Spatial Data Infrastructure (SDI) in China

*Some potentials and shortcomings*

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Abstract

A Spatial Data Infrastructure (SDI) is required to make the spatial data be fully used and well shared by the society. In China, SDI’s has also been established progressively. A thorough understanding of the potentials and shortcomings about SDI in China has a positive significance to clearly identify the future direction and actions.

In order to find out the potentials and shortcomings of SDI in China, the current situation of SDI and SDI in China have been assessed through literature review and interview. Then a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis has been developed. Based on the current experiences of SDI development in China, the thesis concludes that China have a good potential to develop its SDI function. It also points out that there still are some weaknesses needed to be surmounted, such as: lacking advanced technology, data duplication, and lack of skilled workforce. There is a big room and capability to improve the development of Chinese SDI well in the future.

Keywords: SDI, GIS, Spatial Data, China
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Abbreviations

AGI ................................................................. Association of Geographic Information
APSDI ............................................................... Asia Pacific Spatial Data Infrastructure
ChinaNet ........................................................... Chinese Public Computer Net
ChinaPAC .......................................................... Chinese Public Packet-switching Data Network
ChinaPDN .......................................................... Chinese Public Digital Network
CMONOC ......................................................... Crustal Movement Observation Network of China
CNKI ................................................................. Chinese National Knowledge Infrastructure
CSDI ................................................................. Chinese Spatial Data Infrastructure
DEM ................................................................. Digital Elevation Model
FGDC .............................................................. Federal Geographic Data Committee
GIS ................................................................. Geographical Information Systems
GML ................................................................. Geography Markup Language
GSDI ................................................................. Global Spatial Data Infrastructure Association
INSPIRE ............................................................ Infrastructure for Spatial Information in Europe
NGDF ............................................................... National Geospatial Data Framework
NIMSA .............................................................. National Interest Mapping Service Agreement
NSDI ................................................................. National Spatial Data Infrastructure
OGC ................................................................. Open Geospatial Consortium
PCGIAP ............................................................ Permanent Committee on GIS Infrastructure for Asia Pacific
SDI ................................................................. Spatial Data Infrastructure
SEPA ............................................................... State Environmental Protection Administration
SWOT Analysis .................................................... Strengths, Weaknesses, Opportunities and Threats Analysis
WTO ................................................................. World Trade Organization
1. Introduction

For human beings, activities such as: mining, farming, forestry, transport, tourism, coastal zone management and community services are directly operating on the Earth’s surface. According to the statistics analysis in the research of Li (2005), about 75% to 80% of the information is geospatial related. Furthermore, the economic and environmental development of the world is based on the use of land, water and other natural resources. Therefore, the researches on spatial information become an important aspect in the information studies about the human society. And setting up the Spatial Data Infrastructure (SDI) has become an important stage which must be taken care of.

The Spatial Data Infrastructure (SDI) has been defined by the Global Spatial Data Infrastructure Association (GSDI) as the techniques, policies, and standards which have the relationship with collection, disposal, storage, and sharing of the spatial data. It aims to provide a reliable, feasible and convenient supporting environment for people to acquire the spatial data (Nebert, 2004). The goal of this infrastructure is to reduce duplication of effort among agencies, improve quality and reduce costs related geographic information, to make geographic data more accessible within the society, to increase the benefits of using available data, and to establish key partnership with states, counties, cities, tribal nations, academia and private sector to increase data availability (Nebert, 2004).

1.1 Reasons of the Research

Developing National Spatial Data Infrastructure (NSDI) in China is a very necessary and very urgently topic. There are five primary reasons, which also have been mentioned in the research by Li in his thesis paper (2005), namely:

Firstly, China is currently in a rapid development, both in economical and societal terms. For instance, the development of traditional industries, government administration, social public service, enterprise production operation, taxation and trade, e-business and on-line medical service are all based on the use of geospatial information.

Secondly, building a NSDI in China is demanded by the sustainable development and the implement of important strategies on the economic development. NSDI could play an important role in developing precision agriculture, agricultural industrialization and strengthening the protection and supervision of the land resources and water resources. In economic development, the spatial distribution of labor, capital, production and market, the dynamic changes and global distribution has an important significance. Geospatial information is the basic information for such information management and decision-making.
Thirdly, building a Chinese Spatial Data Infrastructure (CSDI) is a premise condition of the participation in global competition. With the increasing trend of global integration, SDI could help people to master the physical geography and human economy within various countries, and posses the competitiveness in the global economic, trade and scientific competition.

Fourthly, SDI is the basic guarantee for the modern national defense constructions. Electronic warfare, information warfare and high-tech war might be a reality in the future, and all of these need the support from real-time geospatial data.

Fifthly, it is the requirement on the mapping agencies to adapt their operations to build a CSDI. At present, building a CSDI is a tremendous progress, but it is still have not fit the demands of national economic construction and social informatics.

Currently, China has developed different SDIs at different levels such as the digital city, the digital province and the digital China. It has already developed the technology of integrate spatial data for the database of business enterprises, and available to carry out various spatial search (Li and Wu, 2004). Despite the achievements, there are still many limitations and drawbacks needed to be improved in the future. They are mainly contained in the following aspects: 1) A uniform theoretical framework has not been set up. 2) Data is just directly related to one or a few data usages, not for multiple usages. Today, there are many scholars who have carried the researches on this aspect. But the researches have not taken the data production and updating into considerations. 3) Data updating is still inefficient. 4) In order to avoid misuse of the data and protect the copyright, the data producing department do not wish to provide the data unless it is charged with a very expensive price. For that reason, data users have to reproduce data. It results in a great waste of the earth. 5) Data standards, is the premise of data production and sharing. As different departments and different industries have different ways for storing data, it influences the data sharing between the different departments and industries (Li, 2005).

Based on the above information, it is obviously that setting SDI as a research topic is very necessary and meaningful.

1.2 Aims of the Research

In this thesis research, the following goals are aimed to be met:

(1) Describing the current situation of how the SDI developed in China.

(2) Analyzing the potentials and shortcomings of Chinese SDIs.
1.3 Structure of the Report

The study of this thesis is mainly constructed by eight sections. As shows in figure 1 the first section introduces the theories about SDI, and points out the research reason and aim. Second section introduces some background theories about GIS and Digital Earth, because SDI just come into being after the GIS developed, and the Digital Earth would be built with the development of SDI. Section three describes the methods of this thesis. The fourth section and the fifth section introduce SDI in the world and SDI in China based on the literature review. Section six shows the results of analysis. Then the principles and relationships among these findings are discussing in section seven. Finally, some conclusions are presented in section 8 based on the analysis and discussion.

![Figure 1: The Thesis Structure](image)

2. Background

2.1 Geospatial Data

According to Rystedt (2000) “Geospatial data or Geographic data include spatial data and descriptive data. Spatial data deal with location and shape (geometry) and relationships (topology) among geographical features. Descriptive data or attribute data deal with other characteristics of the features.” This definition could be expressed as figure 2.
In SDI, there are two types of spatial data: geometry and geography. The geospatial data is stored in different systems or models (SSQA.net, 2008). For example, Open Geospatial Consortium (OGC) developed Geography Markup Language (GML) to express the spatial data. Like the point could be described as:

\[
\begin{align*}
&\text{<gml:Point gml:id="p21" srsName="urn:ogc:def:crs:EPSG:6.6:4326">} \\
&\text{<gml:coordinates>45.67, 88.56</gml:coordinates> </gml:Point>}
\end{align*}
\]

2.2 GIS

At the end of the 20th century, the information technical innovation entered an era of high-speed information transmission and globalization (Li, 2005). Geospatial data and spatial analysis are not needed only in earth science, but also in urban planning, cadastral agencies, civil engineering and many other areas. A paper map has many disadvantages, such as limited area coverage, low accuracy and hard to be made and kept. Combined with the development of aerial photography, remote sensing and computer science, Geographical Information Systems (GIS) came into being as a new and useful spatial information handling and mapping tool (Burrough and McDonnell, 1998, p4-12). GIS has been defined by Burrough and McDonnell (1998, p.11), as “a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes.”

In China, although GIS technology started relatively late, it has been more and more used by government departments and large enterprises (Zhao, J. and Zhao, Y., 2000).

2.3 Digital Earth

In February 1993, a new concept which named “information highway” has been advanced by Bill Clinton, who is the former President of the United States of America. The concept of “information highway” is used to promote the development of the information society.
Meanwhile, for the purpose of correctly expressing, describing and searching the spatial information data, Clinton signed the Executive Order 12906 to build the “National Spatial Data Infrastructure (NSDI)” in April (Federal Register ed., 1994)

In January 1998, the former US Vice President Al Gore advanced the idea of “digital earth” in the report which named “The Digital Earth: Understanding our planet in the 21st Century.” Al Gore described the Digital Earth as a virtual representation of our planet that enables a person to explore and interact with the vast amounts of natural and cultural information gathered about the earth. It means that the information technology has come into the daily working, life and entertainment. Digital Earth is not an isolated science item or technique target, but a target for promoting the economic development, increasing employment opportunities and satisfying the demand of development of creation of new techniques (Gore, 1998).

The development described above, clearly indicate that the advancing of SDI is very necessary for the development of our societies, but that it is including significant problems which also should be our focus.

3. Method

For this thesis, the primary purpose is to introduce and describe the current situation of SDI in China and find out the potentials and shortcomings. Since there is a large quantity of situational factors, there is a use to reduce them into a more manageable profile. For this reason the SWOT method was used. “SWOT analysis is an important support tool for decision-making, and is commonly used as a means to systematically analyze the internal and external environments of an organization by identify the strengths, weaknesses, opportunities and threats” (NetMBA, 2007).

In order to do this systematic analysis, the backgrounds and situations of CSDI should be familiar with, at first. And this investigation was based on a literature review. The literatures which relevant with the Chinese SDI has been searched from the Chinese National Knowledge Infrastructure (CNKI) and some other bibliographic databases by several key words, such as: SDI and Digital Earth. Then the articles or academic papers which described the SDI or SDI in China comprehensively would be selected. Additional information was obtained through interview with a Chinese expert. After gaining a thorough grasp of SDI in China, these situational factors are classified as strengths, weaknesses, opportunities and threats. From the classification the potentials and shortcomings may be identified.

4. SDI in the World

SDI is gaining recognition and being recognized as an important research area by most countries in the world. Because it could help human beings make full use of the information
mediums, and improve the national competitive position in the world. Different countries have used different methods to deal with SDI for their own demands. There are some examples to show how the SDI is developing in different countries or areas, are now presented.

4.1 National Spatial Data Infrastructure (NSDI) in USA

In order to promote the development and sharing of geospatial data among federal, tribal, cities, local governments, academia and the private sectors, in the United States, a NSDI has been built under the calls of Executive Order 12906 by Federal Geographic Data Committee (FGDC). This NSDI provides the metadata, framework data, standards, services and partnerships fundamental (FGDC, 2005). The U.S. federal government is responsible for providing the funds for the NSDI building, meanwhile the private investment is promoted through the tax and legal policies (Federal Register ed., 1994). Learning from the training program of NSDI (2007), the core of NSDI which named National Geospatial Data Exchange Center (National Geospatial Data Clearinghouse) has been established by the FGDC and the governments of relevant states. Through the Clearinghouse, the geospatial data producers, managers and users have been connected as a network.

The tasks and plans of NSDI are (FGDC, 2004):

1) Enhance the understanding and comprehension of the ideas, prospect and benefit of NSDI through technology extension and comprehension. FGDC has provided a series training program which related to the NSDI through the internet.

2) Find out the unified solution for the geospatial data generation, acquisition and application to satisfy the demands of different users.

3) Encourage all stakeholders to provide the geospatial data. FGDC states that everyone is the stakeholder in building the NSDI. The NSDI framework data themes include: transportation, hydrographic data, elevation, orthoimagery, cadastral, geodetic control and governmental units boundaries. All the organizations and people could search these domestic geospatial metadata through a single user interface, and free advertising and providing their spatial data under the principle of “truth-in-labeling”.

4) Setting up good collaborative relationships among different organizations to support the development of NSDI. In the USA, FGDC, Geospatial One-Stop (GOS) and the National Map are three national geospatial initiatives. For the purpose to avoid the duplication, they hold summit regularly, to discuss their responsibility and promote their corporation.
4.2 National Geospatial Data Framework (NGDF) in UK

In the UK, there are more than 40 government departments and other organizations producing spatial data on their own demands. Thus, a problem of duplication on spatial data is unavoidable. The driving factor of the development of NGDF is that the government, enterprises and individuals have some strong requirements. For instance, to improve the efficiency and effectiveness of the government, provide new employment opportunities by promoting the application of geographical information, to develop new markets, and forecast the future demand of geographic information. Facing these factors, in 1995 at the Association of Geographic Information (AGI) conference, the idea of NGDF was carried out due to the requirements from government, legal and business environment (Nansen, Smith and Davey, 1995). The emphasis of the development on NGDF lays on the practical projects and data providing services. The data query and data integration could be realized through the mechanism which named “askGiraffe”. It is available on www.gigateway.org.uk (Hadley and Elliott, 2008).

NGDF is an unofficial organization which made up of relative government and commercial sectors. The funds come from National Interest Mapping Service Agreement (NIMSA) activities, project investments and the members of it (NGDF, 1998).

The strategic targets are (Hadley and Elliott, 2008):

1) Promote the understanding of geospatial data, and make it to be easier accessed by users.

2) Using standards and guideline to make the spatial data could be better integrated.

3) Encourage the wide implementation of geospatial data.

4) Provide the assurance for data consistent and specify the quality of data.

5) Provide the suggestions and inquiries about how to manage the geospatial information data for government.

Different from other SDIs, NGDF provides a set of basic data rather than a data base, and it attended to create an information environment rather than a framework (Hadley and Elliott, 2008).

4.3 Asia Pacific Spatial Data Infrastructure (APSDI)

APSDI has been designed as a database network by the Permanent Committee on GIS Infrastructure for Asia Pacific (PCGIAP). There are four parts: framework, technical
standards, basic data and network interface that compose the whole APSDI. The infrastructure covers the whole region, and provides the basic spatial data for the exploiters of the economic and environment within this region (Holland, 2000).

The aim and plan of APSDI have been introduced in the paper of Parker (2000) as:

1) Identify the data quality to satisfy the regional and global mapping and GIS requirements.

2) Establish appropriate legal procedure and rule of management for data query and sharing.

3) Document for the members’ key geo-data bases and agencies.

4) Support each member to implement the cadastral development.

5) Attract funds to support the development of SDI for its members.

4.4 Infrastructure for Spatial Information in Europe (INSPIRE)

Relation to satisfy the demands of human activities and the promotion of environmental development in Europe, Directorate-General (DG) Environment initiated the idea of INSPIRE in 2001. Until 14th March, 2007, the directive of INSPIRE has been finally passed by the European Parliament and the Council of the European Union. The establishment of INSPIRE is based on the community level SDIs (INSPIRE Geoportal, no date).

The directives of INSPIRE (2007) shows that the key goals and tenets are:

1) Timely and effectively collect the geospatial data.

2) Seamlessly combine the spatial data among the members of the European Union (EU).

3) Regular the data level, make the data could be share among different level governments.

4) Specify the data quality and scope of application.

Furthermore, besides the researches on the technology aspect, facing the impact from Socio-Economic impact, people started to pay more and more attention to the benefit and cost aspect on SDI (Craglia, 2006).
4.5 Global Spatial Data Infrastructure (GSDI)

From the United Nations Conference 1992 on Environment and Development in Rio de Janeiro, more and more countries have realized that the environment problems, such as: pollution, fish stock and toxic wastes, became global problems and limitless by the national boundaries. They found that sharing geospatial information data and the experiences on building SDI could reduce the cost and duplication of effort in collecting (Nebert ed., 2004). In 1996, the individuals who interested in this subject concentrated together and organized the non-profit organization, GSDI association. Until now, there are more than 50 members in this organization (GSDI, no date).

One of its main tasks of GSDI is to implement the global mapping projects which focus on developing the spatial data products in the scale of 1:1,000,000 and smaller. It provides a tool to help the policy-makers illuminate the global environment affairs of the human society (GSDI, no date). Since 1996, GSDI meeting has been held regularly, China participates in its activities as the members in A level. (Li, 2005)

Based on the development of SDI in the world, the trends of it have been summarized by Rajabifard, Feeney and Williamson (2002) as:

(1) As the processes of economic globalization and informatics continuous, SDI has been more and more recognized by countries and regions. Building a GSDI has become an international activity, although different countries or regions have their own national goals and strategies.

(2) The technique of spatial data acquisition and processing has been developed rapidly. It is requirement for the spatial data community to cope with the challenges which appears in the modern information society.

(3) Web GIS has become a main trend of the development of SDI, building database, data transmission and application services are all implemented online. It makes the application of spatial data could go deep into different aspects of life, family and the whole society.

(4) The development of Global Positioning System (GPS) technique has matured In the United States, Russia and Europe, the satellite positioning systems has been continuously strengthened, not only for the military purposes, but also for transportation and other purposes like the monitoring the crustal movement for predicting earthquakes.
5 SDI in China

After the concept of Digital Earth was announced, developing a SDI in China was paid high attention by Chinese government and researchers. The State Planning Commission drafted “The suggestions on promoting the development and application for SDI in China” which transmitted by the General Office of the State Council in July 2001. Driven by the demands from implementing the policies of Reform and Opening, developing social-economic and accessing spatial data, China has developed its own SDIs at different levels such as the digital city, the digital province and the digital China. It has already obtained some achievements such as developing the technology of integrating spatial data for the databases of business enterprises, and available to carry out various geospatial search (Li and Wu, 2004). In order to understand the detail situation of how SDI is developed in China, an interview (Appendix I) was carried out with Zhigang Hong who is the director of key laboratory of Chinese academy of surveying and mapping, and introduced in the following parts:

5.1 Data Themes

China is rich in the environmental data resources and basic geospatial data resources. The data themes include: Mineral Resources, Oceans, Hydrology, Ecological Environment, Natural Disasters, Traffic, Forestry and Natural resources. Since 1949, Chinese governments have invested a huge amount of money for the land survey, and a large number of geospatial information of high quality in specialization, systematization and standardization has been collected. According to statistics, since 1950s, China has already collected about 5 million aerial photos. But these photos were not completely digitalized. From the end of 1970s China has began to introduce the foreign satellite remote sensing data and ground reception facilities to provide the satellite remote sensing data for various fields. Currently, China could receive and process remote-sensing data which comes from 11 different domestic and exotic satellites.

At present, China has formed a certain scale of the land resources database and has the capability of continuing accessing and uploading the spatial data. Meanwhile, they also completed the nationwide scope geospatial databases with the scale of 1:4,000,000, 1:1,000,000 and 1:250,000, the 1:10,000 Digital Elevation Model (DEM) databases for the seven major rivers, and the satellite images database with the resolution of 30-meters. 25 GPS tracking stations have been established to provide the service of spatial data reference. Furthermore the 1:50000 SDI project has been started.

In addition, China has built spatial databases and monitoring stations for different industrial sectors, such as mining, water conservation, and ecological protection. Some spatial databases have also built for transport, forestry, and other resources by the corresponding departments and units to enhance the ability to obtain information continuously.
5.2 Technologies and Networks

In recent years, with the advancement of Chinese public communication network, a series of breakthroughs have been made in the data sharing technology. Since the ninth five year plan, with the rapid progress of communication network technology, a foundation for the development of Chinese SDI has been laid. Currently, the Broad Band Network is widely covering in China. By the end of 2003, there were more than 80 million internet users in China.

At the same time, different professional departments have set up the network systems to communicate different business data by the demand of the development. State Environmental Protection Administration (SEPA) has established is special transmission network which covering 32 provincial capital cities and 110 other urban cities for the transmission of the environmental information satellites. International financial aid has supported most of the urban environment information networks that have been established.

For the earthquake monitoring, the Crustal Movement Observation Network of China (CMONOC) has been built by the ninth five year plan. At present, accurate and timely data transmission has been basically realized among the seismological stations which are covering national wide in China.

To accessing, processing and transmission the remote sensing images, at present, four state-level data receptions and service systems have been established in China: the meteorological satellite application system, the remote sensing satellite ground station, the application system for resource satellite and the application system for ocean satellite.

In order to promoting the application and sharing of the geospatial information, a website which named “China Spatial Information (CSI)” has been built. It has become an information center among related units for data reception, processing, production, distribution and sharing service.

To dealing with the information security problems, the relevant state departments are planning for the national space information security system. The information sharing network is a complex network. It is involved in different industries, different departments and different fields. So it meets more complex security problems. From the perspective of network management, information security could be divided into network security, system security, data security and information security. All the appropriate steps should be taken to keep the safety of the information transmission and use.
5.3 Standards and Policies

The standard system is a scientific and organic system composed of a certain kind of standards inherently. And repeating affairs and conceptions could be regulated in a unified way by standardization (Li, 2005). Spatial data standardization is an important part of developing SDI in China. A series of SDI standards and policies for preliminary framework has been formed, at present (See Appendix II).

These standards and policies focuses on information technical and spatial data. At present, most standards are related to the technical aspect, the standards of geospatial information would become the main target in the SDI research (Liu and Jiang, 2008)

5.4 Applications of SDI in China

Chinese NSDI has played an important role in the economic and social development, and it is used to provide spatial data for the disaster relief and ensure the safety of nation, life and property. These applications are not only reflecting the role of SDI, but also promoting the development of SDI.

The development and application of Chinese Geographic Information System (GIS) have reached a certain scale. Based on the application of spatial information base, the formation and development of GIS industry has been driven. Since the ninth five year plan, natural disaster monitoring, dynamic monitoring of resources and the environment, crop yield estimation, and a series of other applications have become the important support for the government management and decision-making. A number of GIS systems have been built and integrated into the ordinary work of the resources and environment investigation and the social economic management.

Since the 1990s, the departments have reinforce their ability to construct the data acquisition, processing, sharing and application and strengthen then cultivation of the GIS human resource, while making and implementing the standards, policies and regulations. In the late 90s, the technology of geospatial information application has evolved in various fields of the economic and social developments, and the geospatial information industry which taking remote sensing, GIS and GPS as main content is rapidly rising.

In order to guarantee and promote the development of SDI, China has built different organizations at national, provincial and departmental level. These organizations make the organizing and coordinating functions on overall planning, project implement, standardization and policy formulation, and efficiently promote the development of SDI.
The strategic goals on Chinese SDI are:

1) Support the development and industrialization on SDI

2) Make overall planning on spatial data integration and sharing to satisfy the demand from building E-government in China.

3) Further clarify the key problems on the developing trends and policies of provincial SDI. Lay a good foundation for building national SDI in China.

6. SWOT Analysis

Based on the primary information which was obtained from the personal interview and the information obtained from the literature review, the Strengths, Weaknesses, Opportunities and Threats on CSDI have been finally found out through the SWOT analysis work. The analysis findings are now presented:

6.1 Strengths

Currently, the development of CSDI has already contained some good foundations and certain advantages. These achievements were mostly manifested as below:

(1) For the data themes: Since 1949, China has invested more than 250 billion RMB Yuan on collecting, processing and distributing the geospatial information, and has already accumulated 5 million scenes of effective aerial images (Li and Wu, 2004). Learning from the personal interview China has gained the following achievements:

On the aspect of mining: A series of databases have been built for mineral resources reserves, mineral producing area and property right registration in mining.

On the aspect of marine information: The geospatial information system has been built in 1:1,000,000 and 1:500,000 scale.

On the aspect of hydrological information: China has built about 36,000 hydrological monitoring stations, 3,000 hydrological stations, 15,000 rainfall stations, 1,000 water level stations, 10,000 groundwater monitoring stations and 3,000 water quality stations. These stations construct a hydrological monitoring network and it is preliminarily equipped with the ability or satisfying the demands of the national economic construction and development.
On the aspect of ecological environment: Various databases have been built for environment monitoring, emission declaration, natural ecology, the quantitative examination guideline in city environment and environmental background data.

On the aspect of earthquake disaster alleviation: China has built 47 seismic stations and 136 earthquake precursor observation at national level.

Further more, a series databases have also been built for other aspects, such as: transportation and forest.

(2) For the technical: as the development of GPS, Remote Sensing (RS), GIS, the network technique and other modern techniques, it provides a reliable support for the setting up of the SDI. At present, GPS technique has already developed to a high accuracy level. The development of high-resolution Remote Sensing system could satisfy the data demand for several new applications. Meanwhile, the GIS technique in China has already developed from the 2D to multi-dimension, simulation and web-GIS. The government also plays a positive role in the setting up of SDI (Li, 2005).

(3) For the application aspect: in the recent years, China has succeed in building the spatial data frame of the Digital Earth and constructed geospatial databases with scale of 1:250000 for the whole country, 1:10000 DEM for the 7 important river of China. And has been taken use to promote the development of every undertaking of China (Ling, Chen and Huang, 2002).

(4) For the data sharing aspect: spatial information sharing environment and technical support capability has been significantly enhanced. At present, Chinese Public Computer Net (ChinaNet), Chinese Public Packet-switching Data Network (ChinaPAC) and Chinese Public Digital Network (ChinaPDN) have already covered the whole state. Further more, the spatial integration and network interconnection have simply implemented for 10 key environment and regional economic databases (Li, 2005).

6.2 Weaknesses

Although CSDI obtained substantial developments, it still contains many problems and could not completely satisfy the developments of social economic and may hinder the construction of SDI. Those problems include:

(1) The problems on data themes: Although China has a large volume of spatial data information but these resources can dispersed, not standardized and mainly analogue, this implies that the main problems of spatial data lies in inadequate integration of resources and inefficient management (Zhou, Wu and Zhang, 2001).
In China, the increase of spatial data mainly relates to port and highway investigations, but the investigations held once every five years. Low quality remote sensing information data, slow updating for the geospatial data and slow development of information service system limit the development of e-government and the development of geospatial information industry (National Geospatial Information Committee, 2004).

(2) The problems on GIS technique: Influenced by lack of new technique, shortage of integration methods for the spatial data, and slow updating speed. In order to build the national GIS system, a large amount of funds need to be invested to buy foreign software and techniques (Chen, 1999). The strengths are not widely used.

(3) The problems on data sharing: As what had already mentioned above, in order to avoid misuse of data and protect the copyright, the data producing department do not wish to provide the data or providing them by a very expensive price. For that reason, data users have to reproduce data. It results in a great waste (Li, 2005).

(4) The problems on spatial information standards and policies: At first, some important data standards, such as: spatial metadata standards, operation standard of spatial metadata system and spatial data sharing models, are still on the planning stage. Secondly, some policies, for instance: the pricing policy of data compensation, market competition policy, benefit drive policy, data classification policy, the policy for data public and security, the policy for copyright and policies for data qualities and standards, have not reach the requirement of application. Thirdly, in China, there are some undeveloped regions which lacking the technique and funds to popularize the use of standards (Chen, 1999).

(5) The problems on SDI application: currently, the geospatial information is just used in some few departments. Most of these departments have built management and application institutions. Some portion of these departments have a rather incomplete understanding of data sharing, they just deal with geospatial data in their own interests. For some departments, mass geospatial data piling up in databases with low utilization rate. However, for some other departments, spatial information is hard to be accessed (National Geospatial Information Committee, 2004).

(6) The problems on personnel quality: Lacking the professional talents who could work under the market rules. The geospatial information jobholders could not adapt the demands of market operation (Li, 2005).
6.3 Opportunities

Entering new century, the rapid development of the technology and the acceleration of economic globalization has provided a good external environment and some opportunities for the development of a CSDI.

(1) China has activity joined some international trade organizations, for instance: the World Trade Organization (WTO). Taking use of the preferential policies in the organizations, more and more foreign advanced techniques, equipments and systems which related to the construction of SDI could be introduced into China and with a lower cost (Li, 2005).

(2) The problems of population explosion, misuse of nature resources, environment pollution and natural disaster are promoting the national public financial system to support the development of an authority, reliable, feasible SDI to solve the more and more rigorous environment problems. People already realized this and much research and investments had been done (Zhou, Wu and Zhang, 2001).

(3) Improvement of spatial data operations. The service of spatial information has been pushed into the borderless and endless competition, and more employment opportunities have been provided. It impels the employers to improve their capabilities of data process and analysis (Li, et al. 2002).

6.4 Threats

There are some opportunities brought by the external environment, and it also brought some threats to the development of CSDI. These threats are concretely represented in the following aspects:

(1) The aspect of technique: Comparing with the developed countries, a big gap contains in the aspect of geospatial information technology. The strength of domestic enterprises is not enough to compete with foreign enterprises. Relying on these foreign technologies may cause the problem that losing both domestic and international market (Ling, Chen and Huang, 2002).

(2) The aspect of market system: Because the region of China is vast, at present, one of the biggest problems for data sharing is still lacking of the economic investment. And the funds are too hard to be arranged just by the market. Chinese public funding may not support the Digital Earth be implemented completely (Ling, Chen and Huang, 2002).

(3) The aspect of sharing data: in the new century, with the development of international communication, more and more foreign mechanisms are participating into the geospatial data
sharing. Some of the data relate to national security. How to ensure the security for the classified information is an important problem need to be timely solved (Li, 2005).

The results of the SWOT analysis could be summarized as table 1, the strengths, weaknesses, opportunities and threats were coexisted in the development of CSDI. It is meaningful to utilize the strength, remove the weakness and be prepared to manage the threats. The motivation can be expressed by the opportunities.

**Table 1 SWOT Matrix for SDI in China**

<table>
<thead>
<tr>
<th>Internal Factors</th>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data themes</td>
<td>· Already accumulated a lot of spatial data. · A series databases have been built in different category, for instance: mining, ocean, hydrology, ecological environment, disaster alleviation, transportation and forest.</td>
<td>· Data resources are dispersed. · Low degree of standardization. · Low digitized degree. · Low update speed. · Inadequate integration of resources and inefficient management.</td>
</tr>
<tr>
<td>Technology</td>
<td>· GPS developed to a continuously, fast level and with high accuracy. · High resolution RS. · GIS developed from 2D to multi-dimension, simulation and web-GIS.</td>
<td>· Lacking new technique. · The strengths are not widely used.</td>
</tr>
<tr>
<td>Application</td>
<td>· Constructed geospatial databases with scale of 1:250,000 in national level. · Built 1:10,000 DEM for 7 important rivers in China. · More smaller scale geo-database with national level is building in plan.</td>
<td>· Limited by popularization of technique and incomplete understanding of data sharing the geospatial data just used in some certain department.</td>
</tr>
<tr>
<td>Data sharing</td>
<td>· ChinaNet, ChinaPAC and ChinaPDN have already covered the whole state. It is providing a good network environment for data sharing. · Spatial data integration and network interconnection have simply implemented for 10 key environment and regional economic databases.</td>
<td>· Duplication of spatial data · Low integration level on spatial data.</td>
</tr>
</tbody>
</table>
### External Factors

<table>
<thead>
<tr>
<th>Standards and policies</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>· Spatial information standards are staying on the planning stage. · Pricing policies, market competition policies, the policies for copyright, data quality and standards have not reach the requirements of application. · Some undeveloped regions lacking the technique and funds to popularize the use of standards.</td>
<td></td>
</tr>
<tr>
<td>Human resource</td>
<td>Large mass of graduated students.</td>
<td>Jobholders lacking the professional talent to work under the market rules.</td>
</tr>
<tr>
<td></td>
<td><strong>Opportunities</strong></td>
<td><strong>Threats</strong></td>
</tr>
<tr>
<td>Technical aspect</td>
<td>· More advanced techniques, equipments and methods. · Foreign techniques, equipments and datasets could be accessed with a cheaper cost.</td>
<td>· Relying on the foreign technologies may cause the lost of the domestic and international spatial information market.</td>
</tr>
<tr>
<td>Financial aspect</td>
<td>· Higher need for investment. · More researches are held on promoting the development of CSDI.</td>
<td>· The demands will not be met. It may disturb the development of CSDI</td>
</tr>
<tr>
<td>Human resource</td>
<td>· More skilled workforce</td>
<td>-</td>
</tr>
<tr>
<td>Application</td>
<td>· Competition and cooperation that relate to information industry promote the improvement of spatial data operations.</td>
<td>· Security problems.</td>
</tr>
</tbody>
</table>

(* The table information is based on the interview and literature review.)

### 7. Discussions

In this section the reasons of the potentials and shortcomings in CSDI are presented. The relationships among strengths, weaknesses, opportunities and threats are also given in there after.

#### 7.1 Comparison

The international situation and domestic situation which CSDI faces both make an important sense on the development of it. Doing a comparison between the international situation and domestic situation could help us well specify the potentials and weaknesses which coexists in CSDI.
7.1.1 International situation

As mentioned in section 4, under the integration of global economic and the development of knowledge economy, building a SDI has become one of the new and hot research subjects in the world. Although different countries or regions have their different aims on building a SDI, but the common motivation is purposing to support the feasible accessing of spatial data, and enhance its reliability. In the information society, SDI plays a more and more important role in collecting, transmitting, sharing and using the spatial information data in various industries. Influenced by the distinction among the culture, the recognition, the policies and the economic development level of different countries or regions, the development level of SDI in the different countries or regions is very different. Learning from section 4, how the SDI developed in the developed countries or regions could be summarized as table 2.

<table>
<thead>
<tr>
<th>Country</th>
<th>Project</th>
<th>Organization or agency</th>
<th>Data themes</th>
<th>Policies or laws</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>INSPIRE</td>
<td>Related departments in European Union and its members</td>
<td>Climate data, natural resources data etc.</td>
<td>Directive of the European parliament and of the council</td>
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<td>USA</td>
<td>NSDI</td>
<td>Federal, tribal, cities, local governments, academia and the private sectors</td>
<td>DEM, remote sensing image, hydrology data, administrative boundaries, transport network data, cadastral data, geodetic data etc.</td>
<td>Executive Order 12906</td>
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<tr>
<td>UK</td>
<td>NGDF</td>
<td>Relative governments and commercial sectors</td>
<td>Nature resources data, environmental data and spatial datasets related to economic, social and culture.</td>
<td>NGDF in UK memo</td>
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<tr>
<td>China</td>
<td>CSDI</td>
<td>Relative government and sectors</td>
<td>Mineral Resources, Oceans, Hydrology, Ecological Environment, Natural Disasters, Traffic, Forestry and Natural resources.</td>
<td>Five Year-Plans</td>
</tr>
</tbody>
</table>

There is a challenge faced by China to catch up the development level on SDI with the developed countries. But it is also has opportunities to promote the development of CSDI by introducing the international advanced technologies and equipments.
7.1.2 Domestic situation

Facing the opportunities and challenges, Chinese governments have noticed that building a NSDI is not only profiting people to access the spatial data, but the development level of SDI is also directly reflecting the development level of the national comprehensive power. More attention has been paid in the built and development on CSDI. It is a good opportunity for SDI development in China, and many important achievements have been reached. As listed in section 6, not only the strengths but also the weaknesses are considered in the development of CSDI. There still are some gaps between China and other developed countries or regions, they are:

(1) The speed of data update is low, and the degree of data digitalization is low.

(2) Advanced technologies have not been popularized in whole country.

(3) Comparing the international standards and Chinese standards, the former one (see Appendix III the ISO standards as an example) plays a more effective role on data management.

(4) Data sharing is a common problem in the world. Due to the complex relationship among the Chinese departments and organizations, that related to SDI, the problem of data sharing is more severe.

In one word, the strengths and opportunities which contains in the CSDI could indicate that the certain potentials exist in the development of CSDI. The problem which is putting in front of us is that how to overcome the shortcomings and threats.

7.2 Opportunities and Threats

There are some relationships among the strengths, weaknesses, opportunities and threats. By utilizing the strengths, there are potentials to catch the opportunities and defeat the threats. The opposite holds for the weaknesses, where China may face the opportunities and lose the threats by those shortcomings. To clear the strengths and shortcomings, a discussion could be made based on the aspects of opportunities and threats.

(1) The introduction of foreign advanced technologies and equipments: As mentioned in last section, introducing foreign advanced technologies and equipments is helpful to improve the international communication and data exchange activities, but it also brought the trouble on national independence. By the strengths that China has already got in technical aspect, there is a potential that China could perform well in the international communication and data exchange activities. And the shortcoming is that the standards and policies have not joined
international track well. They may also be security problems in the international information exchanges.

(2) **The construction of national public finance system:** By the influence of economic globalization Chinese governments have changed their functions. More and more attentions and funds have been invested into the construction of SDI and the national public finance system has been built. The potential is that the development of CSDI could be promoted by it. But the problem is also resulted by the government intervention, whether it could fit the rules of market economy or not.

(3) **The quality of spatial information jobholders:** It is undoubtedly that human resource is the basic key for the development of SDI. The demand of talent is increasing, while the competition becoming more and more furious. As the labor force resource in China is abundant, the certain potential contains. But lacking the professional talents who could work under the market rules is one of the shortcomings.

7.3 Looking into the future work

It is hard to define the weights for the potentials and shortcomings of CSDI and to evaluate how it developed. But there is one thing could be clearly stated, that the **Strengths and Opportunities** which owned by CSDI show that: CSDI is able and possible to develop well in the future. Simultaneously, considering the weaknesses and threats CSDI should be developed under a firm model. I call this model “SDI Pyramid” (Figure 3):
As the figure 3 shows, policies, standards, technologies and human resources are four important factors of SDI. SDI is founded on the support of them. Meanwhile, a mutual influence contains among the policies, standards, technologies and human resources. According to the different service targets or areas, CSDI could be classified as: sectorial level, local level and national level. Specific spatial data objects service specific departments or organizations. For example: agricultural sectors pay more attention to the spatial data which relate to the condition of the cultivated areas, and the transportation departments more concern the spatial data with highway facilities. For this reason CSDI could be classified into different departmental SDI. China has many provinces, cities and countries. SDI has also been built in different areas by local governments. So in China, there is a national SDI and some other SDIs which could be classified as local level SDI. Different department level SDIs construct the local level SDIs, and different local level SDIs form the national level SDI. They assume a pyramid shape. In order to promote the development of CSDI, the most important thing is improving the development of policies, standards, technologies and human resources to create a favorable environment for it. Furthermore, the departmental level SDI and local level SDI should be established well to lay a solid foundation for CSDI.
Based on this finding the further research could be done in the following areas:

(1) How to strengthen the management of the classified data resources.

(2) How to support the researches about the key technique and industrialization for SDI.

(3) How to establish and complete the policies and standards for SDI.

Generally speaking, facing the opportunities and threats, there are both potentials and shortcomings on the development of CSDI. Based on the demands of enhancing the international competitive strength and protecting the national security, it is important to take use of the potentials and overcome the shortcomings to catch the opportunities and win the challenges, and to lay the foundation for the formation and development of SDI in China.

8. Conclusions

This thesis introduces the backgrounds of SDI. Along with continuous increase in the needs for geographic information, many countries in the world are making great efforts to develop National Spatial Data Infrastructures (NSDI), constructing regionally or globally multi-scale geospatial data framework to meet the needs of all sorts of application. And same in China, the thesis mainly describes the current situation of SDI in China from different impacts, such as data resources, technologies, networks, standards, policies and applications.

Based on the work on this thesis, the following conclusions can be made:

● The main weaknesses are:
  1) Lacking advanced technologies
  2) Data duplication
  3) Lack of skilled workforce

● Facing those weaknesses, the potentials on the development of CSDI should be related to reduce the effect of them:
  1) Information technique in general should be developed and industrialized to promote the development of CSDI. Further more, intellectual property protection should be strengthened to ensure a sound development of the geospatial information market.
  2) Transforming the function of the government to complete the establishment of SDI standards to stop the data duplication, and strengthen the spatial data sharing and classified management for information security.
  3) Train managerial and technical talents for SDI. Promoting the development of SDI in undeveloped regions and inferior trades to decrease digital gap and build the e-government in China.
Building SDI is a huge system engineering task. It needs both theory and technology supports. Although some potentials and shortcomings have been found in this paper, there are more features that could be researched in the future studies. And according to the potentials and shortcomings which have been found out, some further researches about how to utilize the potentials and overcome the shortcomings could be made.

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References


Appendixes

Appendix I

Q1. The situation of geospatial data related to SDI in China.

Q2. How does the technology and network on SDI develop in China until now?

Q3. Introduce the standards and policies of SDI in China.

Q4. How is SDI applied in China at presently?

Q5. Which achievements have been gained, while developing SDI in China?
## Appendix II

**Chinese spatial data standards** provided by Hong Z.G. translated by myself  
(interview, 2008)

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Appendix III


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