Comparative Analysis of Three Planning Support Software (PSS) Programs and Current Applications of Planning Support System in China

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Abstract

In this paper we first compare planning support system (PSS) with Geographic Information Systems (GIS) and Spatial Decision Support System (SDSS), then summarize the typical achievements about PSS in recent 20 years. We also make a critical judgment about the three main PSS software in Western Countries, namely: What if?, CommuntyViz and INDEX. The comprehensive reviews about PSS will contribute the deeper understanding on PSS and promote its wider applications in China.

1. Introduction

In urban planning, people have come to realize that, facing a city with quicker development, the planning problems are usually diverse and complex, and using traditional GIS technology itself cannot fully meet the increasing planning needs. Therefore, an integrated information system framework-planning support system (PSS) was proposed, which combines

a series of computer-based analytical methods and models in a GIS environment in order to support the planning task at all level[7].

Table 1. The differences between GIS, SDSS and PSS

	GIS	**SDSS**	**PSS**
Users	GIS Analysts	Domain Experts	Planners
Key Points	A set of tools Spatial data Spatial analysis GIS algorithms General flatform	Short-term decision Spatial and Non-spatial Data Spatial problem solving Decision support models Domain oriented platform	Long-term decision Spatial and Non- spatial Data Uncertainty and scenario planning Urban planning models Public participation platform

The concept of planning support system is closely related to geographic information system (GIS) and spatial decision support system (SDSS) (Table 1). PSS is served for urban planning and related technical analysis by combining urban development models, forecasting techniques with GIS and database technology. PSS provides a convenient and easy-to-understanding interface in order to help planners effectively use and analyze large amounts of spatial and non- spatial data, and to assist planning decisions. PSS bases on the long-term policy evaluation and decision, while SDSS is usually for short-term decision making[24]. Geertman and Stillwell[9] in 2004 argued that the similar feature of PSS and SDSS was to use the powerful information technology and existing professional knowledge to help planners and decision makers learn about planning and decision environment, so as to improve the efficiency and accuracy of planning and decision-making. This understanding reflects the tight connection between PSS and SDSS. However, PSS is generally used in the analysis of a variety of possibilities on the major issues and future development strategies, in order to compare, interactively discuss and communicate, which ultimately assists in reaching an agreement. By comparison, SDSS focuses on specific issues and goals in order to achieve

decision-making. This understanding reflects the differences between PSS and SDSS.

2. History and development of Planning Support System (PSS)

Planning support system has been developed for 20 years, and there are some representative achievements (Table 2). Among them, four books are published[3, 4, 8, 10]. It was commonly acknowledged that the concept of PSS was first proposed by Britten Harris in 1989, who believed that PSS is a combination of a series of computer methods and models, which supported specific planning tasks through the integration of the system interface[12]. Therefore, PSS consists of three components: specific tasks of planning and research, including planning data; models and methods of analyzing and forecasting; methods of transferring data into planning information. Batty in 1995 pointed out that PSS was as a branch of geographic information systems, particularly in supporting planning exploration, expression, analysis, visualization, prediction, design, monitoring, and planning seminar. PSS described by Klosterman in 1997 and 1999, and by Brail and Klosterman in 2001, was a kind of specific information technology applied by planners. They thought that PSS integrated three important parts: information, modeling and visualization. PSS, as reported by Geertman and Stillwell in 2003, was based on geographic information technology, and they integrated a series of parts (theory, data, information, knowledge, methods, tools, metadata, etc.) to support specific planning tasks. Klosterman in 2005 concluded in his article "Update on PSS" that though the concepts of PSS are controversial, there are some core elements which gain agreements. Klosterman focused on the classification of planning support system, and proposed two types of PSS: one kind of PSS used for planners to analyze, forecast, and design tasks; the other kind of PSS used to enhance the planning of expression and communication. At the same time, according to the four major tasks (change of land use; comprehensive forecasting; 3D visualization; impact assessment) as well as the four tech-

nologies (large-scale model of the city; basic rules model; change-of-state model; CA model), Klosterman classified the 13 kinds of PSS (Table 2, Table 3). Brail in 2008 focused on the categories of new PSS tools used in the field of urban planning in his book "Planning Support Systems for Cities and Regions", including introducing PSS software SLEUTH, LEM, What if?, UrbanSim, INDEX, CommunityViz. The book was divided into four parts: how to treat PSS; regional scale; urban scale; and PSS practice. In the second book published by Geertman and Stillwell in 2009, they introduced excellent PSS practices of the planning support system in recent years, and analyzed new technologies and methods required for next-generation PSS. The book consisted of four parts: existing PSS applications and evaluations; the design, development and implementation of PSS; new methods of planning support system; public participation in the PSS.

In summary, the existing literatures in western countries mainly illustrated PSS from the general introduction, lacking the typical and horizontal comparison analysis. In recent years, the concepts of PSS have been introduced and applied in China, as well as case studies that have been carried out at different cities. However, due to the availability of PSS software, and the difference of the planning framework between China and Western countries, the actual case studies are still relatively limited in China at present stages.

Table 2. Development of PSS

Year	Researcher	Publication	Core Contributions
1989	Harris	Journal of the American Planning Association	《Beyond Geographic Information Systems: Computers and the Planning Professional》 Proposed the concept of the PSS[12].
1993	Harris, Batty	Journal of Planning Education and Research	《Locational Models, Geographic Information, and Planning Support Systems》 Explored the relationship between PSS and GIS. And proposed the two core requirements: one is carry-

			ing out the optimization of the planning program, and the other is to assess the implementations effect[13].
1995	Batty	Regional development dialogue	《Planning support systems and the new logic of computation》 Proposed PSS as a branch of the geographic information technology, in particular used in supporting exploration, expression, analysis, visualization, forecasting, design, monitoring, and planning issues which need discussion[1].
1998	Bishop	Computers, Environment and Urban Systems	《Planning support: hardware and software in search of a system》 Argued that the early PSS is generally loosely coupled. It is recommended to adopt a unified interface mode to develop PSS [2].
1999	Klosterman	Environment and Planning B: Planning and Design	《The What if? Collaborative planning support system》 Proposed to build a practical and operational system software platform which can support planning[15].
1999	Hopkins	Environment and Planning B: Planning and Design	《Structure of a Planning Support System for Urban Development》 Proposed a detailed PSS system framework structure. Its core is geographical models and planning element[14].
2001	Brail, Klosterman	ESRI Press	《Planning Support Systems: Integrating Geographic Information Systems, Models, and Visualization Tools》 The earliest PSS book composed by 15 papers[4]. The book consists of three parts: PSS Overview; simulation forecast of PSS; visual PSS.
2002	Geertman	Environment and Planning B: Planning	《Participatory planning and GIS: a PSS to bridge the gap》 Suggested that a notable feature of

		and Design	the PSS is to promote public participation in planning[8].
2003	Geertman, Stillwell	Springer Press	《Planning Support Systems in Practice》 A book of Planning support systems which is based on cases[9], divided into five parts: the systems and techniques for enhancing public participation; the auxiliary planning process tools; strategic planning for PSS; land use and infrastructure of PSS; and environmental planning of PSS.
2003	Piracha DetlefKammeier, Kai Liu	Urban Planning Overseas (in Chinese)	《Planning support system - combined with computer technology creatively guide Pakistan's Punjab province, a case study of industrial location decisions》(in Chinese) Translation Article. It is the first article that introduces the concept of planning support systems in Chinese open publications[23].
2004	Geertman, Stillwell	Computers, Environment and Urban Systems	《Planning support systems: an inventory of current practice》 Summed up the main features of the representative PSS systems and provided the future development trend of PSS [10].
2005	Klosterman, Pettit	Environment and Planning B: Planning and Design	《An update on planning support systems》 Summarized planning support systems according to planning tasks and technical characteristics[16].
2005	Ningrui Du, Yuan Li	Engineering Journal of Wuhan University	《Planning support system (PSS) and its application to decision-making for urban spatial development》 Domestic applications first published about planning support system[7].
2006	Yeh, Xiaodong	Beijing: Science Press	《Geoinformation and Urban Planning System》

	Song, Xinyi Niu, Xia Li		This book introduces the difference of practice cases[29].
2007	Yin Long	Beijing: Chemical Industry Press	《Planning Support System: Theory and Practice》 Systematic and comprehensive introduction to the theory and method of the PSS and its practical application[19].
2008	Brail	Puritan Press	《Planning support systems for cities and regions》 Focused on the representative PSS tools, including SLEUTH, LEM, What if?, UrbanSim, INDEX, CommunityViz[3].
2009	Geertman, Stillwell	Springer Press	《Planning Support Systems: Best Practices and New Methods》 The book aims to introduce the recent excellent PSS practice, divided into four parts: existing PSS application and evaluation; PSS design, development and implementation; planning to support new methods; PSS public participation[11].
2010	Brommelstroet, Schrijnen	Environment and Planning B: Planning and Design	《From planning support systems to mediated planning support: a structured dialogue to overcome the implementation gap》 Pointed out that an important bottleneck of the planning support system is communication issues. Proposed the concept of coordinated planning support system .The essence is to advocate public participation in the planning support system. Takes Amsterdam as an example to explain the way of the realization of the coordinated planning support system[5].
2010	Ying Long	Journal of Tsinghua University (Sci &	《Urban planning support system definition, objectives, and framework》

		Tech)	Intended to establish a planning support system framework. Summed up planning support systems that can be used in a range of models and methods[20].
2010	Zhou Jie	East China Normal University	《Exploring the Application of the Planning Support System Based on CommunityViz》 Introduced CommunityViz and its demo application[30].
2010	Yuan Li	Urban Studies	《Planning Support System: Current Situation and Reflection》 Analyzed the development problems of support systems from four aspects: data processing, analysis model, the results representation, and system platform. Also pointed out that the next stage of PSS development should focus on these four aspects: supporting multi-source data, the model of simplicity, supporting scenario planning, and analysis results can be evaluated[18].

3. Comparison analysis of the three PSS software

In this paper, we selected three typical PSS software systems, which are mainly used for supporting land allocation and land use impact assessment. They are all commercially available software in the market (Figure 1, Table 3), and are operated on the mainstream GIS software (ARCGIS) or support the mainstream data format (SHP). Also, they have a relative high market share and the case studies based on the three PSS are commonly reported. What if? is mainly used in the generation of planning scheme (scenarios). The application field also includes supporting the decision for public facilities expansion, open space protection, the future population size estimation, and population and employment density distribution, and so on. The uses of What if? software are divided into three steps. The first

step needs to produce a Unified Analysis Zone (UAZ) by combining all the related spatial vector data into a single SHP file in general GIS software. The UAZ file records all the elements that will be used in the next stages. The second step is putting UAZ data into What if? and generating a project file after completing attribute in-putting, field matching, factor selecting, weighting, etc. The last step is to create different land allocation scenarios by composing different suitability scenarios, demand scenarios, and land use control scenarios.

1) What if? provides suitability analysis model. The function allows users to make traditional suitability maps and reports by considering a series of natural factors such as slope, soil, dangerous landfill, etc. The model also allows the users to add policy factors, for example, land-use changes policy (transferring agricultural land use into residential).
2) What if? can be used for land use demand forecast. The model allows the users to specify future land use demand assumptions which include projected population and employment growth, future residential properties, the assumed employment density, the number of expected open space and recreational land.
3) What if? simplifies the rules of land allocation. The future land allocation is assigned by balancing the suitability and demand of each land use types.

The advantage of What if? is the ease of use, allowing the users to use a single interface for preparing and evaluating suitability policy and plan scenarios. The easy to understand interface and easy operational characteristics of What if? make it accepted not only by the government officials and interest group representatives, but also by common people. Another merit of What if? mainly lies in its operational ability with minimum data requirements. What if? successfully reflects the concept of "plan with people" rather than "plan for the plan" , while the model is simple and supports the best available data (BAD principle). The disadvantage of What if? is that it can't check traffic facilities, fiscal policy, and other planning decision relationships; it can't test space interaction and it is not behavior

based; it has no used random utility or discrete choice theory to explain and predict the behavior of city driving force; and it has not considered the interrelationship of land, housing, labor and infrastructure market, or not provided any program to adjust the price changes of supply and demand.

INDEX PlanBuilder (shortly for INDEX) is mainly used in the evaluation of planning scenarios. INDEX can compare the advantages and disadvantages of different planning scenarios. It can also simulate the regional transportation development situation and enable real-time public participation. Using INDEX software is basically divided into three steps. First, it needs to have an established analytical template, including the coordinate range and projection methods of the study area, land use classification and color expression patterns, the choice of evaluation index, etc. The second step is importing available data, including research boundary, land use, transportation network. Accurate attribute field matching is the key of importing external GIS data into the INDEX template. The third step is building a variety of planning scenarios by importing or modifying on the basis of current land use scenario.

1) INDEX supports the concept of parameter (template) design. It provides templates to choose and adjust, and mastering its parameter setting will no doubt greatly improve the efficiency of the system application.
2) INDEX owns separate functional modules. INDEX has nine different modules: regional, research, case, element, index, evaluation and weight, case comparison, visualization and link. The regional module provides geographical and hierarchical way to organize the study area; the research module is defined by geographic area or by the research content which has been classified on focus; the case module is used to establish a planning scheme or case, which can be actual or predicted situation; the element module includes database of supporting indicators computing; the indicator module provides users with a range of indicators; the evaluation and weight module offers the users the option of the importance of indicators and establishes the acceptable rating

range of index score; the case comparative module are operated by using tables and maps; the visualization and link module is used to show the module results and connect with other models.

The advantage of INDEX model is to support all stages of the planning process. It takes full advantages of GIS mapping capabilities, combined with perfect urban influence measures to provide an effective and stable planning tool which has the ability of evaluating the development scenarios and monitoring the implementation of long-term land-use for the community. However, the disadvantage is that it needs detailed and accurate GIS data, and professional index of using the model; in order to provide a complete land use and transportation impact prediction, the four-step travel demand model must be used in parallel.

CommunityViz can assist city managers and the public to make decisions in city planning, land use planning, resources, environmental protection, and transportation planning. Mainly it is used in three-dimensional visualization and public participation in urban planning and design. There are some typical application modes of CommunityViz: 1) we could do suitability analysis of land plot to get the suitable plot development sequence and spatial distribution, then based on this (as Phase layer) apply Time Scope to analyze different classification stage of architectural space distribution, 2) we could use the tool of Land Use Designer to create a land use planning scheme, then take this as the foundation layer to do Built-out analysis, to complete the construction of the layout of the space, and can further use Custom Impact Wizard to conduct the index statistics and the Impact Analysis of the distribution of buildings.

1) CommunityViz is strong at 3D and visualization. A wide range of people, such as professional planners, general planning personnel, land owners, and interested citizens can use this software to understand and determine the direction of community development. It also can evaluate community land use patterns, visualizing the results with graphics and diagrams.
2) CommunityViz provides different style of suitability analysis. Both the CommunityViz and What if? Software systems can oper-

ate suitability analysis, but the functions are different. CommunityViz mainly solves certain types of objects (discrete geometry goals, such as building) for the suitability of other environmental (factors). What if? examines the suitability of the whole research area (continuous distribution objects, such as land) through overlay the polygon data.

3) CommunityViz assists plan design and produces scenarios. CommunityViz and INDEX both provide land-use planning and design. The former is called the Land Use Designer while the latter called Paint Editor. Using this kind of tool can create attributes automatically, for example default population, employment, building density, resource utilization, population of children per household, consumption of household water, per household tax, waste water displacement, etc. What the difference is that INDEX provides external input mechanisms, which support importing a batch of external data.
4) CommunityViz provides a flexible assessing toolset. Similarly, both CommunityViz and INDEX provide an index evaluation function. In contrast, the INDEX system is more systematic, diversified, and hierarchical (including living, employment, accessibility, environment, etc.), while Custom Impact Wizard provided by CommunityViz has more flexibility.
5) CommunityViz owns open data management styles. In data management, what differs from INDEX is that CommunityViz uses the dynamic attribute list to centralize management of space objects, and different solutions (such as architectural layout) will be stored for the same space objects. On the other hand, INDEX establishes respectively different Personal Geodatabases to manage objects of different schemes independently.

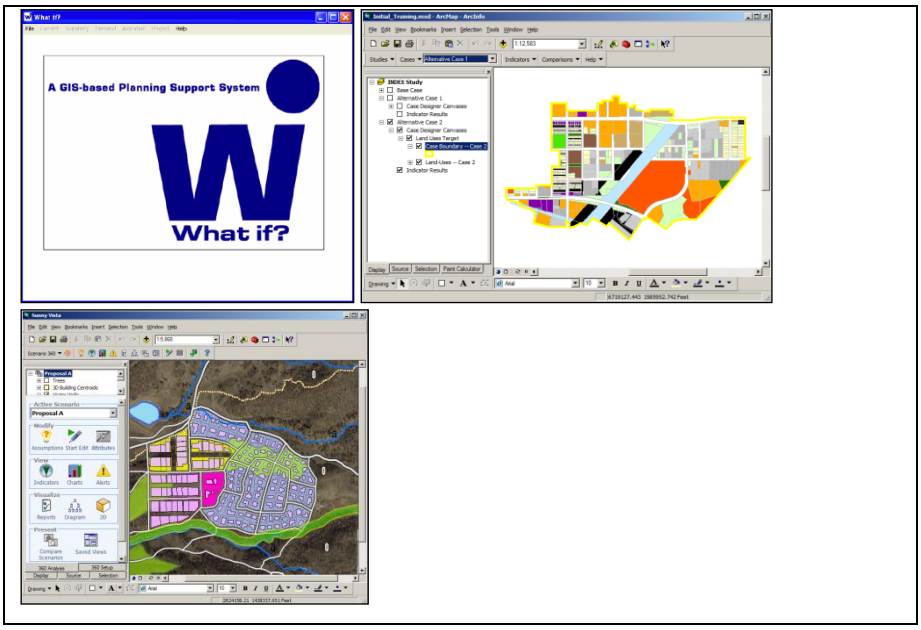

Fig. 1. Interface of What if?, INDEX and CommunityViz

Table 3. Comparative Analysis of Three PSS softwares

	What if?	INDEX	CommunityViz
Support SHP format	√	√	√
Based on ArcGIS Flatform		√	√
Stand-alone software	√		
Support for Suitability Analaysis	√		√
Support for Scenario Genreration	√		
Suport for Scenario Edition		√	√
Support for Economic and Traffic Evaluation		√	√
Support for 3D Visualization			√

4. The practice of Planning Support (Systems) in China

In fact, the researches of planning support system in China started in 1998[27], but the proposed concept at that time was not connected to GIS components. The concept of PSS from western countries and the promo-

tion of commercial PSS softwares in China closely relates with Chinese planning practice in the past 20 years. We could classify the practice of planning support (systems) in China into different groups. From the aspect of planning concepts, planning support systems aims at presenting the idea of intensive development, economic development, urban safety, aesthetics, social equality and public participation, with the use of multiple resources of data and quantitative research methods. From the aspect of planning tasks, planning support systems are used to make support for urban future development, rational allocation, scientific management, intelligent city and policy evaluation. From the aspect of planning types, planning support systems have been implemented in all stage of urban planning, including concept plan, master plan, regulatory plan, urban design and theme research, etc.

Table 4. Current Practice of Planning Support (Systems) in China

Classfication	**The Content of Practice**
Planning Concepts	Intensive development; Economic Development; Safety; Aesthetics; Social Equality; Public Participation.
Planning Tasks	Urban Future Development；Rational Allocation；Scientific Management；Intelligent City; Policy Evaluation.
Planning Types	Concept Plan；Master Plan；Regulatory Plan；Urban Design；Theme Research.

Compared to the three PSS software systems in Western countries, the operational and commercially available PSS software in China is quite limited. One of the reasons is that the stage and mission of Chinese urban planning is different from that of Western countries, which objectively decides the demands of market. After the industrialization, the urban spatial form layout of the West has tended to be stable and mature, and large-scale urban construction and urban sprawl has been basically completed. Thus, the main stage and mission of the West has turned to promoting the quality of public service, strengthening the administration, and reinforcing the enforcement and evaluation of policy, etc. The auxiliary system software also

reflects in enhancing the effectiveness of policy assessment and public participation. In China, the discipline of urban planning mainly derives from architecture. And the current mission is to solve issues like urban spatial form layout and spatial strategic adjustment, etc. Based on the master plan, the detailed planning and urban design have been made and spread to the countryside all over China. So, the most popular operational planning support (systems) is in fact the planning design system software that bases on computer-assisted design system, such as AutoCAD, Xiangyuan software, Hongye software, and so on. These kinds of software are also called planning support system software in China even though they are on a basis of CAD in data management and analysis rather than of GIS. However, they've become the major supporting systems of the work that serves urban planning. From the viewpoint of tendency, such kinds of software have possessed some functions of GIS, such as terrain analysis, slope analysis, aspect analysis, network analysis, report generation, parameterized graphical association, 3D visualization and so on. The advantages of GIS include massive data management and space-attribute integrated management. In terms of handling large scene, rapid query and spatial analysis, Chinese planning software is more difficult to accomplish these tasks.

Another reason of the lack of operational planning support system in China is the development situation of Chinese GIS. This involves two aspects: software development and GIS data sharing mechanisms. Domestic GIS software in the market, like SuperMap and MapGIS, have occupied a certain market share and own the similar GIS functions like ArcGIS platform. However, because of the development stage and maturity, the redevelopment on the basis of domestic GIS software is limited. In the three western PSS, two of them are operated on the basis of ArcGIS and the other one (What if?), is now considering transplanting to ArcGIS. The difference in data sharing mechanism between China and the West is also very obvious. In western countries and at various resource websites, the spatial data and attribute data can be downloaded free of charge from the data management center, which provides convenience to the connection of spatial data and attribute data and to GIS analysis. This data sharing and

standardization management mechanism lays a foundation to the promotion of planning support system in western countries. For example, many parameter inputs in the three major PSS are based on the property fields the spatial data may have, which adjust to the Western data types and analysis patterns. However in China, it is difficult to obtain the spatial and non-spatial data because of security mechanism.

In recent years, Chinese planning support (system) practices focus on two main aspects. One is studying Chinese cases by means of introducing and using the mature planning support system software in the West, which focus on bringing in the core concept of western mainstream planning support system and adjusting relative parameters to generate the expected results[6, 17, 30]. The other aspect is proposing the origin and prototype system, which focuses on introducing the planning model and the procedure of the system[21, 22, 28, 26]. However, in China, the articles about the three PSS are limited. We have implemented a case study by using What if? in 2003 (in Dutch), and its prior exploration. Later on, a western professor took Beijing as an example to do research by using INDEX (in the U.S.). The articles about systematically introducing Communityviz have shown up but are limited to the demo case study. It believes that in the near future, there will be more and more articles analyzing domestic cases by tools of western planning support software and the development of origin systems will emerge.

5. Further development of Planning Support (System)

Three main PSS in Western countries have provided good models for the next development of planning support system, especially in the field of scenario planning, plan evaluation, and 3D visualization. Further development of planning support system can be concluded as follows:

(1) The trend in development of planning support system is certainly consistent with that of geographic information systems and spatial decision support systems. In the past few decades, GIS has gradually developed

from a single operating system into a network operating system, and now into a service-based user system. Thus, the planning support system will also develop along the path, acting more and more prominent in network applications, 3D visualization, and user-oriented services. Judging from the functions and application effects of the foreign three planning support system software, the data input and output will be based on online service, meanwhile interactive function will also gradually increase the possibility of public participation in urban planning. In addition, due to the rapid development of computer software and hardware, touch panel computers will be getting more and more applied to urban planning, which will play a positive role in promoting the spot modification and feedback of planning schemes, eventually making the new city planning models about "planning for everyone" and "everyone participates in planning" feasible. In fact, many successful community plannings in America have benefited from the effective use of new planning support system, which give community members the right and a feasible way to participate in urban planning. Advanced hardware facilities and appropriate function services gain the development of planning support system a further breakthrough.

(2) Another trend in the development of planning support system can be certainly consistent with the inner development trend of urban planning discipline. More and more plannings are confronted with uncertainty and policy guidelines in the future, so urban planning should do more work to the acculturation of certainty and uncertainty, and rational analysis of spatial layout and comprehensive benefits under different policy guidelines, including environmental/ecological benefit, the traffic benefit, social fairness efficiency, economic cost benefit, and so on. The compilation of urban planning will give more and more consideration to the influence of global climate, regional carbon emissions, social harmony and resources for sustainable development. The develop trend of the discipline will lead the development of planning support systems to the multi-purpose user system, scenario planning system, design analysis-benefit evaluation integrated system, filling the gap between specialized planning data and policy changes and the popular way of information transmission.

In March, 2011, the urban planning discipline in China was classified as a first class discipline by the state council academic committee of China, which will certainly promote the rapid development of new techniques in urban planning in China. At the same time, the planning geographic information sharing mechanism which supports planning support system is continuously improving. The internet resources from national mapping agency and international scientific data sharing platform provide significant supports for the free access of space data and share application, and China's step on improving the data sharing between government departments is quickening. Also, according to the research of Vonk[25], the lack of understanding on planning support systems and the limitations of application experience of the registered planners are also bottlenecks which limits the development of the planning support system. Therefore, with the rapid development of related techniques, the popularization of planning support system, the widely carrying out of case studies and enhancing related training, publicity, and promotion will greatly promote the further development of the planning support system.

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