National Report of China to ICC 2003

# The Progress of Cartography & Geomatics in China（1999-2003）


THE CHINESE SOCIETY OF GEODESY,

PHOTOGRAMMETRY AND CARTOGRAPHY

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（National Report of China to ICC 2003）

Chinese Society of Geodesy, Photogrammetry and Cartography

Since the 11th General Assembly of the International Cartographic Association in 1999, China has seen great progress in the cartography and Geomatics. New theories of cartography are developed. The cartography technologies changed dramatically, Technologies of GIS are advancing rapidly in the direction of practicality. Educations keep on making progress. New academic works, maps and atlases are produced.

## 1. New cartography theories

### 1.1 The system and deepening of map spatial cognition theory

The reasons that the map spatial cognition theory is favored by Chinese map scientists are twofold: one is that human can not cognize geographic environment and take advantage of geographic conditions without map science at any time, but we can't explain how people use maps to cognize spatial geographic environment and about what the structure of spatial geographic environment information stream is. The other is that scientists have to "tell" the computer what to do and how to do when producing maps are produced by means of computer cartography. It requests that map scientists must exactly know the knowledge used in mapping and the process of thinking during the mapping. These two problems are the same thing to explore how human's brain processes the spatial geographic environment information.

The kernel of map spatial cognition is to explore how human's brain processes the spatial geographic environmental information. In *theoretical cartography* (Wang Jiayao, et al., published by the PLA press, 2001), the structures of the human cognition system, which includes human brain's basic functions, the mechanism of the brain's attention distribution and the human information processing system, are researched. The abilities of human's spatial cognition to perceive shape, size, orientation, position, dimension, time and correlations are analyzed. The main sense channels and means of spatial cognition, including capturing, storing, integrated expressing spatial geographic environment information by people's seeing, touching, hearing and smelling, etc., are researched. It provides spatial frames, accurate visual estimation and impression to spatial distributed objects in quantity, and the correlation of all kinds of geographic elements or phenomenon for the construction of a whole geographical concept and mental by means of spatial cognition like maps, so that it can help people to set up the correct spatial relation mental and rectify the false mental. It considers the cognition mapping and mental map as two important concepts in map spatial cognition and makes experimentations to analyze the cognition mapping in actions of map space, the cognition mapping in map using, computer simulating the abilities of cognition mapping, the process of mental engendering, the functions of mental in thinking, the

characteristics of mental map, etc. It puts forward that the map spatial cognitive process includes apperceiving process, idea process, memory process and thinking process. It also analyzes and researches on the theoretical and practical significance of map spatial cognition to cartography expert system, geographic information system, spatial data visualization, etc.

## 1.2 The developing of the theory of map vision reception in digital mapping

The electronic map is one of the main products of digital mapping, which is generally displayed on the computer screen. The electronic map is dynamic, interactive and multimedia, and so on. The color is so important in the electronic map design that the research of the vision reception focuses on the problem of the color reception in electronic map (Chen Yufen, Transaction of Surveying and Mapping Academy in Zhengzhou, 1999, Vol.16 No.3). By making trails, testing and analyzing, map scientists think that the color is very important because the electronic map is restricted by display hardware so that the exertions of symbol's shape, size and structure are restricted. Since the colors of the electronic map can be changed and adjusted flexibly, it is convenient for users, and it advances the effects of the electronic map greatly. In using color's lighteness to express the sense of grading, tests have indicated that when the color is graded according to lighteness in the electronic map, the excessive classifications will result in longer time for the tests to distinguish the color grade and the decline of veracity ratio, and the time and the right ration of distinguishing have relation to color. In color matching in the electronic map, tests have showed that if undertone is selected as back color in electronic map, then the buff is the optimum color as back color, and the French grey is next to the buff; if fuscous color is selected as back color, then the navy blue is the optimum color as back color. The fore-color isn't suitable for back color and it must have enough contrast between fore-color and back color. Namely, it must be easy to distinguish graphs and back color. Whatever back color or fore-color is, the lighteness must not be excessive high. Otherwise, people will feel glared and be tired for a long time. (Wei Wenzhan et al. Transaction of Wuhan University, information science edition, 2002 Vol.27 No.5) consider that pixel is the media of element and symbol. They give the mathematical definitions and combined equations of the eight vision variables brought forward by Yu Liansheng, including shape, size, direction, density, structure, color and position, and make clear that the pixel consists of finite vision variables, and the map symbol is composed of finite pixels, thus a lot of map symbols can be acquired. Thereby, it shows that the map symbol design and creation have enormous potential.

## 1.3 Research on Geo-information Graphic Methodology—developments and innovations based on classical Geo-information Graphic Methodology

The research of geo-information graphic methodology has been sparked by academician Chen Shupeng of Chinese Academy of Sciences. Chinese map scientists have acquired significant progress in this domain. For example, the Graphic Methodology for Geo-information Science published by the Commerce Press in 2001 has summarized the traditional methods of geo-information graphic and has lucubrated on its notions, its basal theory and methods, and its applications. The researches on hydrology graphic methodology have obtained persuasive results, such as the graphic methodology of evolution of the Yangtze River watercourse, the information

graphic methodology of Drainage structure, information graphic methodology of Delta, information graphic methodology in coastal area, numerical simulation of the tide current and graphic methodology, current field graphic methodology in the Taiwan Strait, etc. The urban information graphic methodology is an effective method and a new thought for city development. It includes urban symmetrical distribution, urban system graphic methodology, small town system graphic methodology, graphic methodology of urban land-use, graphic methodology of urban traffic system and graphic methodology regulation of urban spatial evolution. The research of landscape graphic methodology has been more systematized, which includes graphic methodology of element content for geo-chemistry, graphic methodology of vertical belt in mountain region, graphic methodology of landslide disaster, graphic methodology of sandy desertification in the west of the Northeast China Plain, shape analysis and its graphic methodology expression of geomorphology in the Loess Plateau, environmental feature analysis of central transition area of China, graphic methodology of regional difference of supply and demand of water resource in western China and graphic methodology of environment population carrying-capacity in western China, etc. All these achievements have offered theories and methods for economy's sustainable development in China.

## 1.4 Research on the linguistic characteristics of spatial information and its automatic understanding mechanism

The Chinese cartographic scientists attached great importance to the research on the linguistics of spatial information. Du Qingyun (Ph.D. degree thesis of Wuhan University, 2000) comprehensively summarized the research achievements in Cartography, Geo-information Science and Knowledge Engineering relating to linguistic model, and put forward an integrated language construction frame of space information. He also constructed an integrated internal model of spatial information based on phonetics, semantics, lexics and syntax, and studied phonetics, semantics, lexics and syntax respectively. With respect to spatial information's automatic understanding, the relations between linguistic understanding and linguistic creation are demonstrated, and the methods to express spatial information's automatic understanding results are analyzed. In addition, two case studies are given out.

## 1.5 Map algebra—a new theory and technical foundation

The research on map algebra began in 1989 (Hu Peng et al., Map Algebra, Wuhan University Press, 2002). An elementary system of map algebra was established about ten years' research. In map algebra, the map graphics are described by the point set. It utilizes the algebra idea which is related to the point set transformation and calculation to roundly and essentially expound the theories and methods of graphic symbol visualization and spatial analysis. The hierarchy of map algebra takes the elliptical earth as an integrated object to research, which exceeds the traditional Euclidean Space's limit, and provides a unitive and normative foundation for the location and research of territorial (up to the global) geographical spatial information. Its main characteristics are as follows:

- It breaks away from the static manner of conventional map making, brings forward algebra methods of the dynamic map making, and creates the transformations and operations

of graph.

- It enhances and develops the operations and applications of grid model in scale-space, such as multiple polygons overlay analysis, theories, methods and precision analysis of efficient DEM establishment.
- It can efficiently resolve a series of technical problems dealing with the international boundary partition.
- It defines line Voronoi diagram, area Voronoi diagram, impedient Voronoi diagram in scale-space and Voronoi diagrams in the global scale-space. All these researches have enriched the results of Computer Geometry.

# 2. The great development of the cartographical technique

## 2.1 The digitizing and integrating of cartography and publication—exploiting new situation on digital mapping

Since the seventies in the 20th century, the digitizing and integrating of cartography and publication have become the fundamental technical means of map-making production's for thirty years' exploitation and research. The digital mapping system has been exploited and it has become productive force. Liu Haiyan (2002) set up and carried out two kinds of technique approaches. One is the integration of digital cartography and map publication, which was supported by map database. When we yield paper maps, we update the established map databases at the same time. For example, it has updated the production of 1∶250000 cooperative maps and its database. The other is the integration of digital cartography and map publication, which is based on the paper map. When we yield the paper map, we establish corresponding map databases at the same time. For example, we produced 1:3000000 People's Republic of China geographic map, founded 1:3000000 map databases, produced 1:5000000 world geographic map and the foundation of 1:5000000 map database of the world map.

## 2.2 Multi-scale expression and cartographic generalization of spatial data

Automatic cartographic generalization is necessary in two cases: one is that people take advantage of the established map databases to produce smaller scale map, the other is that GIS users want to display spatial data clearly with multi-scale and analyze spatial data. People have explored and researched it for a long time. However, people really have made a great breakthrough only in recent years. Ai Tinghua (2002) studied the supporting data models and methods of generalization in urban map database, and mainly researched on the Delaunay triangulation network model's applications in urban cartographic generalization. Wu Fang (2002) studied automatic cartographic generalization's interoperable approaches, and brought forward the compositive strategy, the conceptual model and the realization of interoperable automatic cartographic generalization. Wang Jiayao et al. (1999) researched the neural network approach of water resources generalization in hydrographic chart, and put great emphasis upon the neural network's structure, operation strategy, network parameter, network study and network realization of soundings generalization in hydrographic chart. Wu Hongtao (2000) researched the applications of wavelet analysis in line simplification in GIS. He mainly studied the relations between

multi-resolution analysis with wavelet theories and GIS graphic data multi-scale expression. Thus, he put forward an automatic cartographic generalization model based on multi-resolution analysis. Zhai Jingsheng et al. (2000) studied on identification, measurement and generalization of linear feature in hydrographic chart, put emphasis upon simulating human's means of graphic character recognition，and introduced Douglas BDT method. He also presented functions of graphic character recognition and measurement, and realized the automatic generalization of linear feature in hydrographic chart. Liu Chun et al. (1999) investigated the reasoning of cartographic generalization of water system features in GIS based on "knowledge Rule". He mostly studied the knowledge regularizations according with cartographic generalization of water system features, and utilized these knowledge regularizations to judge the generalization process and select generalization algorithm. Gao Wenxiu (2002) researched thematic data generalization in GIS based on knowledge. He gave emphasis to the research of the classification hierarchy, knowledge content, knowledge expression, knowledge application of the generalized rules, which were necessary in the course of thematic data generalization in GIS. Qian Haizhong (2002) studied automatic generalization algorithm base on the Agent. He mostly researched the monitor and control agent in cartographic generalization and designed a monitor and control Agent model which can monitor and control the whole automatic generalization operation. Fan Hong et al. (2002) researched point element annotation's optimal allocation based on genetic algorithm. He adopted genetic algorithm with overall search characteristics and advanced an approach of point element annotation holistic optimal allocation.

### 2.3 The quick advance of the engineering of national foundational geographic information database

At the present time, we have completed 1:5000000 the world map database, 1:4000000, 1:3000000, 1:1000000, 1:500000 and 1:250000 databases of topography, toponymy, digital elevation model, geodesy and gravity. For the important regions and the main flood -preventing regions of seven large rivers, we began to digitize 1:50000 and 1:10000 foundational geographic information and construct databases. Presently, we are mainly building countrywide 1:50000 digital elevation model databases, digital raster databases, digital orthophotomap databases and important regions topographic frame element database construction. According to the need of local economic construction, some provinces, municipalities and municipalities directly under the central government accordingly achieve 1:10000 digital elevation model databases and digital orthophotomap databases construction of important regions (Guo Gexin , 2002; Shang Yaoling 2001; Li Deren et al.,2002 ).

## 3．The advance of geographic information engineering technology

### 3.1 The development of GIS software with independent copyright

The development of GIS software with independent copyright in China began at the beginning of 90s in the 20th century. In recent years, it has made new progress. Now, there are many representative commercial GIS softwares, such as GeoStar, MapGIS and SuperMap.

GeoStar (Wuhan Geo Information Engineering Technology Co. Ltd) was developed from 1993. It was part of the popular GIS foundation software. It obtained the second prize of national technology progress in the year of 2001. Now, the series software of GeoStar has already owned a complete production line of data collection, data processing, data analysis and web publication. It is widely used in city planning and management information system, land use changes dynamic monitor system, land bargaining system, valve real time dynamic management system, mobile communication analysis and management system and city electronics governmental affairs website.

MapGIS is the earliest release software with independent copyright in China. MapGIS above version 6.1 is a new generation called COMGIS, which has high performance of spatial database management, spatial analysis and DEM analysis, image analysis, 3D terrain draw and convenience of quadric development functions. The applied softwares based on MapGIS include the national territory management information system, communication network system, water supply pipeline net system, gas pipe net information system, synthesis pipe net system, electric power network system, city planning information system, environmental protection GIS, GPS navigation and scout system, motion GPS navigation system and 3D digital landscape system.

SuperMap (Super Map GIS Technologies, Inc.) passed the testing organized by the Chinese software testing center in the year of 2000. It is a kind of absolute COMGIS foundation software and is made up of core, cartography, topology, three-dimension, and so on. Users can use it conveniently to create and develop GIS system. It can also be integrated with other information systems, or embeded into other information systems. Now, there are many platform softwares, such as SuperMap Deskpro, SuperMIS, SuperMap Survey, Super Form, Super MapGIS and Super Workflow.

## 3.2 Research of GIS data model and data structure

Data model and data structure are the most basic problems of GIS. In recent years, researchers have done a lot of researches. Wang Qingshan (2000) brought forward an object-oriented geographic data model (OOGDM) based on the analysis of geographic spatial cognitive model and geographic data model. He has also given out some examples. Xu Yuntao et al. (1999) took advantage of object-oriented technology to integrate multi-media data and spatial data, and gave out a multi-media spatial data model and the realization process of system based on this model. Zhang Mian (1999), Yuan Xiangru (2000) et al., researched the characters and related theories of hypergraph spatial data model, and integrated the hypergraph model and the object-oriented model with the object oriented technology, and gave out an application example based on hypergraph model, and brought up a distributed hypergraph model for internet GIS. Wang Lei et al. (2002) put forward a kind of object-oriented data model of 3D GIS in order to solve key problems like spatial irregular entities and the description and organization of their relations. Yang Bisheng et al. (2000) put great emphasis on the approach of constructing building's model, and brought up a kind of layered and combined model and some functions like dynamic display, spatial analysis, interactive operator based on this model. Sun Min et al. (2002) brought forward a method to reconstruct all kinds of complex geological objects by simplifying constraints and an approach of expressing geological objects with gradual-change attribute and break-change attribute. Gong Jianya(1999) researched the object-oriented spatio-temporal data model and set

forward the direct supporting object nesting and variable length records. He made the temporal information mark on the idiographic attribute fields and used the object oriented data model to express and process. Gong Jianya(1999) also researched the four-dimension spatio-temporal data model based on object-oriented and hypergraph-map theory. He expanded the concept of hypergraph-map, namely he used hyperchain to link the dynamic changing information of three-dimension objects, and combined all kinds of spatio-temporal relation information. He used the spatial data models of muti-layers buildings, digging mine tunnels and environment to research four-dimension spatial data model and its realizing methods. Lu Feng et al. (2000) sublimated the pattern of traditional transportation network layout to the pattern of non-flat surface. He designed the concept modeling and logical modeling methods based on transportation network non-flat surface data model, which could make up the shortage of traditional arc—node GIS data model in the city transportation network modeling.

### 3.3 Research on the uncertainty of spatial data in GIS

Along with the development and widely application of GIS, the uncertainty problem becomes a remarkable problem to people. Zhang Jingxiong et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 1999 Vol.28 No3) described and analyzed the uncertainty of position and the uncertainty of attribute by using field mode. Dai Honglei et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 1999 Vol.28 No2) researched the position error propagation laws of polygon overlay in vector GIS. Shi Wenzhong (ACTA GEODAETICA et CARTOGRAPHICA SINICA，2000 Vol.29 No.1) researched the uncertainty model of general curve in GIS. He gave out a calculation model of vertical direction errors ($\varepsilon_\delta$) and a calculation model of maximum direction errors ($\varepsilon_m$). He also gave out the results of modeling and visualization and compared the results with the cases of straight line and circular curve. Dai Honglei et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA，1999 Vol.28 No.3) and Tong Xiaohua et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 1999 Vol.28 No.1) researched respectively the uncertainty visualization model of the random straight line location and the uncertainty model of circular curve in vector GIS. Tang Guoan (ACTA GEODAETICA et CARTOGRAPHICA SINICA，2001 Vol.30 No.4) took five Chinese regions of different relief types as experiment area and used the comparative analysis method to research the map DEM terrain description errors, influence factors, measurement method and the mathematics simulation way of errors. In addition, Liu Wenbao et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA，2000 Vol.29 No.1) researched the uncertainty attribute data in vector GIS. He researched the uncertainty attribute region types, errors of boundary location and sampling errors of region quantitative attribute data in interior region, and synthetically analyzed the measurement and propagation of the uncertainty attribute data.

### 3.4 Research on spatial information visualization and virtual reality technology

Spatial information visualization and virtual reality are always concerned by Chinese map

scientists. Sun Hongjun et al. (2000) researched and realized the global data organization, data exchange, three-dimension modeling of digital earth and the rapid transformation of rectangle grid data to triangle network data. They realized the three-dimension dynamic expression of earth shape with the three-dimension visualization theory and the OpenGL technology. Lin Hui et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 2002 Vol.31 No.1)studied the concept, character and basic framework of virtual geographic environment by the numbers. They set up the framework of distributed geography environment and had experimentations. They also analyzed the relations between virtual geographic environment and human sustainable development. You Xiong (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 2002 Vol.31 No.1) researched and realized a battlefield environment simulation system with virtual reality technology. Wu Lixin et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 2002 Vol.31 No.1) researched the theory of three-dimension geographic simulation and developed a virtual mine system. Ma Jinsong et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 2002 Vol.31 No.1) researched the visualization and virtual reality modeling of coast oceanic tide simulation. Wan Gang et al. (ACTA GEODAETICA et CARTOGRAPHICA SINICA, 2002 Vol.31 No.1) studied the ground feature geometric modeling technology of virtual city.

### 3.5 Research on spatial data warehouse and data mining

The researches on spatial data warehouse mostly focus on the frame structure and data organization. The research of spatial data cube is magnetic among them. Zou Yijiang (a research on spatial data cube, Ph.D. degree thesis, 2002) believed that spatial data cube was one data cube that could be constituted by non-space dimension, space dimension, figure measurement, space measurement, and put forward the spatial data cube's expression form and multidimensional data organizing and storage method of spatial data cube. He also discussed analysis operation principle of the data cube, developed an experiment system——space data cube system, and gave out some examples of spatial data cube analysis.

More and more Chinese scholars attach importance to the research on spatial data mining and knowledge discovery. Di Kaichang (spatial data mining and knowledge discovery, Ph.D. degree thesis, 1999) composed the first Ph.D. degree dissertation in that realm in China. In this thesis, he brought forward the technique and theoretical frame of spatial data mining and knowledge discovery (SDMKD), and researched and expanded basic theories, and discussed inductive study and its applications in spatial data mining, and set up a spatial data clustering algorithm named MMC based on mathematics morphology. Zhou Haiyan (a research on spatial data mining, Ph.D. degree thesis, 2003) researched a progressive refinement approach to spatial association rule mining in detail, and brought forward a new idea of mining spatial association rule based on spatial data cube. She also made use of the spatial statistic analysis to discover spatial relation and spatial association rule, set up a new spatial clustering algorithm based on Genetic Algorithms, exploited the Voronoi diagram’s applications in spatial data mining, and gave out a series of applications.

## 3.6 The progress of digital earth construction in China

In November, 1999, the first “International Digital Earth Conference” was held in Beijing China. The Chinese government advanced the strategy mission to construct Chinese digital earth.

The Chinese digital earth constructions are mostly “the digital river” and “the digital city”.

With respect to “the digital river”, “the digital Yellow River” engineering is the most representative. On July 25, 2001, The Yellow River Water Conservancy Committee under Chinese Water Conservancy Ministry declared to start the “the digital Yellow River” engineering. From October 18th to 20th at the same year, the proseminar of “digital Yellow River” engineering was convoked. Many specialists got together to discuss the frame, the structure, the function, the programming, and the key technology, mechanism, relevant policy of “digital Yellow River”engineering (Construction Digital Yellow River Engineering, 2002). In January, 2002, there were twenty well-known colleges, scientific research units and companies domestic and overseas handed over their engineering programming frames of “the digital Yellow River”. All these programming frames were commented by experts. Finally five cooperation units were selected. From September 6th to 8th at the same year, Yellow River Water Conservancy Committee organized experts to check and accept the layouts handed over by the five units. The report of “digital Yellow River” engineering programme is completed in December, 2002. The programme layouts consists of 11 special sub-reports, including the “digital Yellow River” engineering programme, digital flood prevention, digital water resources management and attemperment, digital water resources protection, digital water and soil conservation, digital engineering construction and management, electronics governmental affairs, public foundation information collection, correspondence, computer network, data and the information resources investigation and integration etc. Now, many items of “digital Yellow River” engineering have already been started.

Chinese “digital city” constructions are in the rise. In September, 2001, an international workshop on “digital city” was held in Guangzhou and collection of articles of digital city theory and practice was published (edited by Laiming et al., 2001). After that Beijing put forward to construct “digital Beijing”, nearly a hundred cities, such as Shanghai, Guangzhou, Shenzhen, Xiamen, Suzhou, etc., bring “digital city” construction into their “The Tenth Five Year Project Program” in succession. According to the trend and characteristics of world informationalization development, Suzhou formally issued The Tenth Five Year Project on the National Economy and Social Informationalization of Suzhou city using advanced experience of “digital city” construction for reference from domestic and overseas cities, combining the actuality and demand of Suzhou’s information industry and city information construction. It definitely put forward the strategical goal —— to establish the digital city whose holistic level is advanced in China until 2005. The conference of Suzhou informationalization committee of experts was convened in October, 2002. By investigating consumer’s demands time after time, the task of researching and compiling the collectivity construction scheme of “digital Suzhou” was completed in May, 2002. Its main achievements consist of the total report on “digital Suzhou” development and construction, the report on collectivity construction scheme of “digital Suzhou”, the report on special construction scheme of “digital Suzhou”. Now, they have already started the correspondence and network, space data infrastructure, electronics governmental affairs, electronic commerce engineering in “digital Suzhou” engineering.

### 3.7 The increasingly wide applications of GIS

The applications of GIS get widespread concern and receive good results.

With respect to city programming and management, many cities have established new-style and practical city programming and management information system (Yan Ronghua, et al., 2001, Pei Yabo et al., 2001) and the city programming and management information system based on intranet (Xie Shijie, 2000), the distributed city programming and management information system of Pudong in Shanghai city (Wu Sheng, 2002). GIS is an effective tool for environment protection. There are 2222 monitor stations in Chinese environment protection system now. The ground monitor network system of environment comes into being, which monitors water environment, atmosphere environment and ecosystem environment in all round. An information network system is established, which analyzes, forecasts and processes environment information. The system includes the national environment information center, 27 province class and 37 city class environment information center.（Wei Qiao，1999; Li Yongzhi et al., 2002; Chen Yunhao et al., 2002）. Along with the citilization in China being quickened, the transportation management becomes an urgent problem that needs to be resolved. The kernel problem to establish the city transportation management information system is to set up the universal network stream's mathematics models that consists of city transportation net topologic structure and network stream models. The representative system is the city transportation geographic information system of Wuhan (Xu Kai, et al., 2002). As an important part of Intelligent Transportation System (ITS), vehicle navigation becomes the hot problem to be researched. It adopts many technologies including GPS signals and GIS roads net data matching technology, fast post road choice technology, best path choice technology, maps rotating quickly and in real time with the vehicle direction technology of language suggestion and language identification. By the way, it is very important to produce electronic map suited to the vehicle navigation system (Xu Gusheng et al, 1999). As an important part of the synthesized transportation network, inland river shipping has been attached importance to by operation department. It adopts the Client/Sever structure to establish the shipping channel management information system to implement the automation management of the channel resources and conveyance business (Shao Lixia etc., 1999). Because the city underground pipes and lines are various and their distributing geographic environments are complicated, it is very difficult for the management and maintenance of them. Many cities establish city synthesized underground pipes and lines geographic information systems to realize scientific and modern management of city underground pipes and lines information resources (Hao Jianzhong et al., 2002; Xie Rong, 2000; Wang Shengcai, 2001; Wang Zhihong et al., 2002）. Maritime boundary delimitation is an urgent mission for many countries. Peng Rencan(2003) analyzed the characteristics and trends of maritime boundary delimitation technology, and researched the key techniques of maritime boundary delimitation. He also put forward the theory and method of ellipsoid-based buffering, and brought forward a new approach based on convex hull of the polygon creating techniques to select baseline point of the territorial sea, and introduced the maritime boundary automatic creating techniques, and developed a maritime boundary delimitation GIS.

## 4. Education and school subject construction

The development of education of cartography and geography information engineering

technology in China is on speaking terms with the need of the national economy and social informationalization construction. Now, an integrated education system is already set up including the technical school student, the undergraduates, the masters , and the doctors.

## 4.1 Technical school education

The technical schools including Zhengzhou Surveying and Mapping School, Nanjing School etc., undertake the task to primarily train the technical professional engaged in the digital map production. They can bring about 500 students graduated from school every year.

## 4.2 Undergraduate education

The universities including Wuhan University, Zhengzhou Information Engineering University undertake the task to train the technical professionals engaged in the production of map and the geographical information system, scientific research and teaching. In addition, there are about 100 universities, such as Nanjing University, Tongji University, the Mining University of china, which recruit and educate the undergraduate students major in the profession of the geography information system. There are thousands of students graduated every year.

## 4.3 Graduate student education

Now, the graduate student educations of that domain are divided into the engineering course and the science. Its secondary subject “the cartography and geography information engineering” is engineering which belongs to the major subject “the science and technology of surveying and maping”. Its secondary subject “the cartography and geography information system” is science which belongs to the major subject “geography”. The number of master annually recruited and educated amount to above one thousand, the number of doctors amount to 200. It has cultivated large quantity of higher level technical professionals for the country economy modernization construction and the national defence modernization construction.

## 4.4 Postdoctoral flowing station and postdoctoral scientific research workstation

Nowadays, there are 10 postdoctoral flowing stations and postdoctoral scientific research workstations of “the cartography and geography information engineering (engineering course) ”and “the cartography and geography information system (science) ” in China. Annually, there are scores of graduated doctors engaged in the research in the postdoctoral scientific flowing stations and acquired lots of excellent academic and technique achievements.

## 4.5 Continued education

Much attention has been paid to continued education in China. It mainly undertakes the high

and new technical training task of the technical professional incumbency and production management personal. There are hundreds of people accepting technique training annually. And It is very important to improve the level of the technical professional incumbency and production management personal.

### 4.6 School subject construction

Nowadays, the speciality of Cartography and Geography Information System of Wuhan University and the speciality of Cartography and Geography Information Engineering of Zhengzhou Information Engineering University have already been ranked as the national emphasis subjects in China.

## 5. Academic works

### 5.1 Publications

The main academic works are as follows:( according to the publishing time)

——Citilization and Urban Geography Information System, Edited by Chen Shupeng, Science Press, 1999

——Introduction of Geography Information System, by Chen Shupeng, Science Press, 1999

——the Applications of Virtual Reality Technique in Terrain Simulation, by Gaojun et al., People's Liberation Arm Press, 1999

——Automatic Machine Research of Geography, by Zhou Chenghu et al., Science Press, 1999

——Cartographic Generalization of Sea Map, by Wang Houqiang et al., Surveying and Mapping Press, 1999

——Cartography Theories, by Wang Jiayao et al., the People's Liberation Arm Press, 2000

——Research on Geo-information Graphic, Edited by Chen Shupeng, Commerce Press,2001

——the Principles of Spatial Information System, by Wang Jiayao, Science Press, 2001

——Geography Information System and its Applications in City Planning and Management, by Song Xiaodong et al., Science Press, 2001

——Urban Geography Information System, by Zhang Xinchang et al., Science Press, 2001

——Virtual Reality System, by Zhang Maojun, Science Press, 2001

——Virtual Geography Environment, by Gong Jianhua et al., Higher Education Press, 2001

——Integration and Realization of Spatial Information System, by Li Deren et al., Wuhan University Press, 2002

——Map Algebra, by Hupeng et al., Wuhan University Press, 2002

——Spatial Analysis and Geographic Visualization in GIS Environment, by Jiangbin et al., Higher Education Press, 2002

——Map Projection Pronsformation Principles and Application, by Yang Qihe, Taylor& Francis, 2000

——Categozical Database Generalization in GIS, by Liu Yaolin, ITC, Disseratation number88,2002)

——Spatial Data Multi-scale Expression and Automatic Generalization, by Wufang, People's Liberation Arm Press, 2003

### 5.2 Maps and atlases

The main maps and atlases have been published are as follows (according to the publishing time):

——National Nature Atlas of the People's Republic of China, China Cartographic Publishing House,1999

——Resource Atlas of Shaanxi Province, Xi'an Cartographic Publishing House,1999

——Administrative Region Standard Toponym Atlas of the People's Republic of China, Star Cartography Press,1999

——Remote Sensing Investigate Atlas of t the Actual Environment Conditions of the Western Region of China, Science Press , 2002

——Atlas of the People Republic of China, Star Cartography Press,2000

——Atlas of the World , Star Cartography Press,2000

——1:30000000 Map of the People Republic of China, Star Cartography Press, 2001

——Atlas of the World Subarea, China Cartographic Publishing House, 2002

——Atlas of the Yangtze River, China Cartographic Publishing House,2002

## 6. Contribution to the International Cartographic Association (ICA)

The 20th International Cartographic Conference – ICC 2001 Beijing was held in Beijing during August 6-10, 2001. The conference was organized by the State Bureau of Surveying and Mapping of China and the Chinese Society of Geodesy, Photogrammetry and Cartography locally. 1157 persons from 57 countries and 4 international organizations attended the conference. There were 7 pre-conference workshops with 250 participants, 4 plenary sessions, 65 oral sessions with 260 papers, 4 poster sessions with 80 papers and 20 commission meetings. The International Map Exhibition with 1200 exhibits from 30 countries, the Chinese Historical Map Exhibition with 140 exhibits, the Barbara Petchenikn Children's World Map Competition with 159 entries from 25 countries, and the IHO Exhibition with 104 exhibits took place during the conference. A Technical Exhibition displayed the latest technologies and products from 43 companies. Around 40,000 visitors came to the exhibitions. It is proved the conference was very successful. It provided a good opportunity for participants to make international exchanges in cartography and GIS and understand Chinese culture and enjoy interesting tourist places. The conference also made ICA well-known across China and let ICA's influence reach more Chinese professionals in cartography and GIS.