

Designing a Title Certificate for the Chinese 3D Cadastre

Changbin YU, Lin LI, Shen YING, Biao HE, Zhigang ZHAO and Yuan WAN, China

Key words: 3D cadastre, title registration, design purposes, design principles, design contents, the paper title certificate

SUMMARY

When the land use pattern changes from an extensive way to an intensive way, the development of 3D land-use has become reality. Due to the vertical heterogeneity of property rights, establishment of 3D cadastre is imperative. Meanwhile, registration and certification of the property rights have become important approaches to serve public and safeguarding legal rights.

Taking the traditional 2D title certificate of real estates as an example, requirement analysis of 3D title registration and registration objects in 3D title registration are elaborated. It is obvious that it is necessary to design a 3D title certificate. Then, taking registration of the right to use land for construction in China for example, design purposes and design principles of the 3D title certificate are proposed. After that the detailed contents of the 3D title certificate are elaborated in detail. Later, a detailed 3D title certificate (i.e. a 3D paper title certificate) produced by the computer is designed which could be manufactured based on C/S (Client/Server) architecture and published based on B/S (Browser/Server) architecture.

Finally, taking some 3D property objects in Shenzhen, China for example, corresponding 3D paper title certificates are elaborated. And the practice shows, that the approach using combined views (i.e. three orthographic views and the surrounding map) in the 3D paper title certificate is beneficial to 3D title registration.

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1. INTRODUCTION

Most of the world's countries have gone through fiscal cadastre and juridical cadastre, and they now develop towards multi-purpose modern cadastre. 2D cadastre is not suitable for utilization of 3D land space any more, and establishment of 3D cadastre is therefore imperative. It needs support from legal, organizational and technical aspects (Stoter et al. 2004). Related sub-topics need further research including design and implementation of the 3D title certificate in 3D cadastre.

2. CURRENT SITUATION IN DESIGNING TITLE CERTIFICATES IN CHINA

2.1 Current Situation of Title Registration in China

As the population and the industry aggregate in the cities, contradiction between people and lands becomes much more obvious. An extensive way to use land is not suitable for the development of modern societies and economies any more. The land use pattern changes from an extensive way to an intensive way, i.e. the development of 3D urban land is adopted, and it is an important research issue in 3D cadastre. The demand for establishing a 3D cadastre is based on the vertical heterogeneity of property rights information, and related research is carried out all over the world (Stoter et al. 2004, Stoter and Ploeger 2003, Wakker et al. 2003, Benhamu and Dovtsher 2003). In China, there is a similar situation, and especially big cities such as Shenzhen, Beijing, and Shanghai are confronted with a significant lack of vacant urban lands (Guo et al. 2011, Zhang et al. 2010).

Correspondingly, the "Property Law of the People's Republic of China" came into effect in 2007. This law aims at safeguarding the basic economic system of the state and maintaining the socialist market economy. And article 136 in this law says "The right to use land for construction (i.e. a kind of usufructuary right in China) may be established separately on the surface of, or above, or under the land. The newly-established right to use land for construction shall not damage the usufructuary right that has already been established." It shows the beginning of support in the legal aspect for 3D cadastre in China.

Registration is a main part and also an important form in cadastral management, and the traditional registration types in cadastre include deed registration and title registration. Deed registration relies on validation of the deed itself. In contrast, title registration focuses on legality of the transaction process (Henssen 1995). Nowadays, title registration has become the main type of registration in cadastre, and it is important for establishing real rights. The term "property" mentioned in the "Property Law of the People's Republic of China" includes immovable property (also called real property) and movable property. Immovable property includes the land and the buildings, fixtures and their affiliated facilities, e.g. real estates, the natural resources which are owned by the state according to the law. Movable properties include all other kinds of properties.

It should be noticed that the creation or transfer of the real right of a movable property shall become effective upon delivery. In contrast, for real properties, registration should be regarded as the determinant for transferring the real rights due to its immovability, and the principle “public notification” should be followed. In the “Property Law of the People’s Republic of China” article 9 says “The creation, change, transfer or elimination of the real right of a real property shall become effective after it is registered according to law; it shall have no effect if it is not registered according to law, except it is otherwise prescribed by any law”. It can be seen that registration is important for the confirmation of real rights.

2.2 Design of Traditional Title Certificates

A rational title registration can provide security for land leasing, legality for land transaction, and it is also beneficial to land taxation. So it can be seen that the title certificate plays an indispensable role in cadastral management (van der Molen 2003). In the “Property Law of the People’s Republic of China” article 17 says “The real property ownership certificate shall be the proof of the holder’s ownership of a real property.”

With development and growth of application fields of title registration in cadastre, it is urgent to design corresponding title certificates (hereinafter referred to as title certificates) including the title certificate of the land, the title certificate of houses, the title certificate of minerals, the title certificate of forests, the title certificate of marine fixtures, etc. In the “Land Administration Law of the People’s Republic of China (2004 Amendment)” article 11 says “People’s government at the county level shall register and record lands collectively owned by peasants and issue certificates to certify the ownership concerned. People’s government at the country level shall register and record uses of land owned by the state by units or individuals and issue certificates to certify the right of use.” In the “Measures on the Administration of the Registration of Urban House Title (2001 Amendment)” article 5 says “The title certificate of the house is the only proof of the legal ownership of the house including possessing, using, seeking proceeds from and dealing with it, and house registered according to law is under protection of the state”. In the “Interim Procedure of Marine Fixtures in Shenzhen” article 5 says that “the title certificate of marine fixtures is the proof of the real right on marine fixtures for the right holder.” It is obvious that title certificates are important to safeguard legal real rights.

Among them, the title certificate of the land and the title certificate of houses are closely related with daily life of human beings, and they are used frequently and widely.

2.3 Traditional Title Certificates of the Land and Houses

Real estates cover land properties and house properties, and they are important components of immovable properties. In China, the development of real estates shall comprise activities of construction of infrastructure and buildings on the land to which the right to use the state-owned land has been assigned in accordance with the laws. Traditionally, immovable properties are regarded as real estates.

In China, a joint registration mechanism for land and house properties was put into practice. This unified registration mechanism (hereinafter referred to as the joint registration) is proposed all over the country according to the “Registration Regulations of Real Estates in

Shenzhen Special Economic Zone” and the ”The Law of the People’s Republic of China on Urban Real Estate Administration (2007 Amendment)”. The joint registration mechanism is elaborated below:

In the primary stage of socialism, the state upholds the basic economic system under which the state ownership shall play a dominant role and diversified forms of ownerships may develop side by side. So, most of the land belongs to the state, and collectively owned land could be expropriated into state-owned land. Therefore most of the citizens only have the right to use land.

Before the joint registration is applied, two kinds of certificates are provided. One is the certificate of land property, and it is the result of initial registration, alteration of registration, etc. of the land. This kind of certificate is issued by the related land administrative department. There are four kinds of land property certificates, i.e., the ”Certificate of State-owned Land-use Right, P.R.C”, the ”Certificate of Collective Ownership on Land, P.R.C.”, the ”Certificate of Collective-owned Land-use Right, P.R.C.”, and the ”Certificate of Other Land-use Right, P.R.C.”. The other is the certificate of house property, and it is the result of initial registration, transferring registration, etc. of the house, and it is issued by the related real estate administrative department. There are three kinds of house property certificates, i.e., ”the House Ownership Certificate, P.R.C”, ”the House Joint Ownership Certificate, P.R.C”, and the ”House Encumbrance Certificate, P.R.C.”. In general, after buying a house successfully, most of buyers will have a ”Certificate of State-owned Land-use Right, P.R.C” (hereinafter referred to as the land certificate shown in figure A in Appendix I) and a ”House Ownership Certificate, P.R.C.” (hereinafter referred to as the house certificate shown in figure B in Appendix I). The land certificate is used to explain the location, the range and related information about the legal status of the land occupied by the house. And the house certificate is used to show the spatial location of the house (e.g. the building number, the floor number, the room number) and its inner planar structure, as well as related information about the legal status of the house.

After the joint registration has been applied, it seems to be much more clear and unified. Through managing the house properties, and regarding the rights of house properties as rights of real estates, the land certificate and the house certificate are unified into one certificate, i.e., the title certificate of real estate (hereinafter referred to as the real estate certificate). It is issued by the related real estate administrative department. In the ”The Law of the People’s Republic of China on Urban Real Estate Administration (2007 Amendment)”, the article 63 says “verification and change of the building title and the usage rights of the land on which the building is located should be recorded separately in the real estate certificate”. There are three kinds of real estate certificates, i.e., the ”Real Estate Ownership Certificate”, the ”Real Estate Joint Ownership Certificate”, and the ”Real Estate Encumbrance Certificate”. In general, after buying a house successfully, buyers will have a ”Real Estate Ownership Certificate” (shown in figure C in Appendix I.)

3. ANALYSIS OF THE 3D TITLE CERTIFICATE DESIGNS

3.1 Requirement Analysis for 3D Title Registration

It can be seen that, no matter if the joint registration mode is applied or not, both registration and certification of real estates covers land and houses which are closely related with each other. In detail, ownership of a house can not exist without a land-use right, but a land-use right can exist without the ownership of a house. However, land use value is embodied by constructing of buildings, fixtures and other auxiliary facilities built on, above, or under the surface of the land.

On the other hand, it is also stipulated that in case where the right to use land for construction is transferred, exchanged, used as equity contribution or endowed, the buildings, fixtures and their affiliated facilities on the land shall be disposed of concurrently (article 146 in the "Property Law of the People's Republic of China"). In case where the buildings, fixtures and their affiliated facilities are transferred, exchanged, and used as equity contribution or endowed, the right to use land for construction occupied by the aforesaid buildings, fixtures and their affiliated facilities shall be disposed of concurrently (article 147 in the "Property Law of the People's Republic of China"). It can be seen that land utilization patterns are essentially 3D rather than 2D. So 3D title registration and the design of the 3D title certificate are imperative.

However, nowadays 2D maps are widely applied for the description of 3D land use space, because for most of 3D land use space the side facades are vertical to the ground plan, and the combined method (i.e. "2D polygons + labelled texts showing heights") can be used. Concerning houses whose spatial shape in 3D is much more sophisticated, a representation by texts is also possible, because the houses have already been built before trading, and the property objects for the houses have been separated by right boundary surfaces. Therefore it is enough to only use text information to identify the unique houses recorded in the 2D real estate certificates.

It should be noticed that it is of great significance to design a 3D paper title certificate for the confirmation of the real right of natural resources such as minerals, forests etc. Because the definition and establishment of the 3D property object overturn the traditional form of confirmation of the real right which only supports 2D title registration (see the "Permit of Mineral Resources Exploration, P.R.C" presented in figure D in Appendix I; see the "Mining License, P.R.C" presented in figure E in Appendix I).

3.2 Registration of Objects in 3D Title Registration

In 2D cadastre, registration objects are traditional planar parcels, also called 2D property objects. In 3D cadastre, registration objects are 3D property objects (Zhang et al. 2010). The 3D property object (hereinafter referred to as the property object) is the closed 3D object which belongs to natural persons or legal persons. Its 3D geographic space is defined accurately, and it is the smallest spatial unit in 3D cadastre. The application fields of 3D property objects cover real estates, municipal facilities and public utilities (e.g. railway tunnels, underground pipelines and cables in the air, underground garages and shopping malls), historical monuments under protection, geological structures (e.g. minerals, soil

pollutants), natural resources (e.g. marine cadastre, forests), etc. (Stoter et al. 2004, Stoter and Ploeger 2003, Wakker et al. 2003, Benhamu and Dovtsher 2003, Ng'ang'sa et al. 2004).

Up to now, there are two kinds of 3D property objects: physical space objects (also called physical objects, real objects) and right space objects (also called right objects) (Stoter and Ploeger 2003, van der Molen 2003). Physical objects are usually much more complicated than right objects in geometry (e.g. detailed outlines and interior components of the building, complicated surfaces of the minerals). This complexity is usually reflected in many aspects including generation of data, design of data structures, spatial analysis, etc. Physical space objects may not correspond with right space objects one to one, but they are related closely. In general, a single physical object is composed of several right objects, e.g. Metro.

In this paper, we only take transferring (i.e. leasing) the right to use land for construction in China as example. In China, the holder of the right to use land for construction shall be entitled to possess, use and seek proceeds from the land owned by the state, as well as entitled to make use of the land for constructing buildings, fixtures and their auxiliary facilities. In light of the socialist public ownership of land in China (i.e. an ownership by the whole people and ownerships by collectives), no units or individuals are allowed to occupy, trade or illegally transfer land by other means. However, the land use right may be transferred by law. Construction units that have obtained state-owned land by paid leasing can use the land only after paying the land use leasing fees and other fees and expenses according to the standards and ways prescribed by the State Council. It can be seen that the right to use land for construction which is a kind of usufructuary right is widely used in China and also of great significance. And the spatial unit that the right to use land for construction is attached on is a sort of right space object, because only after the right to use land for construction is registered successfully, physical space objects (e.g. buildings, fixtures and other auxiliary facilities) could be built in it. So in the 3D title certificate designed in this paper, only the right space object is involved.

3.3 Design Purposes of the 3D Title Certificate

Design purposes of 3D title certificates could be summarized as follows:

Legally, similar to a 2D title certificate, a 3D title certificate is also used to safeguard legal rights of the holder, and it is issued by the related land administrative department. As a result of title registration, it is under the powerful protection of the state.

Functionally, a 3D title certificate is used to describe the spatial shape and related right information of the 3D property object. As mentioned above, there are four types of land certificates in China, i.e., the "Certificate of State-owned Land-use Right, P.R.C", the "Certificate of Collective Ownership on Land, P.R.C.", the "Certificate of Collective-owned Land-use Right, P.R.C.", and the "Certificate of Other Land-use Right, P.R.C.". After 3D title registration, the shape of the property object recorded in the 3D title certificate should be 3D instead of 2D.

3.4 Design Principles of the 3D Title Certificate

Based on the above information, the design of the 3D title certificate should follow two principles:

(1)Completeness of Design Contents

The recorded objects in the 3D title certificate are 3D property objects. Therefore the spatial shape and related property information of the 3D property object, as well as the spatial shape and related property information of the 2D land occupied by the 3D property object should be both covered in the 3D title certificate. This also coincides with the current situation that both 2D and 3D parcels exist in 3D cadastral management. Completeness of design contents is the fundamental principle.

(2)Convenience of the Operations

Organization of 3D spatial data is much more difficult than that of 2D spatial data. However, similar to production of a 2D title certificate, operations for producing a 3D title certificate should be convenient and as fast as possible to follow the requirements of OA (i.e. office automation). In addition, not only a visualization of the 3D title certificate is needed, but also certain advanced editing capabilities should be provided.

The detailed implementation of the above two principles belongs to technical aspects. For the first principle, the accurate description of the spatial shape of the 3D property object should be focused on. So, based on the cadastre-oriented 3D spatial data model which is designed reasonably, the 3D geo-database should be built, and also the 3D geo-database and current 2D geo-database where 2D parcels are stored should be linked. For the second principle, besides the contents mentioned above, user friendly visual interfaces are needed as well. Design of operations should serve the design of contents.

In the process of producing the 3D title certificates as shown in figure 1, many departments and staffs are involved including surveyors, mappers, verifiers, and users of the certificates. Among them, surveyors are responsible for field surveying, and mappers (i.e. cartographers of the certificates) are responsible for detailed work in producing the certificates including mapping, and verifiers (i.e. checkers) are responsible for verifying the certificates. The 3D title certificates are finally issued by related real estate administrative departments, and users of the certificate are the holders of the rights.

4. IMPLEMENTATION OF THE 3D TITLE CERTIFICATE

4.1 Concrete Design of the 3D Title Certificate

Based on the above design principles, specific contents of the 3D title certificate should include spatial shape and related property rights information of both the 3D property object and the 2D property object (i.e. 2D land occupied by the 3D property object).

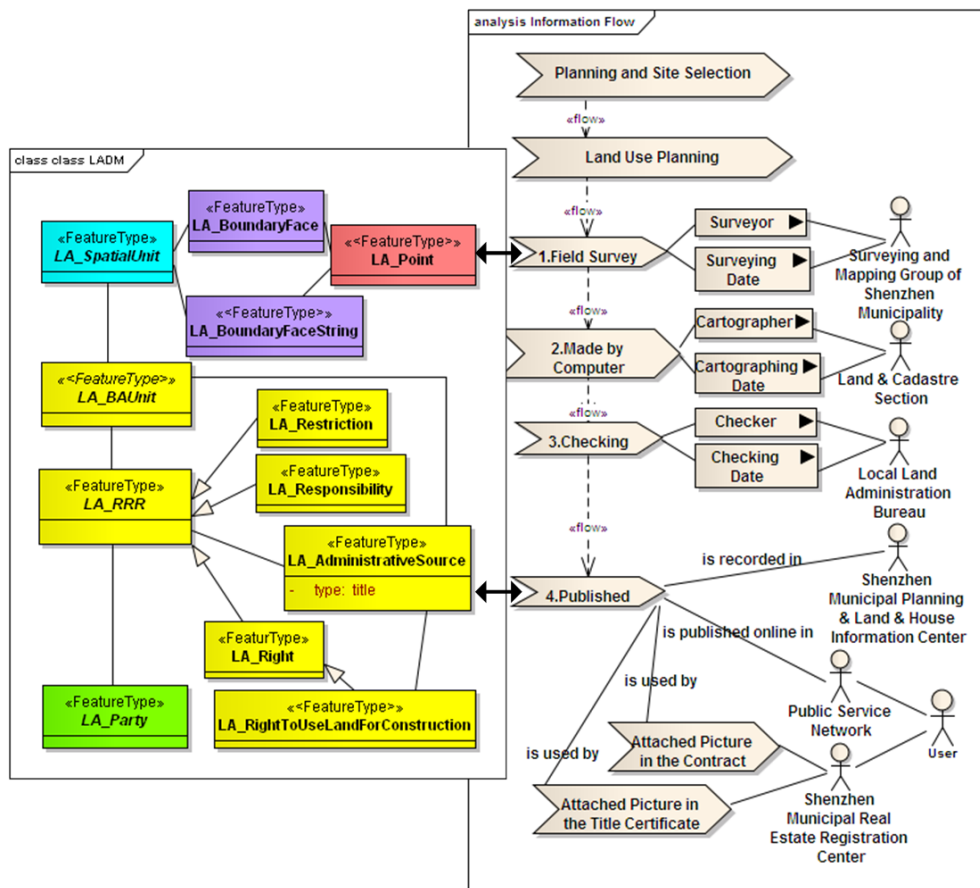


Figure 1. Information Flow Showing the Parties Involved in the Process

In detail, the following contents should be covered:

- (1) **Spatial shape of the 3D property object:** It covers geometric information including 3D boundary points, projected 2D area, and 3D volume. It also covers basic surveying and mapping information including measuring coordinates, height datum, and scale.
- (2) **Related property rights of the 3D property object:** It covers traditional property right information including 3D parcel number, 3D parcel user, land-use type, etc. It also covers surveying and mapping information including surveyor, surveying date, mapper, and mapping date, as well as verification information including checker and checking date.
- (3) **Spatial shape of the 2D land occupied by the 3D property object:** It covers geometric information including 2D boundary points and 2D area. It also covers topographic information and topological relationships between the 2D parcel and surrounding objects.
- (4) **Related property rights of the 2D land occupied by the 3D property object:** It covers 2D parcel number, 2D parcel user, land-use type, etc. It also covers surveying and mapping information and verification information.

Up to now, most of the property right information of a 3D property object comes from that of the 2D land occupied by the 3D property object. Therefore only the 3D property right information is recorded. And it is enough to use texts to describe property right information. However, the description of the spatial shape of a 3D property object seems to be much more difficult. When the property object is modelled in 3D instead of 2D, only 1D is increased.

Nevertheless the expression of the spatial shape of the 3D property object is a big challenge which is mainly reflected in the following two aspects:

(1)The Difficulty in Surveying of 3D Property Objects

For 2D cadastre, a 2D parcel is composed of several boundary lines, and each boundary line is composed of two boundary points. So the immediate constructing primitive of the 2D parcel is the boundary line, and a 2D parcel could also be constructed by ordered boundary points.

For a 3D cadastre, geometrically, construction of a 3D parcel must refer to four types of entities (i.e. boundary points, boundary lines, boundary surfaces, and bodies). In detail, a 3D property object is composed of several boundary surfaces, and each boundary surface is composed of several boundary lines, and each boundary line is composed of two boundary points. For the definition of a 3D property object, hierarchical construction by geometrical primitives (i.e. point, arc, and polygon) and topological primitives (i.e. node, edge, face, and body) is needed. And the construction of the spatial shape of a 3D property object recorded in the 3D title certificate is based on the cadastre-oriented 3D spatial data model which has been already designed and proposed (Guo et al. 2011, Ying et al. 2011).

However, both geometrical primitives and topological primitives finally come from boundary points. In other words, the immediate surveying and mapping data in cadastre are boundary points. Surveying of boundary points in 2D cadastre it is relatively simple, because 2D parcel boundary points are obtained through collecting on the spot. The coordinates of every boundary point are recorded in the certificate of surveying and mapping, and are also labelled in the 2D title certificate. In a 3D cadastre, it is rather complicated, because field surveying of 3D parcels is impossible. In practice, survey plans and accurately described planar drawings are regarded as certificates of surveying and mapping. Later, the coordinates of the 3D boundary point are composed of the 2D coordinates with its height at, above or below the ground level (Stoter et al. 2004). This graphic method is based on results of current 2D surveying and mapping. However, it has limitations, because the side facades of the 3D property object must be vertical to the ground plan. In other words, only surveying of prism-like 3D property objects built by extrusion is available (Ledoux and Meijers 2011, Onsrud 2003). In some cases, the spatial shape of 3D property objects can be rather complicated (e.g. a part of a stadium overhanging a road) (Tang and Yang 2009, Ying et al. 2011). Here it is not suitable to use the graphic method. Meanwhile, the coding rule for 3D property objects is closely related with surveying and mapping of the 3D property object, but there is no unified coding rule for 3D property objects yet.

(2)The Difficulty in Representation of 3D Property Objects

No matter whether the title certificate of the 2D parcel or the title certificate of the 3D parcel, is taken into consideration, the intrinsic designing idea is that the spatial shape of the parcel can be represented by multiple planar views (e.g. isometric view, three orthographic views, profile drawing, architectural structure plan). In 2D cadastre, it is feasible, even if only 2D boundary points are provided. In 3D cadastre, reconstruction of 3D property objects from these finite views is not always feasible, especially for those 3D property objects which have multi-components or concave components. Similar situations exist in other fields such as medicine, geology, mechanical engineering, architecture, etc.

4.2 A 3D Paper Title Certificate

Based on the above, the idea to design a detailed 3D title certificate is proposed, i.e. a 3D paper title certificate. The 3D paper title certificate can be printed on paper when finished, and all spatial information and property right information is recorded on it.

The 3D paper title certificate is composed of two pictures, i.e., the main picture and the auxiliary picture. Both the main picture and the auxiliary picture are 2D projections of the 3D property object. The main picture is designed to show relatively comprehensively the spatial shape of the 3D property object. A perspective similar to the axonometric perspective, as well as the wire-frame mode are adopted, and hidden-line technology is also employed to enhance the realistic sense of the 3D object. This is lacking in most of current cadastral maps or survey plans (Tan and Hussin 2011). The auxiliary picture is designed for further depictions of the spatial shape of the 3D object from different perspectives. Here the idea to show 3D effects of components in engineering is employed (Zhao 1991), i.e. three standard projection views (i.e. projection drawings) including the front view, the side view, and the top view are shown. The effect of the top view is similar to the effect of the survey plan.

Besides the independent spatial shape of the 3D parcel, the spatial relationships between the 3D parcel and the surrounding objects are also important. They are also reflected in the auxiliary picture of the certificate. Included are the relationships between the parcel and surrounding homogeneous geographical objects (e.g. adjacent relationships between the parcel and nearby parcels), and the relationships between the parcel and surrounding heterogeneous geographical objects (e.g. relationships between the parcel and the terrain, i.e. if it is situated above, on, or below the terrain; relationships between the parcel and nearby roads).

For the design of the 3D title certificate, design details should also be taken into account, including the list of boundary points, etc. Boundary points are immediate surveying and mapping data, so they should be shown clearly and completely. In 2D cadastre, there may exist a large amount of boundary points in case of complicated 2D parcel shapes. If surveying is done in 3D, boundary points can be much denser and their number can be huge. In order to show the boundary points, a table listing them can be integrated. If their number is huge, additional pages can be attached.

It can be seen that, similar to design of the 2D title certificate, the spatial shape of the 3D property object is also described by finite planar views. But every view in the 3D paper title certificate is only a profile of the spatial shape of the 3D property object. However, the method combining "three orthographic views + the surrounding map" has been used to show spatial shape of the 3D property object as much as possible. For a successful implementation it is important that the 3D paper certificate can be produced by computer.

4.3 Manufacturing and Publishing the 3D Paper Title Certificate

It saves a lot of time to produce the 3D paper title certificate by computer. In general, this is covered by two modules, i.e. a manufacturing module and a publishing module respectively. Additionally graphical user interfaces are used to help involved staffs to produce the certificate step by step.

The manufacturing procedure of the 3D paper title certificate covers a lot of complicated interacting operations like the hidden-line process of the wire-frame model, the production of three orthographic views, editing of property rights information, and printing of the certificate. Therefore it is suitable for the C/S structure which can make full use of the powerful editing capabilities of the client side. In contrast, the publishing procedure is relatively simple. Here only browsing and downloading of the 3D paper title certificate is involved. It is suitable for the B/S structure which can take advantage of the capabilities of browsers in a distributed environment.

4.3.1 Manufacturing of the 3D Paper Title Certificate based on C/S Structure

Taking Oracle 10g as the database, ESRI ArcGIS Engine 9.3 as the visualization development environment, and Microsoft .Net Framework 3.5 as the key development framework, this module has been implemented using DLL (Dynamic Linking Library).

The 3D paper title certificate covers two parts including the main picture and the auxiliary picture. For producing the main picture, the following steps are necessary: “import attribute data”, “import graphic data”, and “import boundary points”. While for producing the auxiliary picture, two steps are included: “import attribute data” and “import graphic data”. At the same time basic interaction tools like zoom in, zoom out, pan, or full extent should be provided. Additionally advanced functions including visibility of the hidden parts, editing annotations of boundary points, as well as exporting and printing the certificate should also be offered.

4.3.2 Publishing of the 3D Paper Title Certificate based on B/S Structure

Taking Oracle 10g as the database, ESRI ArcGIS Server 9.3 as the visualization publishing environment (the application server already included in it), and IIS (Internet Information Server) 6.0 as the web server, the module has been implemented.

Published certificates can be searched online by the parcel ID, and functions of browsing and downloading of both the main picture and the auxiliary picture are provided. Basic interaction tools including zoom in, zoom out, pan, and full extent could also be offered.

5 CASE STUDY

Taking the building of Zhongxin Telecom Equipment in Shenzhen, China as an example, the design of the corresponding 3D paper title certificate is elaborated below.

The manufacturing of the 3D paper title certificate based on the C/S structure covers two parts: Firstly, manufacturing of the main picture of the certificate. It describes the spatial shape and the property rights information of the 3D property object presented in figure 2. Secondly, manufacturing of the auxiliary picture. It describes the spatial shape of the 3D property object from different perspectives as well as relationships between the 3D property object and the surrounding objects (see figure 3).

The publishing of the 3D paper title certificate based on the B/S structure also covers these two parts. But it only focuses on browsing and downloading the certificate which is shown in

figure 4 (only the main picture). More examples including Excellence Century Center, Hongkong-Shenzhen Western Corridor, and the Underground Parking Lot of Houhai Center(already leased; its 3D paper title certificate is presented online, see <http://www.szpl.gov.cn/tdzpg/landpic.aspx?exchangeId=20110406001>) are illustrated in Appendix II.

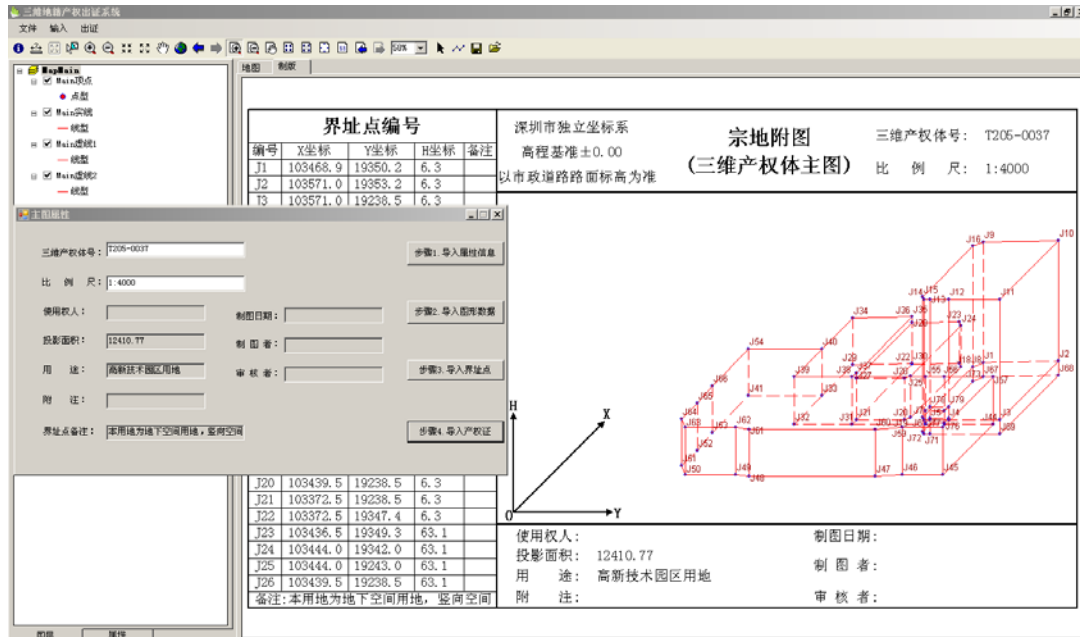


Figure 2. User Interface for Manufacturing the Main Picture of the 3D Paper Title Certificate of the Building of Zhongxin Telecom Equipment

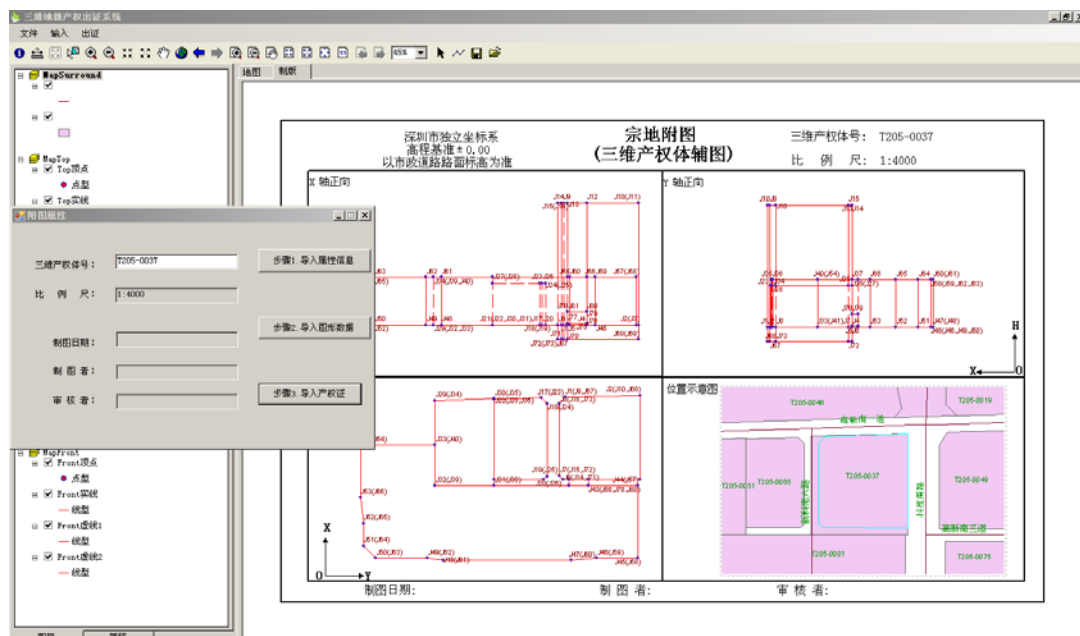


Figure 3. User Interface for Manufacturing the Auxiliary Picture of the 3D Paper Title Certificate of the Building of Zhongxin Telecom Equipment



Figure 4. User Interface for Publishing the Main Picture of the 3D Paper Title Certificate of the Building of Zhongxin Telecom Equipment

5 CONCLUSION

The establishment of a 3D cadastre needs cooperation between legal, organizational and technical aspects. In this paper, design purposes are elaborated mainly from the perspective of laws. The design process is elaborated mainly from the perspective of organizations. Design principles and design contents are analyzed mainly from the perspective of technologies. At last, a detailed 3D title certificate (i.e. a 3D paper title certificate) is designed, and several cases are taken as examples for detailed explanations. Practice shows that the strategy to combine three orthographic views with the surrounding map together to express the spatial shape of the 3D property object is beneficial to 3D title registration.

Hopefully what has been discussed in this paper could provide some references for 3D title registration or the design of 3D title certificates in 3D cadastre.

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APPENDIX I: SOME CERTIFICATES

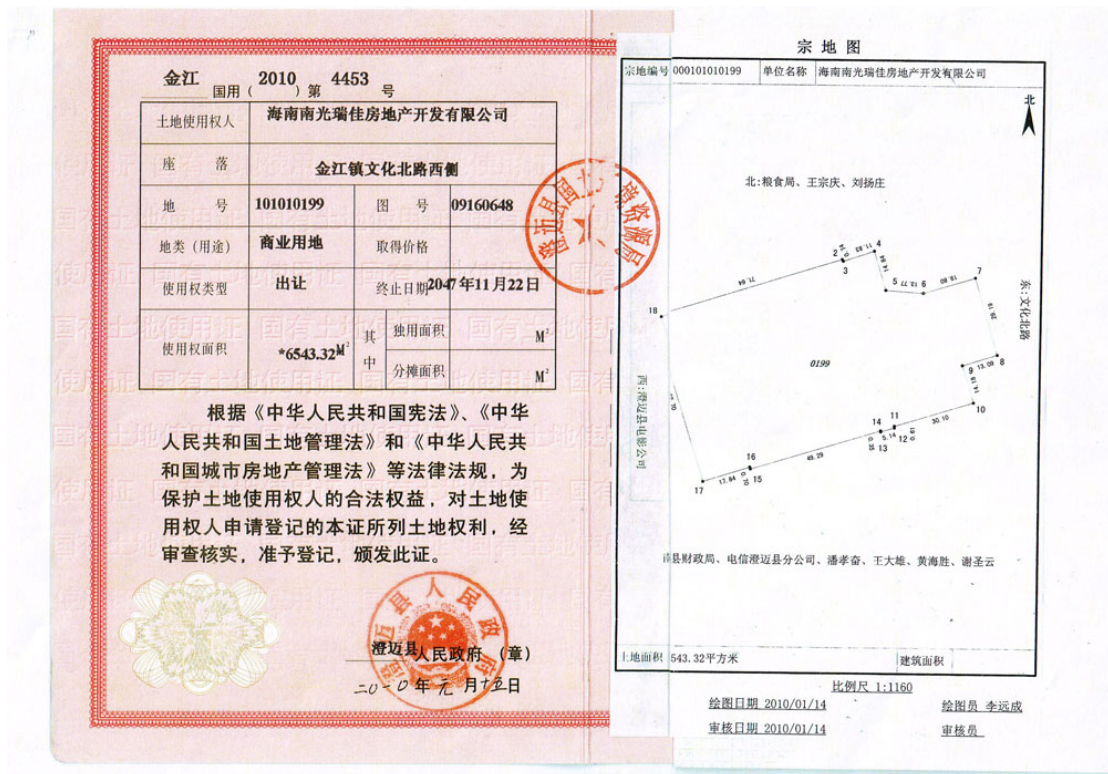


Figure A. Certificate of State-owned Land-use Right, P.R.China

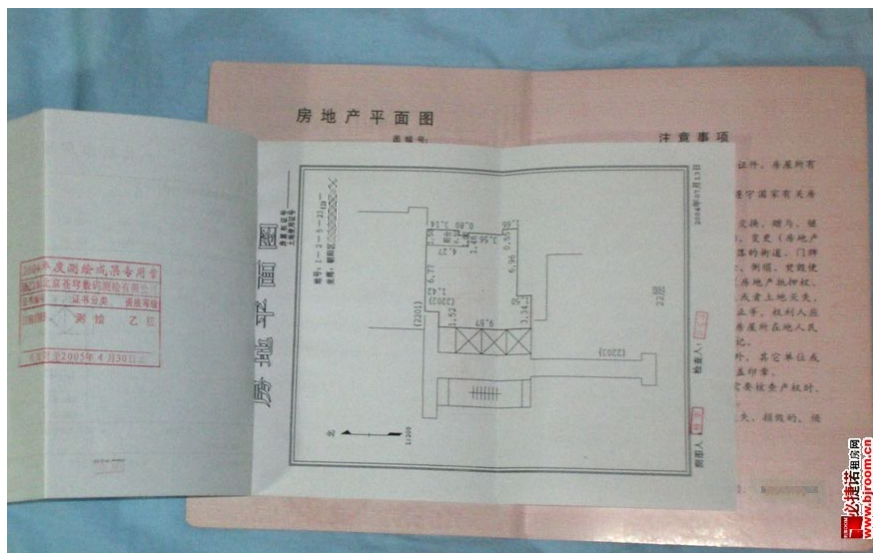


Figure B. The Auxiliary Page of House Ownership Certificate, China



Figure C. Real Estate Right Certificate in Shanghai, China

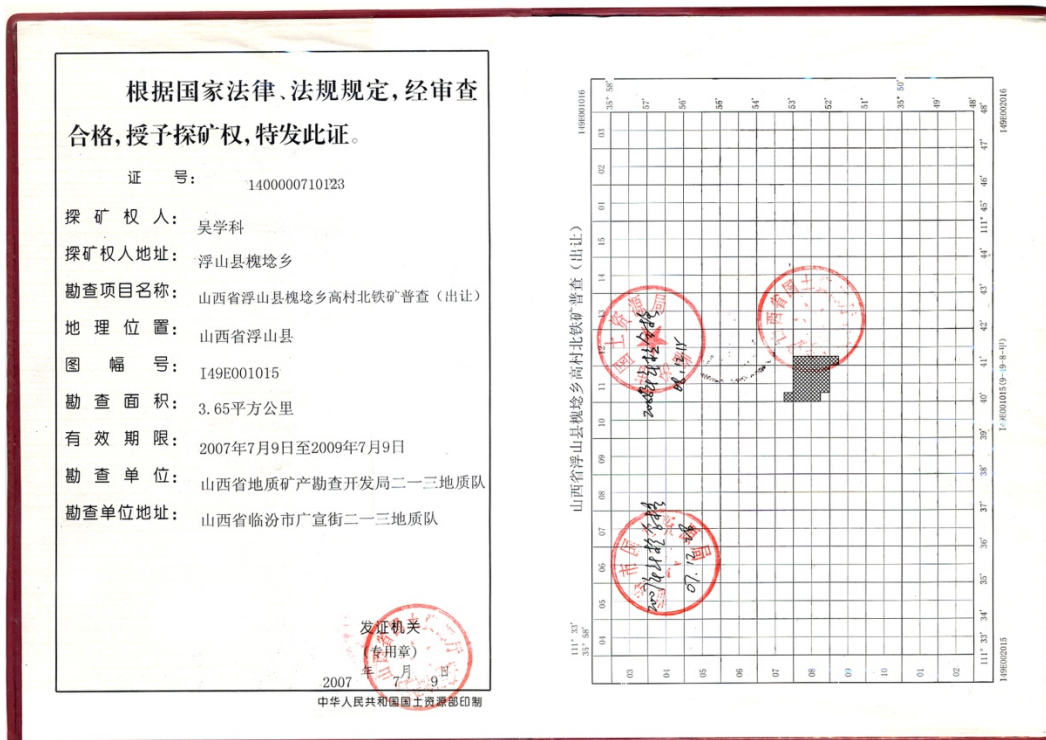


Figure D. Permit of Exploration for Mineral Resources, China

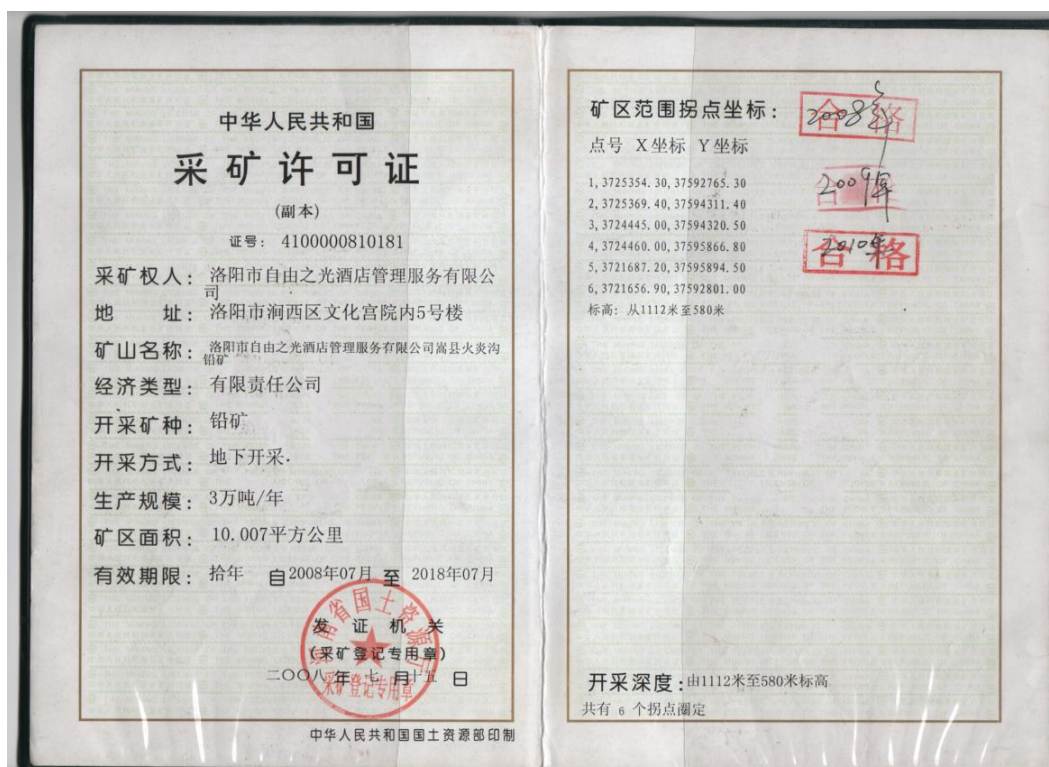


Figure E. The Duplicate of Mining License, China

APPENDIX II: OTHER CASES

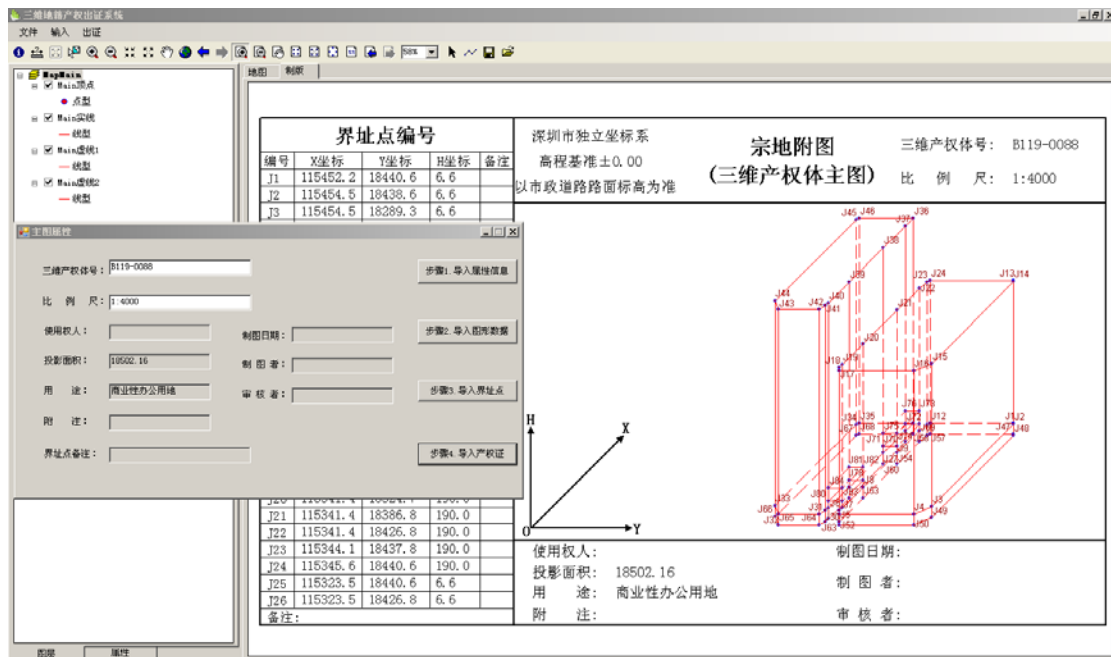


Figure F. User Interface for Manufacturing the Main Picture of the 3D Paper Title Certificate of Excellence Century Center

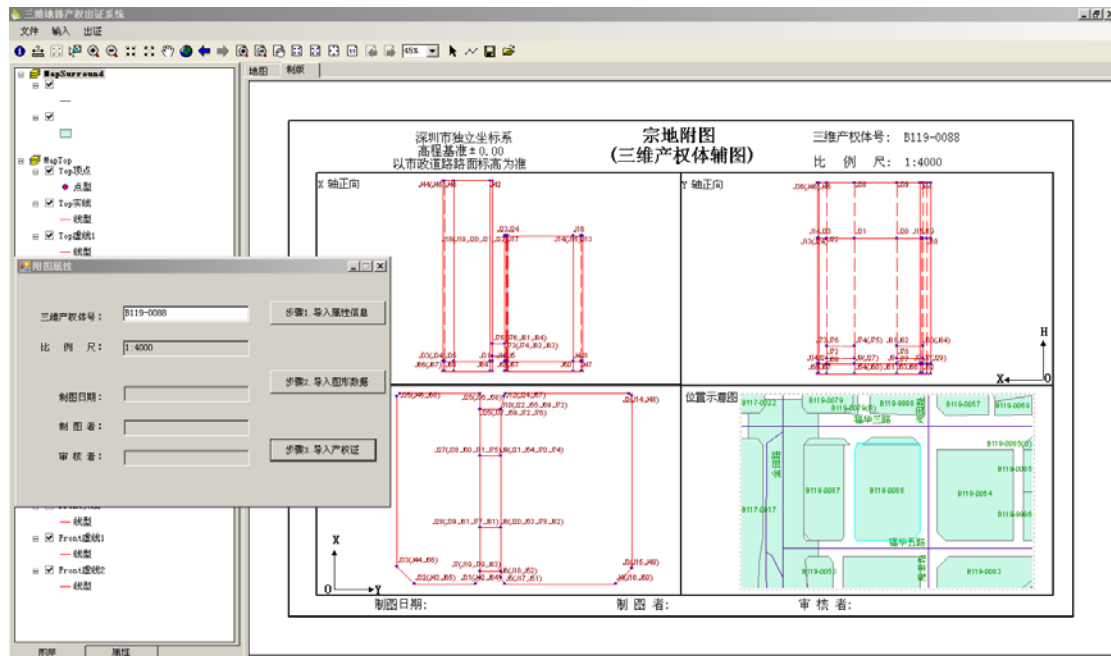
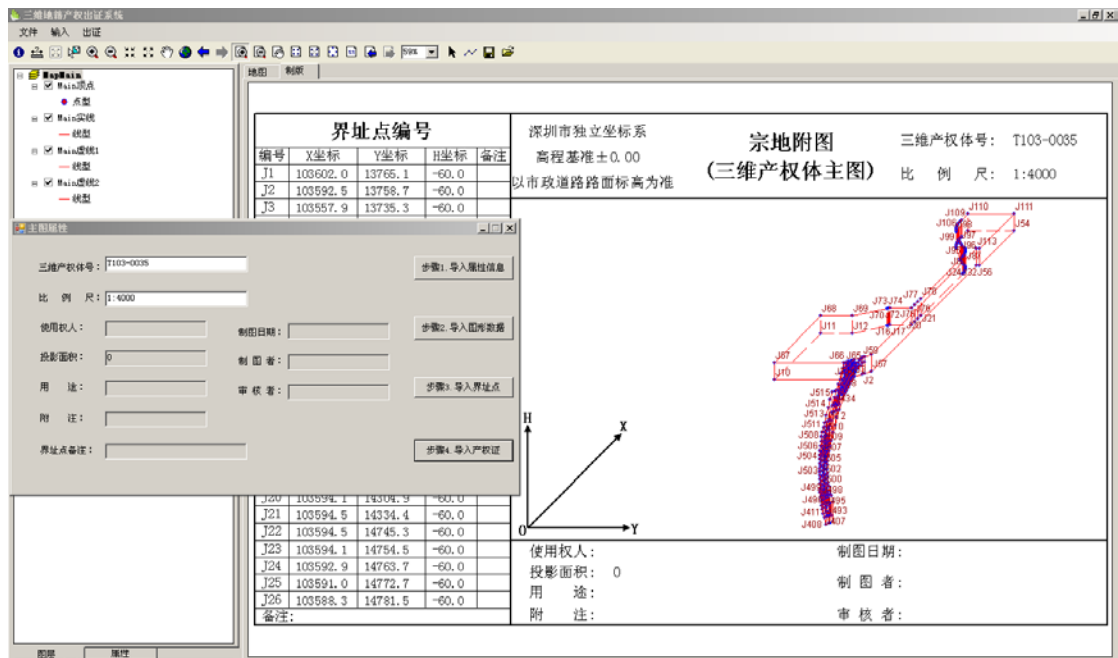


Figure G. User Interface for Manufacturing the Auxiliary Picture of the 3D Paper Title Certificate of Excellence Century Center



BIOGRAPHICAL NOTES

Changbin YU is a PhD candidate at the School of Resource and Environmental Science, Wuhan University. He received both his B.S. (2009) in Geographic Information Systems (GIS) and his B.S. (2009) in Computer Science and Technology (CS) from Wuhan University. Now his PhD is supervised by Prof. Renzhong GUO. His current interests include 3D cadastre, 3D modelling and topology study, as well as WebGIS.

Lin LI is a professor at the School of Resource and Environmental Science, Wuhan University, and the chair of the Department of Geographic Information Science. He received his PhD in photogrammetry and remote sensing from Wuhan University in 1997 and has worked on cartography and GIS for many years. His current interests include 3D cadastre, computer-aided cartography, geographic ontology, and LBS.

Shen YING is an associate professor at the School of Resource and Environmental Science, Wuhan University. He received a B.S.(1999) in Cartography from Wuhan Technical University of Surveying and Mapping (WTUSM), and MSc and PhD degrees in Cartography and GIS from Wuhan University in 2002 and 2005, respectively. His research interests are in change detection, incremental updating and generalization in multi-scale geo-database, 3D GIS and cadastre.

Biao HE works in the Urban Planning, Land and Real Estate Information Center, at the Urban Planning, Land and Resources Commission of Shenzhen Municipality. He received his PhD in GIS from Wuhan University. His current interests include 3D cadastre, GIS programming and computer graphics.

Zhigang ZHAO works at the Urban Planning, Land and Resources Commission of Shenzhen Municipality. He received his PhD from Wuhan University. His current interests include 3D cadastre, 3D modelling and topology study.

Yuan WAN received his PhD from Wuhan University. His current interests include 3D cadastre and WebGIS.

CONTACTS

Changbin Yu
School of Resource and Environmental Science, Wuhan University
430079 Wuhan University
China
Tel.:+86 13098870840
+86 13028851221
E-mail: yuchangbinboy@gmail.com

