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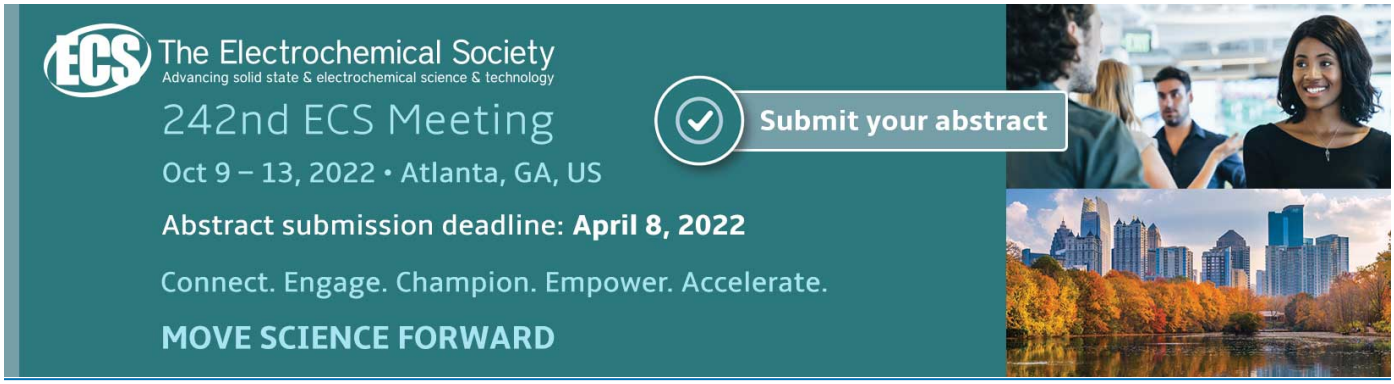
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CIM And CIM Platform Practical Use in China Review

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Abstract. City Information Modelling (CIM) is becoming an important base model of Smart City and Digital Twin City, which can realise intelligent city design and management. Lately, CIM has become the focuses of urban planning and design studies. Under the influence of building information model (BIM), smart city and three-dimensional city simulation, city-level information modelling, CIM connects different BIM levels integrates the spatial expression effect of GIS. This review introduces CIM development from using generating procedures, such as rules and typological processes, to analyse urban scenarios to form the city full information scene through the integration of BIM, GIS, and IoT. The paper also overviews the technical path of construction with CIM implementation, problems existing in the current practice of CIM technology, including all information of digital and lightweight data, scene fast calls and data standard uniformity, etc. Following the latest CIM progress, the paper puts forward some ways to realise the effective use of CIM in urban planning and design. The further review focuses on big data security, publicity, urban design element and CIM platform practical use in China.

1. Introduction

With the emergence of Computer-Aided Design (CAD) in the 1970s and Building Information Modelling (BIM) software in the 1990s, architects digitised architectural drawing elements and toolbox. Early in 1930, the consensus reached regarding the standard symbolic representations and architectural elements. However, the urban planners and designers have a different approach to the cities, from stories and narratives, painted cityscapes to complex mathematical models and computer simulations [1]. For an urban planner, a plan is often a written document [2]; it is a dynamic database of urban variables for an urban analyst. Therefore, urban design can be understood as art and arranging urban design elements such as streets, sidewalks, buildings, building facades, landscaping, etc., in urban space [3, 4]. There is a challenge and need for urban planning and design professionals to integrate analysis data with a design capability to expand GIS with a BIM in urban planning as City Information Modelling (CIM). It should also include the design qualities of cities in three dimensions: the planning and development process and the regulatory environment and design practice. Due to the complexity and integrated knowledge of theories and urban form histories; methods for observing and measuring; understanding of urban environments and transportation that role in shaping cities [5], there is a need to represent this complexity of the city by creating a digital platform to enable these multiple scales and enable designing.

This paper aims to overview the definition of CIM and the CIM in general because there is a lack of tested and working CIM models worldwide that connect urban planning with present and future built environment; therefore, there is a need to create and tools for the estimate of the main parameters used for urban design quality determination. Having an instrument with a set of parameters predicting how new or redeveloped construction will affect public spaces will give planners a powerful tool for simulating different scenarios for future projects, selecting only the best, eliminating excessive costs and improving and cities quality.

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2. City information modelling (CIM) definition

City information modelling is not a new phenomenon, but lately, CIM has become a significant focus of various field scholars, especially urban planning and design studies. City information modelling connects different tools and software such as CAD, BIM and GIS. The CIM concept has emerged from the need of connecting the 2D model with third dimensional and urban elements. According to [1], CIM has been developed as a framework to create a digital tool for the design of future cities. In the scientific literature and journals, there is no precise definition of city information modelling (CIM). Reviewing the scientific literature and scholarly articles [6-12], it is possible to state that CIM is perceived and understood as an information model that is generated from GIS and data.

Fan Xue et al. [13] states that 3D city model routs come from the Geographic Information System (GIS), which is a base for city information modelling (CIM). Most of the city tree dimensional models are based and build on the data from the GIS, photogrammetry and laser scanning [14]. The general core understanding and use of city information modelling via a various field of science are to empower the digital technologies by representing their capacities and demonstrate if through a various field of use, such as transportation, urban climate, morphology and other smart city features [13]. However, there is no agreement on the general definition of the CIM city and the element and tools of urban design that are not present.

The article published in 2005 by Hamilton et al [15]. has described the concept and challenges of the nD (GIS plus CAD) urban information model. The research outlines the system-based city models are using limited data sets for particular fields such as transportation and others [16] The article describes CIM's contents, and it is pointed that the objective of their research was to build up an integrated Open System City Platform [17]. Later, Arivaldo [18] has done a deep discussion on CIM and try to clarify the concept and terminology of city information modelling, which is more than just an extension of the BIM concept. Hisham [19] points out and provide a view of the definition CIM was coined. However, Hisham's statement was taken and considered as highly simplistic, not contributing to the understanding of the idea of CIM in all its extension and complexity.

Gil, Almeida and Duarte [10, 11] later developed CIM's concept to support tools for using GIS & CAD, gradually from the concept through the analogy with BIM [2]. Based on this concept, Stojanovski [20] tried to model and analyse urban scenarios by extracting the morphological structure of urban elements to proceed CIM toolbox.

The definitions, development and use of CIM concepts are presented in Table 1. There is a certain degree of overlap and close correlation in the development of these concepts. It also reveals the composition and application of CIM at different stages.

Table 1. Scholars' different definition of CIM

Date	Researcher	Definition
2005	A. Hamilton, H Wang, etc.	nD Urban Information Models "integrate the multidimensional urban aspects like economy, society and environment with 3D urban model plus temporal dimension. ND urban information model will provide comprehensive information support to various urban planning application systems."
2010	Hisham	"More recently, a new term was coined, CIM or the City Information Model, which aims to transform the urban planners way of handling their plans just like architects."
2011 2012	José N. Beirão, José P. Duarte, Nuno Montenegro, Jorge Gil	"The CIM will be able to extend the use of Geographic Information Systems (GIS) in urban planning as decision support tools [1],

		through integration with the Computer-Assisted Project (CAD), constituting a tool to support the project".
2015	Zhiqiang Wu	CIM is City Intelligent Model. BIM is a monomer, CIM is a population, and BIM is a cell of BIM. To solve the problem of a smart city, BIM of a single cell is not enough. It requires a large number of cells plus CIM composed of various connected networks. (Translated)
2018	Stojanovski	"Urban planning and design professionals need digital tools that like GIS integrate data for analyses, but they also have design capabilities. There is a need to expand GIS with a BIM analogy in urban planning and design referred to as City Information Modelling (CIM)."

Until the present day, there is no consensus on the concept of city information modelling (CIM). However, in the year 2020, Guangzhou Municipal Housing and Urban-Rural Development Bureau (Technical manual for 3D digital review of construction drawing, 2020) in China gave the first official definition of CIM. The CIM definition is described as follows: "In building information model (BIM), Digital Twin (Digital Twin), geographic information system (GIS), the Internet of things (IoT) technology as the foundation, such as integration of the urban underground, indoor and outdoor, history and status quo of the future multidimensional information model data and urban awareness, build up 3D Digital city information organic synthesis of the space, and in accordance with the planning, construction, management of the floorboard of the process and result of the city." This new CIM definition covers the main content and development direction of CIM. In China, CIM has mainly considered a smart city construction platform, which can realise intelligent urban management, which can help solve smart cities' problems and achieve the goal of sustainable urban development.

New technological developments, smart cities and digital ubiquity emerge new digital city models. Within design digitalisation, architects and urban designers are pushed towards digitalisation to generate city plans, building drawings automatically. On the contrary to the digital era, the classical urban design tradition comes from the design skills of sketching, model making and experience of human scale, that helps better to create liveable cities and vibrant places [2, 21, 4] rather than drafting two-dimensional plans. The new digital tools and software help create algorithms for analysis of digital data and digitising the urban design to a certain extent, which illustrates the possibilities to combine different elements into City Information Modelling (CIM) [20]. The fore-mentioned elements help generate the analysis of cities and three-dimensional city modelling very efficiently with statistical data by using programmes such as CityEngine, Esri, and others. However, the urban design toolbox consists of the artistic design elements, rules and principles, and design knowledge that mentioned digital software could not provide.

3. City information modelling (CIM) and model

Urban planning and design are complex, which need to consider many city factors, such as the physical structure, economic, social and environmental factors. The visualization of the three-dimensional urban scene is helpful to solve urban planning and design problems and make decisions, as well as to work communication and cooperation [15]. The emergence of city information modelling is based on this demand, gradually enriched with the rapid development of information and storage technology.

The city has a great dynamic change, and the rapidly changing society makes it more difficult to predict the development of the city. The study of CIM is a developing dynamic process, which goes through the process from model to modelling. In view of the background of the emergence and development of the CIM concept, the original intention of CIM is to solve the problem of visual display of urban environmental data sets required by urban design and planning. Before 2010 the study of CIM (City Information Model) used the words" Model", suggests that it aimed to make design support tools. At this time, the two-dimensional model is still used instead of the real three-dimensional space model.

[7]. When the concept of BIM introduced, the word "Modelling" was used to explain what CIM is. Thus, CIM had more meaning in it. It contains all the process of city development, from city design to construction and finally the management. If we analyse the word semantically, CIM can be explained as single words: "City", "Information", and "Modelling", where each word has more meaning and content (Figure 1).

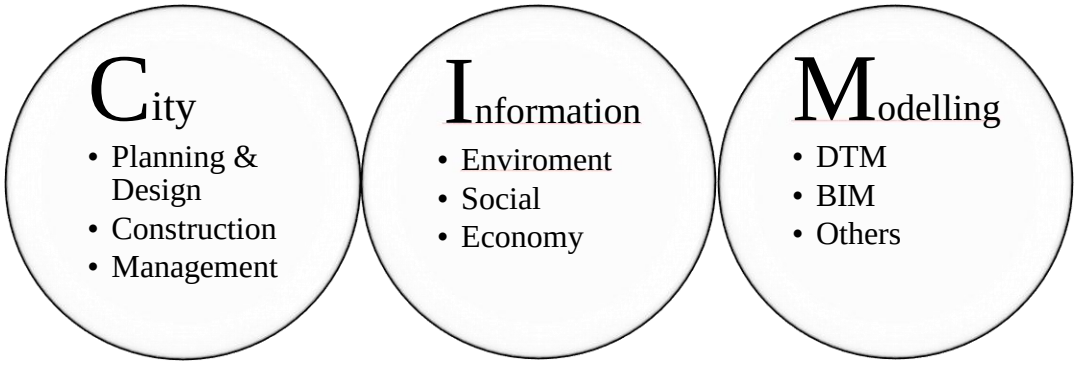


Figure 1. The understanding of CIM composition from the semantic perspective

CIM can be divided into single words: "C (city)", "I (infromation)", and "M (modelling)". "C" is all the process of the city， from planning and design to management. "Information" means all the recessive information such as environment, and "M" Represents all the digital Models (Table 2).

Table 2. Connotation of CIM - From model to modelling

Time	Institutions or individuals	Name	Component	Applied Area
2018	Stojanovski	City Information Modelling	GIS+ BIM+ IoT	City Planning/ Construction/ Management
2012	José Beirão	City Information Modelling	GIS+CAD (By analogy with BIM)	Urban design
2010	José N. Beirão, José P. Duarte, Nuno Montenegro, Jorge Gil	City Information Model	GIS (By analogy with BIM)	Urban design
2005	Hamilton, A., Wang, H., et al.	nD Urban Information Model	GIS+CAD（ nD）	City Planning/ Managemen

The main goal of the previous research on CIM is to realize the information modelling of CIM to realize the visualization requirements of urban information management. The city is in the process of continuous renewal and development. Only by combining VR and IoT technology to realize the real-time management of the city can it meet the current demand of smart city construction. Therefore, in the recent research of CIM, researchers in the field of computation are more active. In the future, the design will pay more attention to the realization of humanization, which will be achieved in CIM development [1]. The application of CIM can be divided into several stages. The first stage is to combine GIS and modelling technology to form a specific range of urban information model, which belongs to the digital construction of urban information. The second stage introduces BIM and VR technologies to achieve a certain degree of a dynamic model for urban information management. The third stage is the introduction of IoT technology, which makes the urban information model have a certain degree of real-time

performance and shows the intelligent management of the city. In the future, CIM will be combined with AI technology to realize more possibilities and realize the wisdom of cities (Figure 2).

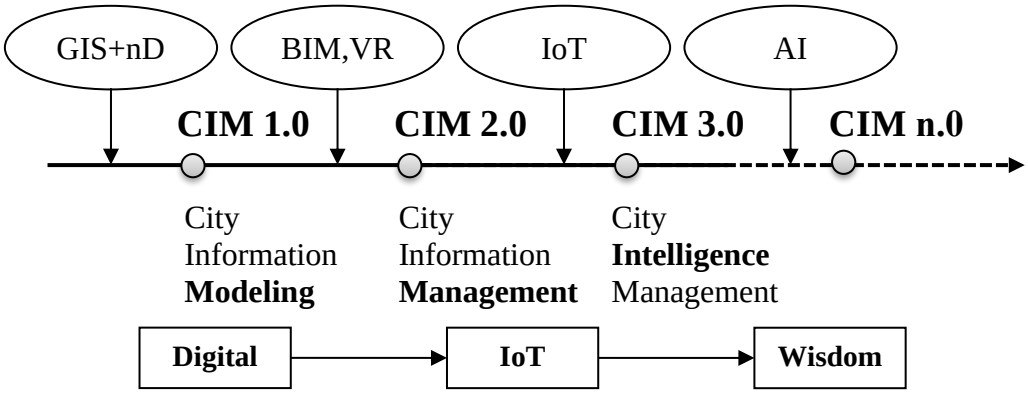


Figure 2. Stages of CIM's development and application

CIM platform is a digital model of digital twin city construction and a supporting platform for intelligent application of urban development and construction management. Based on the CIM platform 3D city digital bottom plate and highly integrated with real-time perception, simulation, deep learning and other information technologies, carrying out all-around multi-dimensional smart city application construction will become an important driving force modernization urban governance capacity.

4. Urban design toolbox and element in CIM

Different types of data sets and design elements are used in GIS, CAD/BIM applications for urban design elements by combining and arranging them. Most of the time the for a design and analysis the quantitively data is used from the physical features [22], like streets, buildings, plots, blocks, census data (residents), and landscape elements like trees, open spaces, parks, etc. while using GIS tools for the design, it is perfect for generating and visualising very generic elements and design tools for drawing, inserting new attributes or editing information. However, it does not represent the perceptual urban design quality and urban design elements or their interaction at block, building, neighbourhood or district scale [20]. According to Taylor [3], GIS-based applications focus on and measure the dynamic features (elements) like traffic flow and people flow economic and social parameters. With the help of algorithms and digital technology, designers can simulate and visualise changes in cities based on the scenarios. However, the existing data sets and physical and dynamic features do not incorporate the urban design elements (toolbox) for urban design qualities, such as imageability, legibility, enclosure, human scale, transparency, linkages, complexity coherence and others [22, 1].

Stojanovski [20] states that urban designers and planners need a modern tool that could incorporate the urban design quality elements along with data and design ability. It is a task for a CIM platform to link the urban data with artistic design principles, including the regulatory or discretionary system planning process. The platform needs to be comprehensive and easily integrated with the planning system and design, transportation, data sets, environmental platforms, and measurements. It would then become a game-changer in the design of cities [5]. The two-dimensional or three-dimensional drawing or a model of a city does not represent the complexity laying within the city, and its experience through townscape, character, sequences of urban spaces, identity and artistry analysed in the classical urban design works of Cullen, Lynch, Jacobs and others in table 3.

Table 3. Classic works in Urban design address perceptual and design qualities (based on [22]).

Year	Urban design thinkers
1889	C. Sitte. City Planning according to Artistic principles
1909	R. Unwin. Town Planning in Practice
1960	K. Lynch. The image of the City
1961	G. Cullen. The Concise Townscape
1977	Ch.Alexander, S.Ishikawa, M.Silverstein. A Pattern Language: Towns, Buildings, Construction
1984	R.Hedman. Fundamentals of Urban design
1986	R. Trancik. Finding Lost Space

Many urban design thinkers and their classic works describe and analyse urban design qualities and design principles, which makes great cities, but not a physical feature of cities. Physical features do not present the artistry and perceptual qualities of the city and urban spaces and how people use them. According to Reid and Otto [22], perceptual and design qualities do not entirely allow us to understand how people experience the places and how they feel them. However, based on these qualities and successful examples, we are enabled to create great places. Figure 3 illustrates the urban design perceptual and design qualities in the CIM platform, referring to the design scale of the city.

<table>
<tr><td rowspan="12">City Information Modelling a(CIM)</td><td colspan="8">Urban design elements</td></tr>
<tr><td rowspan="2">City 2D</td><td colspan="6">City / urban region</td><td rowspan="12">Adaptability
Distinctiveness
Dominance
Clarity
Spaciousness
Sensuousness
Coherence
Formality
Openness
Identifiability
Imageability
Intelligibility
Visibility</td></tr>
<tr><td colspan="5">Urban neighbourhood (city block)</td><td rowspan="3">Networks of routes /street layout</td></tr>
<tr><td>City 3D</td><td colspan="4">City block (plot)</td><td rowspan="3">City block frontage/ pertinent strip</td><td rowspan="3">Routs/ Street spaces</td></tr>
<tr><td rowspan="4">Building Information Modelling (BIM)</td><td colspan="4">Plot</td></tr>
<tr><td colspan="2">Building</td><td rowspan="3">Building facades</td><td rowspan="3">Open spaces</td></tr>
<tr><td colspan="2">Building storey</td></tr>
<tr><td>Rooms</td><td>Building elements</td></tr>
</table>

Figure 3. Generic UD perceptual qualities for CIM (modified by authors based on Stojanovski, [1] to include the perceptual qualities)

The following challenges of the urban design elements integration into the CIM platform are creating the methodology to measure these elements. It is indeed a challenging and highly subjective task that could only rely on the best practices and case studies worldwide.

5. CIM platform practical use in China

The CIM's application in the world is not mature yet, and there are many problems in the urban planning and design integration process. Most scholar research is in the field of smart city, which is still in the explorative stage. Due to the rapid urbanisation and dynamic development in China, more and more people are living in cities. Urban planning and urban design professionals try to make city life better and more convenient. The development of urban informatization in China cities over the past 20 years has experienced three stages: digital city, smart city and new smart city [14]. These three stages do not develop in sequences, but sometimes they exist simultaneously. As a key technology of the new smart city, CIM has been rapidly promoted in China's urban construction and development in the past five years. In China, CIM is more often referred to as the CIM management platform.

In November 2018, the letter of the Ministry of Housing and Urban-Rural Development [23] was issued regarding the Application of Building Information Modelling System in the Examination and Approval of Engineering Construction Projects and the Pilot Work of the Construction of City Information Modelling Platform [23], which promoted the CIM infrastructure platform at the governmental level. Later, the sub-centre of Beijing, Guangzhou, Nanjing, Xiamen and Xiong'an New Areas are the pilot projects for constructing the BIM system and CIM platform. In 2019, "Letter of the General Office of the Ministry of Housing and Urban-Rural Development on the Pilot Construction of CIM Platform", Guangzhou and Nanjing (Figure 4) started the CIM platform's pilot construction. Besides, official documents and news of relevant provinces and cities have indicated that CIM infrastructure platform construction will be promoted in 2021. It includes pilot cities for new urban construction (new-type urban infrastructure construction for short) and related cities for rapid follow-up. (A list of cities to promote the construction of primary platform of city information modelling in 2021 https://mp.weixin.qq.com/s/pjFnygOeaX0oOk6FSQnIYA).

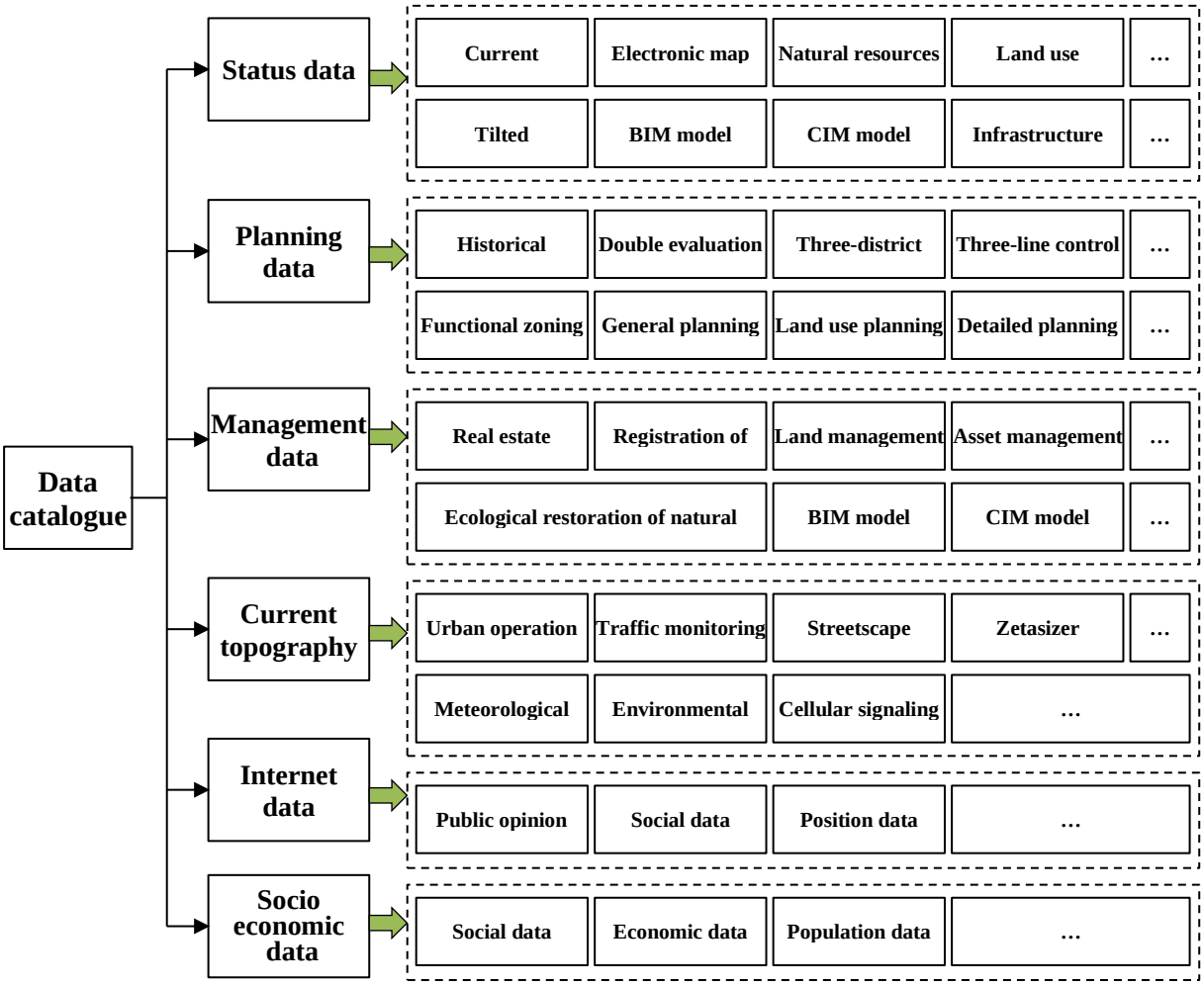


Figure 4. Nanjing CIM platform data system（based on the Wu, [13] table）

CIM had rapidly developed in China cities may answer the question following：First, the rapid development of AI and 5G industry in China has provided opportunities for the construction industry and in-depth application of CIM platform implementation. Second, the exploration of the 3D real scene model based on GIS in the surveying and mapping industry and applying BIM in the construction

industry provide a rapid production possibility for data collection of the urban model. At present, the Ministry of Housing and Urban-Rural Development is carrying out the digital preservation of historical buildings, sound urban underground space information action, new building BIM drawing review, etc., which are all prepared for the comprehensive development of urban model informatization [24]. Third, the implementation of the government's top-down policies promotes the construction of the CIM platform. Four, due to the CIM construction policy promotion, clear requirements were put forward with policy guidelines for CIM from the governmental level.

CIM platform construction brings together much information [13], making the urban space transparent and inevitably brings security risks. Some information may belong to national secrets or personal privacy, so some data collected by CIM need to be operated confidentially. These need platform researchers to pay attention to and combine cryptographic technology to solve.

6. Discussions

The article discusses the present and future challenges of the CIM platform development as a comprehensive tool for planners and urban designers. With the rapid computation and technological integration into design and planning system, CIM is considered a machine that creates urban designs with the help of algorithms and AI. However, the CIM is a framework platform that should be improved and extended with a comprehensive measurement methodology that could help planners and urban designers in the design process [24].

7. Conclusions

The city information modelling is not a new phenomenon, although there is still no consensus on the definition of CIM, it is an important technology and a tool for the entire process from planning, urban design to urban operations, management, scenarios modelling in the digital age. The development of the IM platform is a dynamic process that has experienced the process from simple three-dimensional visualization to the whole process of urban construction and management and is moving towards a more humanized future with IoT and AI technology. With the help of AI technology and clearly defined urban design element, it would become a powerful tool that could calculate with the help of algorithms the quality of the proposed design. The creation and integration of the urban design elements would eliminate place lessens and monotonous suburban developments. It might become a powerful tool for cities regeneration and a key to quality design. The leading role of AI and 5G technology and the government promotion of the construction of the CIM platform has been widely carried out in China, which will be the best experimental field to test the concept and assumption of CIM in the real China and other cities.

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