RESEARCH ON ESTABLISHING A MORE OPEN AND SYSTEMATIC NATIONAL GEO-INFORMATION STANDARD SYSTEM -- TAKING CHINA'S GEO-INFORMATION STANDARD SYSTEM AS AN EXAMPLE

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ABSTRACT:

Geo-information can be found, collected, released, shared, stored, combined and applied through geo-information standards. Building geo-information standard system is the basis for a country or organization to carry out the construction of geo-information standards. The excellent geo-information standard system can maximize the effectiveness of all geo-information standards in the system, so as to ensure that new geo-information sources and technical tools can be fully used. According to the analysis on the challenges of the construction of geo-information standards and standard systems in various countries by the author, most countries (including China) need to establish a more open and systematic national geo-information standard system and implement more flexible policies and measures for standards management. In this paper, the specific implementation measures proposed to improve China's geo-information standard system include 1) using policies to encourage the formulation, transformation and utilization of international standards 2) accelerating the top-level design of the construction of relevant information technology standard systems with geo-information as the core element, 3) filling the gap of standards construction by relevant group or enterprise according to the development requirements of geo-information industry, 4) evaluating and monitoring the important and concerned geo-information standards, etc. We think that the above measures will effectively improve overall openness and build better connection with the international standards, and ensure the scientific and forward-looking features during the construction and design of the standard system.

1. INTRODUCTION

Geo-information can be found, collected, released, shared, stored, combined and applied through geo-information standards. The adoption of advanced standardization theories, concepts and technologies can not only promote the management and sharing of geo-information collected by government department and the public, but also help the country to improve the legal and policy framework of geo-information management.

The construction of geo-information standard system is the basis for a country or organization to carry out the building of geo-information standards, which shall be open and systematic. Both of the development history of economic and science have proved that an overly closed environment will reduce the development efficiency and competitiveness, which reflects the importance of openness (Percivall, 2010). While the importance of systematicness is reflected in that the standards constituting the standard system are interrelated, interactive, constrained and complementary to each other, instead of independent elements. Therefore, building an open and systematic geo-information standard system will make all geo-information standards in the system maximizing their effectiveness, so as to ensure that new geo-information sources and new technical tools can be fully used.

This paper mainly analyses the construction status and development characteristics of international geo-information standards and standard system. On this basis, it proposes the key suggestions for building a more open and systematic national geo-information standard system. In addition, this paper also expounds how these key suggestions should be implemented by the example of the construction of China's national geo-information standard system.

2. THE SITUATION AND CHALLENGES OF INIERNATIONAL GEO-INFORMATION STANDARDS AND STANDARD SYSTEM CONSTRUCTION

2.1 Construction situation

International geo-information standardization organizations represented by ISO/TC 211 and OGC have been successively established in the world, and regional geo-information standard system frameworks represented by INSPIRE have been formed and popularized. The comprehensive geo-information standard research has been carried out, and a series of different types of geo-information standards, technical reports and technical specifications have been formulated (Stefano, 2010 and Brodeur, 2019).

ISO/TC 211 Geographic information/Geomatics founded in 1994 is for standardization in the field of digital geographic information. This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to

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the Earth. These standards may specify, for geographic information, methods, tools, and services for data management, acquiring, processing, analyzing, and transferring between different users, systems and locations.

Open Geospatial Consortium (OGC) founded in 1994 is an international not-for-profit standards organization. At present, there are more than 500 members from different countries and regions, including public and private sector organizations. The focus of OGC work is to formulate standards related to geographic information and location-based services. Different manufacturers and various GIS products can define the interface of open services, the coding of geospatial data storage and the methods of spatial operation according to these standards.

Infrastructure for spatial information in the European Community (INSPIRE) is a decree on the construction of European Spatial Information Infrastructure issued by the European Parliament and the European Council in 2007. The purpose is to establish a unified EU spatial information infrastructure and realize the sharing of environmental spatial information across the EU, and facilitate cross regional policy decision-making and application. At present, related laws and regulations, data specifications, metadata and network services, data and service sharing, spatial data services and report monitoring mechanism have been widely adopted in European countries, including some Asian countries. The top-level design experience of INSPIRE standard series has also been extended to relevant countries and regions.

The open international standards formulated by these organizations are generally the product of practice and experience accumulation, which facilitates the publication, discovery, access, maintenance and use of geospatial information across a range of applications, systems and business enterprises. In fact, most technology and data providers in the world have also implemented these standards in their products and services to ensure seamless interoperability with other technology systems and the whole user group. According to the current construction situation of geo-information standard system and related standards in various countries around the world, the common challenges are as below.

2.2 Challenges

2.2.1 Improve openness while maintaining competitiveness: There is no doubt that international standards occupy a dominant position in the use and promotion of national and regional standards. In particular, the international standards that have been reached a consensus cannot be easily resisted. In recent years, countries with the leading position of geo-information industry in the world attach great importance to the combination of geo-information standard construction and industrial development, and take the formulation and export of technical standards as an important part of industrial development. industrial influence and seize more international market. Especially in the most competitive technology field, these countries convert core technologies into patented technologies, and integrate patented technologies into relevant standards, and then promote the achievements of standard construction worldwide through multinational enterprises and various international organizations, so as to form industrial competitive advantages and firmly grasp the direction of industrial development.

However, recently, the integration of different high technologies has made many technical fields be redefined and divided. There are still gaps in the R & D and standard construction of many new technologies, which provides emerging countries in the geo-information industry more opportunities. Therefore, most countries have to participate in international competition more openly and provide stronger policy and resource support for technology research and standards construction. So that relevant achievements will be used to enhance

2.2.2 Strengthen connectivity with relevant information industries: In the development process of information industry, geo-information has played the role as a connecting link in all kinds of information. As an information carrier, geo-information system provides geospatial analysis functions for many other information technology branches. In 2018, the top 8 disruptive technologies in the world (such as artificial intelligence, augmented reality, block chain, UAV, Internet of things, robot, virtual reality, 3D printing, etc.) proposed by PwC, the world's top accounting firm, are directly related to geo-information and technology, or indirectly related to geospatial analysis functions. Using geo-information standards together with a series of general ICT standards, it can realize the interoperability between various devices, networks, sensors and systems, and build a wide range of connections between unconnected businesses in different industries. Therefore, in the context of full integration of technologies, the open standard is the first choice to improve the sharing of geo-information and technology, and it also makes products, technologies and data sources in different industries work together or operate seamlessly to avoid isolated islands of information and technology.

2.2.3 Make the standards at all levels more systematic and coordinated: The coordination and unification of relevant standards in the geo-information standard system and the overall benefits brought by the formulation and implementation of standards have gradually become the focus of geo-information standard construction. As the emergence and application of new geo-information technology, in order to improve efficiency and flexibility, different organizations have independently formulated and adopted different geo-information standards and standard systems based on their own requirements. These works may result in different standards and standard systems in the same field with different construction objectives, contents, paths and scope of application. Although they generally refer to the standard system and series standards of ISO / TC 211 and OGC, there are inevitable differences in the definition of relevant terms and the division of technical level. If this situation occurs in the formulation process of standards at different levels and cross fields in the same country, multiple standards that cannot be coordinated with each other would be applied to the same field, which would cause great inconvenience to the implementation and further improvement of standards.

2.2.4 Get good feedback from the evaluation: Standards and standard systems need to be updated and improved regularly because they need to adapt to new data forms, technical trends and application requirements. Moreover, they should be basically consistent with the general international standards and standard system to ensure the consistency of data connectivity, technical interoperability and management concepts in the international context. In addition, changes in new national policies and regulations, as well as changes in the role and needs of standard setters, must be reflected in the formulation and implementation of standards and standard systems in a timely manner.

Therefore, formulating and implementing policies and procedures to evaluate the scientificity and applicability of standards and monitor the implementation effect of standards in the industry is an important part of forming a closed loop of geo-information standard system construction. However, at

present, most countries lack the necessary awareness and effective implementation path in the regular evaluation and follow-up monitoring of relevant standards, and have not established a mechanism to effectively improve standards and standard systems by using relevant evaluation and monitoring results.

3. SUGGESTIONS ON THE CONSTRUCTION OF GEO-INFORMATION STANDARDS AND STANDARD SYSTEM

Based on the above challenges, most countries (including China) need to establish a more open and systematic national geo-information standard system and implement more flexible policies and measures for standards management.

By summarizing the relevant methods that have achieved good results in the world, we put forward the following construction methods, hoping to provide reference for the construction of geo-information standard systems and the implementation of relevant policies in various countries.

-Strengthen the relationship with relevant international standard organizations and actively participate in the formulation process of relevant international standard systems and specific standards;

-Identify data and technologies with different sharing rights, and strive to promote the transformation and application of international standards.

-Promote the effective integration of various standard systems, standard contents and professional standardization technology organizations in relevant information technology fields, with the spatial link and carrier role of geo-information in various data.

-Establish a multi-level systematic national standard system including national standards, industrial standards, local standards, group standards and enterprise standards, which will break the limitations that the current standard preparation and revision mainly depends on the government and solve the problem of dislocation of government and market roles to a certain extent.

-Carry out regular evaluation and monitoring on the standards at all levels that have been formulated and officially released, and adjust the standard level and standard system composition according to the evaluation and monitoring results.

4. THE CONSTRUCTION OF GEO-INFORMATION STANDARD SYSTEM IN CHINA

4.1 Work progress

In China, the technical docking work with ISO/TC 211 and other international geo-information standardization organizations is undertaken by the National Technical Standardization Committee of Geo-information (SAC/TC 230) established in 1997. It is a technical organization engaged in drafting, approving and releasing national standards and industry standards in the field of surveying, mapping and geo-information. It consists of three sub-technical committees, including the "Information Technology Sub-Technical Committee" (SAC/TC 230/SC1), the "Surveying and Mapping Sub-Technical Committee" (SAC/TC 230/SC2) and the "Satellite Application Sub-Technical Committee" (SAC/TC 230/SC3).

The "Data Security Law of the People's Republic of China" promulgated by the Chinese government in June 2021 has made important policy support for international exchanges and cooperation in the use and management of data including geographic information, such as "the state actively develops data security management, data international exchanges and cooperation in the fields of development and utilization, participates in the formulation of international rules and standards related to data security, and promotes cross-border security and free flow of data".

According to the relevant policies, the plan of establishing an open and systematic standard system that also covers a wide range of existing standards has been proposed. Several standardization technical committees are jointly responsible for the construction of this geo-information standard system. The author's department is also involved in this work. Therefore, based on the relevant research results, this paper will propose key measures on the construction of the geo-information standard system.

4.2 Construction situation in China

4.2.1 The openness of standards: In past 20 years, Chinese experts have participated in the formulation and revision of more than 60 international standards. In 2016, the "Geographic information— Content components and encoding rules for imagery and gridded data— Part 1 Content model" （ISO/TS 19163-1:2016）was officially released, which was formulated by Chinese experts, becoming the first international geo-information standard formulated by China. By the end of 2021, there are 8 relevant international geo-information standards compiled by Chinese experts, of which 4 standards have been released, 2 standards will be released soon, and 2 standards are under preparation. It shows that China is more actively participating in the formulation and revision of international standards. However, since the establishment of ISO/TC 211, more than 80 international standards have been issued, and more than 20 standards are being revised. Among them, the proportion of standards formulated by China is still relatively small, and the influence of relevant results is still limited.

China's standards number and name	International standards number
GB/T 19333.5-2003 *Geigraphic information-Conformance and testing*	ISO 19105: 2000
GB/T 19710-2005 *Geographic information- Metadata*	ISO 19115: 2003
GB/T 25528-2010 *Geographic information-Data product specifications*	ISO 19131: 2007
GB/T 25530-2010 *Geographic information - Services*	ISO 19119: 2005
GB/T 25597-2010 *Geographic information －Web map server interface*	ISO 19128: 2005(E)

Table 1. Some international standards adopted by China.

In addition, in the field of geo-information, China has initiated the citation and transformation of international standards, and adopted more than 30 international standards as national standards, most of which are basic standards. In this process, relevant organizations are more concerned about converting international standard texts into national standard texts, and simply incorporating them into the national geo-information standard system according to classification. But they failed to establish a supporting work mechanism and formulate effective implementation measures to ensure the consistency of relevant standards in the standard system. In particular, many national standards and industry standards did not fully learn from these international basic standards when they were formulated, nor did they make appropriate revisions in a timely manner,

resulting in difficulties and disputes in the application of some standards (Chen, 2021).

4.2.2 The cross-industry standards construction: Geo-information and related technologies are widely used in China's machinery manufacturing, software R & D, transportation and urban management, etc. The standards formulated in these industries all involve the achievements and application service of geo-information. Due to the lack of unified planning and top-level design, the achievements of geo-information standard construction have become fragmented, and the dynamic relationship with standards in other branches of information technology is not close enough. For example, government agencies and related organizations such as National Bureau of Surveying, Mapping and Geo-information, China Earthquake Administration, China Meteorological Administration, and China Maritime Safety Administration all participated in the construction of the CORS system. Therefore, they have successively formulated CORS standards and technical specifications applicable to their respective businesses (Li, 2015). However, due to the lack of necessary coordination and consistency of these standards and technical specifications, the interconnection and service sharing of CORS are actually limited.

4.2.3 The standard construction at all levels: As of 2021, China has formed a standards set consisting of 178 national standards, 161 industry standards, and more than 50 local standards in geo-information field, including series of geo-information standards for geodesy, photogrammetry and remote sensing, map compilation and printing, navigation and location services, geographical national conditions monitoring, and database construction, etc. (Zheng, 2019 and Ma, 2020). Most of these standards are based on the needs of geo-information production and services, and are used to optimize specific production processes and service effects (Deng, 2019). However, when it comes to common content, standardized citations and indexes between standards have not yet been implemented. And with the continuous strengthening of geo-information service attributes, there are still obvious deficiencies in the construction of relevant geo-information standards and professional standard systems in the field of achievements and application service.

Standards type	Standards number	Standards name
National standards	GB22021-2008	*Basic specifications for national geodesy*
	GB12319-1998	*Symbols, abbreviations and terms used on Chinese charts*
	GB12320-1998	*Specifications for Chinese nautical charts*
	GB50026-2007	*Code for engineering surveying*
	GB21139-2007	*Basic requirements for standard data of fundamental geographic information*

Table 2. Some basic national standards in "Geographic Information Standard System (2009)".

The "Surveying and Mapping Standard System" (NASG, 2017) and "Geographic Information Standard System" (National Technical Committee for Geographical Information, 2009) are the technical basis for the construction of China's geo-information standards. The two standards systems are closely related, with a number of common standards, but differ in how they were constructed and the specific standards covered. For example, the application service class of "Surveying and Mapping Standard System" is divided from the perspective of the application of surveying and mapping results, but the application service class of "Geographical Information Standard System" focuses on the service type, exchange and platform application of geo-information. Moreover, the content of the two standard systems is determined according to the basic and fundamental needs of the development of China's geo-information industry. The standards incorporated into the standard system and widely used are still national standards and industry standards led by the government, and the supply of local standards, group standards and enterprise standards has been insufficient for a long time (Zhu, 2018).

Standards type	Standards number	Standards name
National standards	GB22021-2008	*Basic specifications for national geodesy*
	GB12319-1998	*Symbols, abbreviations and terms used on Chinese charts*
	GB12526-1990	*Specifications for long range electro-optical distance measurement*
	GB12327-1998	*Specifications for hydrographic survey*
	GB17501-1998	*Specification for marine engineering topographic surveying*
	GB12320-1998	*Specifications for Chinese nautical charts*
	GB50026-2007	*Code for engineering surveying*
	GB50308-2008	*Code for urban rail transit engineering survey*
	GB20263-2006	*Navigable Electronic Map-Basic Requirements of Security Processing Technology*
	GB21139-2007	*Basic requirements for standard data of fundamental geographic information*

Table 3. Some basic national standards in "Surveying and Mapping Standard System (2017)".

4.2.4 The evaluation and monitoring of standards: The objects of standards construction are always in a state of rapid increase and change. But the average period of formulation and revision of geo-information standards led by the government in China is 3 years, which is difficult to meet the standardization needs of active technology development fields. Therefore, fully encouraging and supporting relevant organizations and enterprises to formulate group standards and enterprise standards is considered to be an important path and means to rationally use social and market forces to fill the gap in the construction of geo-information standards and dynamically maintain the standard system (Tan, 2019).

However, at present, most of China's domestic geo-information group standards and enterprise standards come from the upgrade of specific patented technologies and the normative design for workflow. Multiple standards in the same field often cannot be

closely linked and consistent in content, and even the standards will form a phenomenon of mutual restriction. In this case, the government and relevant institutions can bring these standards into the national geo-information standard system only by making them form a hierarchical, coordinated and supporting ideal structure with relevant national standards and industrial standards through policy means and effective measures, which is also an important task for the construction of geo-information standards in China.

4.3 Construction measures in China

4.3.1 The formulation, transformation and utilization of international standards: Firstly, more attention should be paid to mastering the construction trend of international geo-information standards. The links between China Geo-information Standardization Technical Committee and three sub technical committees and relevant international standard organizations (such as ISO / TC 211 and OGC) should be strengthened. The basic resources needed in leading and participating in the formulation of new international geo-information technology standards should be guaranteed.

Secondly, paying more attention to the standard construction of new technologies that would affect the development of geo-information industry. In addition to the regular formulation and revision of geo-information standards by the government and relevant organizations according to their needs, it is necessary to encourage and guide social groups, enterprises and scientific research institutions to lead or participate in the development of international standards in the field of new technology, so as to give full play to their convenient advantages in capital, technology and personnel exchanges with relevant countries, organizations and enterprises.

Thirdly, accelerating the transformation and application of international standards in China is important. Taking necessary consistency test between the new standards and the international standards that have been incorporated into China's geo-information standard system before the release of the new standards, and speeding up the real integration of domestic standards at all levels with international standards.

Finally, according to the requirements of national security and personal privacy protection, classifying and determining the geo-information that can be opened or restricted to share, so as to promote the rational circulation and use of geo-information to the greatest extent, which will promote the formulation of technical standards and the construction of standard system in fields such as data processing, achievement management, application services and so on.

4.3.2 The formulation and improvement of cross industry geo-information professional standard system: The professional fields of geo-information branches represented by "navigation and location services" and "aerospace remote sensing applications" involve the effective integration of various technologies and are also widely related to other industries. Therefore, building a perfect professional standard system in these branch professional fields is one of the important tasks of the construction of China's geo-information standard system. These professional standard systems will also integrate the fragmented geo-information standards that have been formulated for different industries and fields.

Taking the most widely used field of "navigation and location service" as an example, whose standard system can be divided into basic general class, management class, data processing class, platform system class and application service class from the perspective of enterprise and information. Combined with the application requirements of "navigation and location services" and the current situation of standard construction in China, several major classifications can continue to be finely classified. Finally, the existing standards will be included in different classifications, and new construction requirements will be proposed according to the blank field of standards construction. At the same time, relevant construction achievements need to be synchronously updated into the new national geo-information standard system as special standards.

4.3.3 The establishment of multi-level systematic standard system: It is very important to combine the existing "Surveying and Mapping Standard System" and "Geographic Information Standard System" to establish a relatively complete geo-information standard system composed of national standards, industrial standards, local standards, group standards and enterprise standards, and to formulate reasonable construction strategies for standards at different levels and play different roles. The construction strategies include:

-Consolidating all existing basic, supportive and restrictive national standards into the new standards system which can be taken as the construction basis for other standards. When the contents of other standards coincide with the contents of these standards, the reference relationship must be clearly indicated in the form of text.

-Based on the requirements for the integration of new technologies and standardized application of new fields, it is also very necessary to formulate and release national and industrial standards that are beneficial to the development of geo-information industry. These standards will be preferentially incorporated into the national geo-information standard system to ensure the basic circulation and application of geo-information.

-By comprehensively comparing the practicability, universality and innovation of the standards, specially taking local standards, group standards and enterprise standards which are formulated due to characteristic needs into the national geo-information standard system, to fill the gap in the standards construction of relevant fields. In appropriate conditions, these standards could be upgraded to industry standards or national standards.

In addition, it is very important to expand the participant depth and scope of relevant groups and enterprises in the preparation and revision of standards. In the future, standardizing and ensuring the development of geo-information industry will rely more on the group standards and enterprise standards formulated by relevant groups and enterprises. The national standards and industrial standards formulated under the leadership of the government will gradually focus on the public welfare needs within the scope of government responsibilities. If these measures were successfully implemented, the dislocation of the roles between the government and the market will be solved to a certain extent.

4.3.4 The improvement of standards evaluation and monitoring mechanism: Finding out the application status of China's existing geographic information standards and determining the role of various standards in the national standard system are the premise of building a scientific, practical and forward-looking national geographic information standard system in China. These goals generally need to be achieved through reasonable evaluation and monitoring of relevant standards.

The evaluation of China's geo-information standards needs to be divided into two cases. The first one is to evaluate the standards formulated by the government, generally including national standards and industrial standards. Since these standards generally play a basic and supportive role and would likely to be incorporated into the national geo-information standard

system, whether to formulate and release them needs to be decided through the early evaluation on their scientificity, systematicness and coordination. The second one is the evaluation on the standards formulated by social groups and enterprises, generally including group standards, enterprise standards, as well as the local standards and industrial standards upgraded from former two kinds of standards. Currently, China has no restrictions on the formulation of group standards and enterprise standards, and mainly relies on market competition to implement or eliminate relevant standards. In order to set a reasonable access threshold for the national geo-information standard system, some industrial standards or local standards that have been upgraded from group standards and enterprise standards should be evaluated in the same way. The evaluation results can be used as a prerequisite to consolidate relevant standards into the national geo-information standard system.

In addition, the builders of the national geo-information standard system need to monitor the implementation effect of the standards at all levels that have been formulated and officially released. The monitored standards should be quoted and applied frequently. Monitoring generally starts from a fixed time period since the standard is released, and the length of monitoring time can be flexible. The monitoring contents of a single standard should at least include public satisfaction feedback, regular maintenance and update, and applicability over time. The monitoring results can be used as an important basis to adjust the level of these standards. According to the monitoring feedback, the builders of the national geo-information standard system can timely add or remove relevant standards in the standard system and put forward suggestions for the timely revision and abolition of relevant national standards, industrial standards and local standards.

5. CONCLUSION AND FUTURE OUTLOOK

The above measures will effectively promote the construction process of China's geo-information standard system, and improve the overall openness and build better connection with the international standards. These measures will also ensure the scientific and forward-looking features during the construction and design of the standard system, and strengthen the standardization and rationality of the standards implementation.

The good standard system can maximize the effectiveness of standards, which will help relevant industries to apply new geo-information data sources and new technologies as early as possible, and extend the application and service boundaries of relevant achievements to the greatest extent. Therefore, the formulation and updating of the standard system will be an important and continuous work. It is worthy to be followed and innovated continuously by related researchers.

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