes, and location, for query. This is far more intuitive compared with traditional asset management.

From Onsite to Office

Under the guidance of T-BIM, a digital twin site that mirrors the actual one can be generated to perform various simulations on the computer. T-BIM standardizes the precision and attribute values of models, and we can directly acquire information such as location, positioning, statuses, and attributes. In this regard, many onsite operations, including asset counting, information collection, and dimension measurement, can be performed directly on models in offices. This cuts down on visits to the site, reduces operation costs, and increases efficiency in routine service management.

From Loose to Object-Based Model Management

The site data structure proposed in T-BIM standardizes site models and model-based data storage and management, facilitating collection, management, modification, transfer, and application of site data. At the same time, a digital site application platform can be established with site data structured in line with the underlying layer. This enables online data sharing and smooth service flow, improves the digital operation capabilities of tower vendors and telecom carriers, and implements co-construction and sharing of information.

From Manual to Automatic

Based on the information model specifications defined in T-BIM, an entity site is digitalized as a twin model. With AI and powerful processing capabilities, computers can assist in many manual operations, such as space evaluation, design drawing, and collection of material information statistics. This reduces the need for manual operations and allows personnel to focus on other operations. In particular, the work efficiency can be significantly increased in terms of batch processing.

6 T-BIM Digital Applications

6.1 Design Drawing and Asset Management

In conventional engineering services, installation and completion drawings are manually drawn by subcontractors or design institutes, which is time- and labor-consuming. Additionally, as a dumb asset, the site infrastructure is difficult to manage. As conventional database management cannot intuitively match asset items with physical goods, inconsistency between inventory accounts and goods may occur.

However, a 3D site model with dimensions and annotations added to the specific plane or view, can be directly exported as an image for infrastructure construction and device installation. This not only reduces the background requirements for personnel on professional drawing software, but also provides accurate information to guide general construction.

The parameter-based 3D model can link sites, models, and information so that any changes onsite are reflected on drawings, models, and data. This also enables onsite assets to be easily managed in the resource management system.

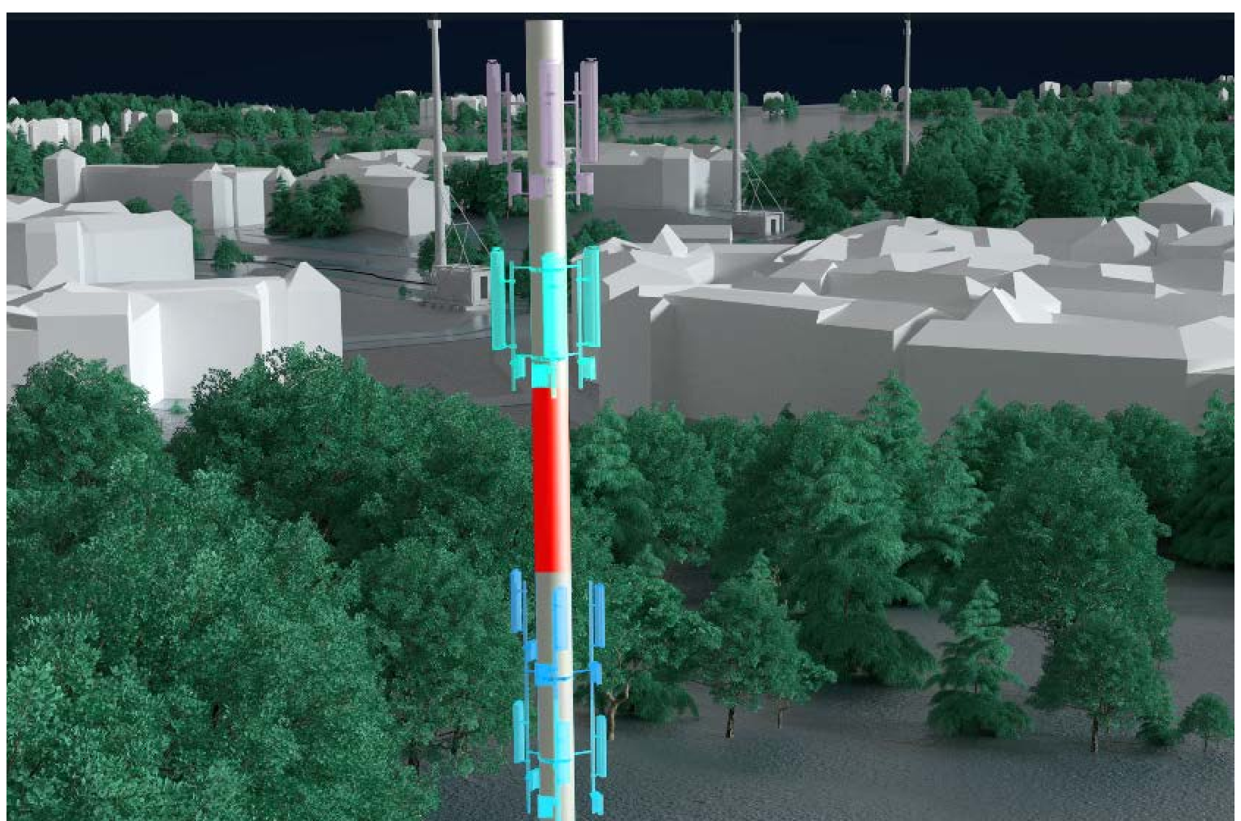
6.2 Antenna Wind Load Pre-evaluation

Antenna wind load pre-evaluation contributes significantly to tower reliability. It requires various parameters of the tower and antenna, including the tower height; designed wind load; antenna size and weight; and antenna position information, such as the mounting height, installation position, and azimuth.

In conventional engineering services, this information is obtained through drawings, as-built documents, and onsite collection. However, missing and inconsistent information and difficult acquisition of on-tower antenna positioning create huge differences between the calculated and onsite models. As a result, it produces high risks to the evaluation of tower reliability.

Leveraging T-BIM to model towers, antennas, and RRUs can enable quick evaluation of the antenna wind load. First, the length, width, height, and weight of antennas are defined in T-BIM. Second, the height, azimuth, and installation position of the antenna required for wind load evaluation can be directly obtained from the model. This eliminates the need to visit the site and view drawings as well as ensures consistency among data, showing advantages of BIM-based application management tools.

In addition, the evaluation tool can calculate and display models in real time. The tool enables you to drag objects such as antennas and RRUs to the tower to observe the impact of antennas on the tower and the reliability of the tower all in real time. This evaluation method facilitates operations and provides intuitive results for common operators. By changing the model view, the load distribution diagram of the tower can be automatically generated, which facilitates viewing.



6.3 Site EMF Evaluation

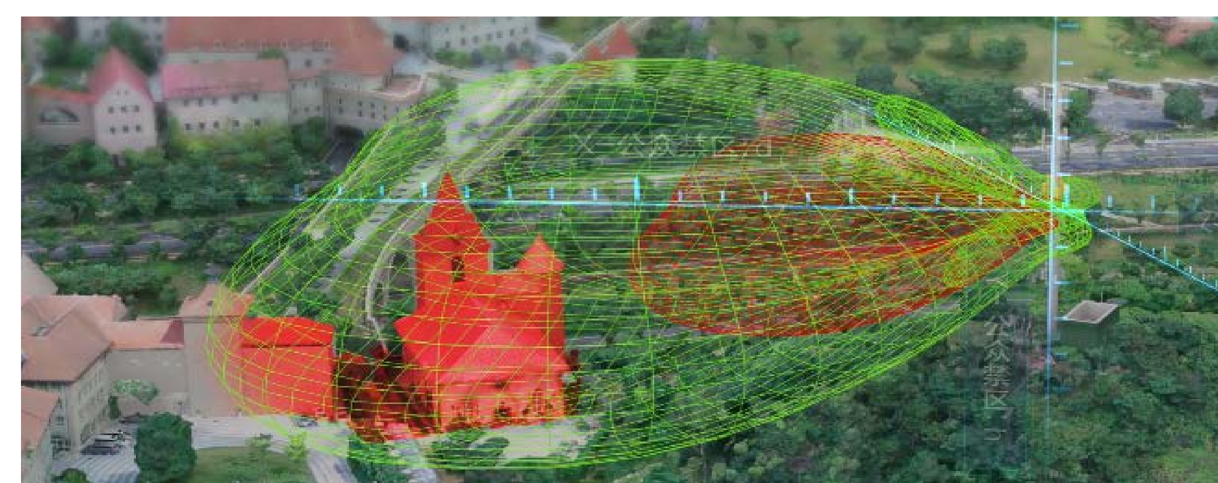
Over time, people increasingly rely on mobile phones, and electromagnetic radiation produced by wireless communications base stations also gains wide attention. Especially in some developed countries, people's concerns about electromagnetic radiation, carriers' focus on transmit power and spectrum, and governments' approval for electromagnetic radiation intensity have led to the demand for evaluation of the electromagnetic field (EMF).

Conventional EMF evaluation is performed using professional software to generate professional and comprehensive reports for municipal approval. As the public cannot intuitively understand the impact of electromagnetic radiation on the surrounding environment, opposition occasionally occurs all over the country.

Based on the characteristics of antennas, ICNIRP specifications, and other local specifications, Huawei can simulate the impact of electromagnetic radiation on the surrounding environment by adding site and environment information with visualized 3D grid electromagnetic lobes. This enables the public to easily understand the impact.

As a 3D model, the lobe shape is parameterized and changes accordingly when parameters, such as the azimuth, downtilt, height, and transmit power, are input in real time. This helps customers quickly evaluate EMF and select the appropriate values for antenna parameters.

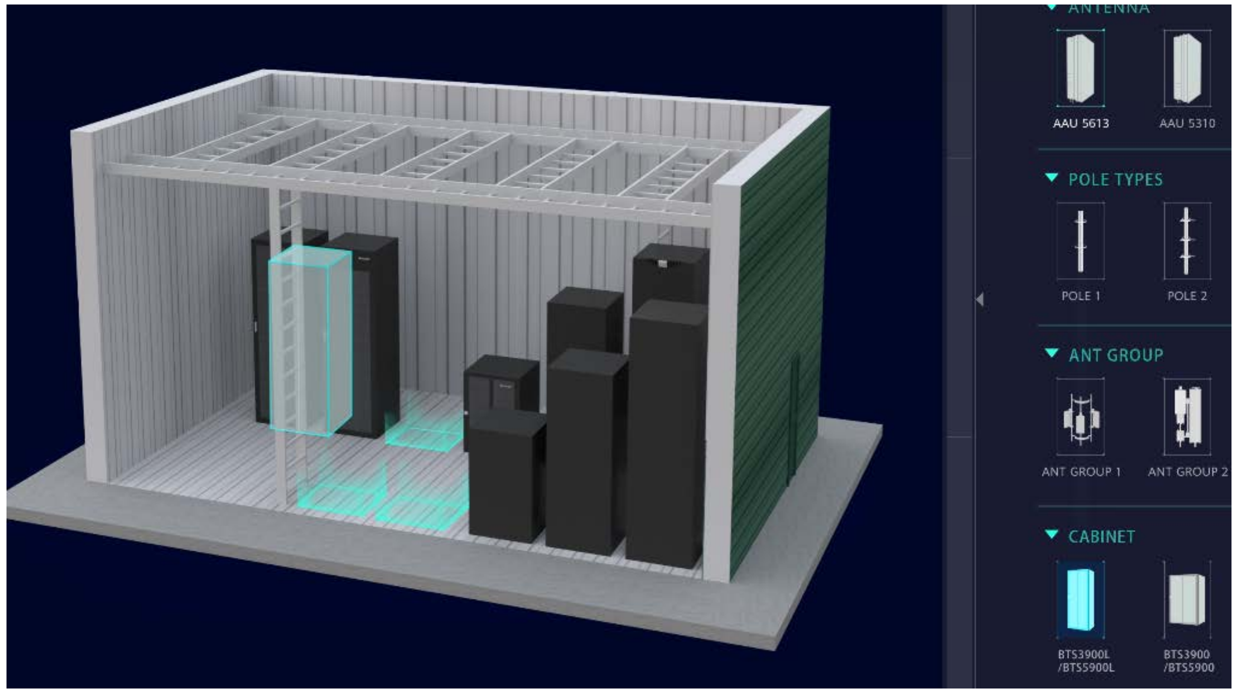
In addition, the 3D model can generate EMF data specific to a plane height or cross-sectional area, which can be used for professional EMF evaluation reports. The visualized operation mode simplifies operations and facilitates report generation.



6.4 Installation Space Evaluation

Due to strict resource utilization requirements from the government, there are an increasing number of shared sites. The emergence of tower vendors also pushes a single base station to be co-constructed and shared by multiple carriers. Equipment rooms and towers are considered as dumb resources for both tower vendors and carriers. It is difficult to know whether the space of equipment rooms and towers is fully utilized and whether there is space for new devices. Because as-built drawings are not updated in real time, onsite surveys have to be performed.

However, Huawei provides the 3D-based evaluation function to determine installation space. In this context, carriers can update site models based on the same set of site data, ensuring site information is accurate. By employing the model collision principle, Huawei can help customers quickly and accurately evaluate the space and provide suggestions for installation positions. In this way, the installation space of sites can be evaluated in batches, reducing visits to sites and saving time and costs of evaluation.



7 Conclusion

Huawei's T-BIM provides a complete set of specifications for information model application systems. It can not only guide carriers on building twin sites, but also help customers handle challenges and implement digital transformation based on the digital site platform. T-BIM integrates site information, standardizes operations with data-based and digitalized sites as well as quality control of collection methods and input data, and replaces active devices with passive devices. As a result, it enables remote O&M, continuous updates, and value increase of site assets.

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