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MODERN MAPPING TECHNOLOGIES OF CADASTRAL WORKS SOFTWARE

The content of modern mapping technologies of cadastral works software has been shown. The characteristic of general problems of modern mapping technologies in different countries and cadastral systems has been presented and explained communication with many different land information systems of different profiles which connected with depending on space data. The main principles, methods and directions of modern mapping technologies of cadastral works software development all over the world have been analysed.

***Keywords**: modern mapping technologies, cadastral works, mapping software.*

***В.В. Тишковець, В.М. Опара. СУЧАСНІ ТЕХНОЛОГІЇ КАРТОГРАФІЧНОГО ЗАБЕЗПЕЧЕННЯ КАДАСТРОВИХ РОБІТ**. В роботі представлені сучасні технології картографічного забезпечення кадастрових робіт. Надана характеристика загальних проблем сучасних картографічних технологій різних країн та кадастрових систем та розкрито взаємозв'язок з багатьма земельно-інформаційними системами різних профілів, які пов'язані з відповідними просторовими даними. Проаналізовані головні принципи, методи та напрями розвитку сучасних технологій картографічного забезпечення кадастрових робіт у всьому світі.*

***Ключові слова**: сучасні картографічні технології, кадастрові роботи, картографічне забезпечення.*

***В.В. Тишковец, В.Н. Опара. СОВРЕМЕННЫЕ ТЕХНОЛОГИИ КАРТОГРАФИЧЕСКОГО ОБЕСПЕЧЕНИЯ КАДАСТРОВЫХ РАБОТ**. В работе представлены современные технологии картографического обеспечения кадастровых работ. Представлена характеристика общих проблем современных картографических технологий разных стран и кадастровых систем и раскрыта взаимосвязь с многими земельно-информационными системами разных профилей, которые связаны с соответствующими пространственными данными. Проанализированы главные принципы, методы и направления развития современных технологий картографического обеспечения кадастровых работ во всем мире.*

***Ключевые слова**: современные картографические технологии, кадастровые работы, картографическое обеспечение.*

Definition of the problem. Mapping technologies could be meant as a using cadastral data in the GIS environment. In order to fulfil the requirement of parcel-based information, the cadastral data set managed using technologies should be concerned on the legal decisions and transactions, legal delineation of boundary, and legally defined rights, responsibilities and restrictions. The relation between spatial data and descriptive data in cadastre, the link between those data is arranged through parcel identifier. The identifier takes a role as reference for indexing and identifying the parcel in the map and their administrative records in database. Every parcel is defined by a unique parcel identifier. The design of parcel identifier is different among countries depends on their previous or existing cadastral system, time and cost effectiveness and cultural reason. The changes of a parcel boundary have consequences for updating the map and the parcel identifier. In many European countries it is compulsory to include the parcel identifier in any deed relating to the property transaction.

Basic prerequisites. The roles of cadastral data for the modern mapping technologies development are not a new concept. Toms[1] stated that cadastral data can be fitted into the context of modern mapping technologiesby two general types of land-related data. First is the "environmental data" that describes natural phenomena such as vegetation, slope, water body, land cover and so forth. Secondly is "parcel-based data" that consist of any information about parcel as a smallest registered unit of land.According to Williamson[2] the core of modern mapping technologiesis parcel-based information. He described the Digital Cadastral Mapping Data Bases which was introduced in 1990's as a spatial reference for the modern mapping technologiesin Australia and New Zealand. It was adopted in some states using different terms such as Geographical Data in New South Wales. They have a common objective to

capture and create a digital database of cadastral for modern mapping technologiesdevelopment. The output of cadastral mapping data bases is a geographical index to visualize cadastral parcel, so a high accuracy is not considered as important as the relative spatial relationship. Chicocinski [3] stated that a modern mapping technologiesare constructed by the link of two types of data: spatial and attribute data. Spatial data have a geometric characteristic which are represented by point, line and polygon. Attribute data is descriptive information about features in quantitative or qualitative value. The system can be maintained properly if data are computerized, thus mean all data is in digital format. He took a sample of the evolution of cadastral from "classical" to "modern" which emerged in Poland at 1991 by converting the existing cadastral from analogue to digital form and creating the construction of modern mapping technologies. In Poland, the modern cadastral which is a computerized system has to include "real estate data" to determine its cadastral identifier, location, boundary route, land use and classification, technical fitting (main connections), land purpose for planning and attributes of real estate (its surface and values). The main role of the modern cadastral is the ability to integrate with other information resources in the frame of modern mapping technologies.

Aim of article. This article is intended to show the results of modern mapping technologies analysis of cadastral data changes and on the basis of some definitions and roles of cadastral data show the need for updating cadastral maps. The article shows that cadastral data changes should concern on updating cadastral map using modern mapping technologiesand applications of digital data collection for cadastral works software.

Summary of basic material. Modern mapping technologies utilize land parcels as the link to the graphic database attributes. The development of Bangkok modern mapping technologies uses cadastral maps as an output of land registration in Thailand, which has been overlaid with large scale rectified photomaps. The land parcel-based map was linked with database attribute from partner organizations (such as electricity, water and telephone) who share the same parcel-based land information (type of building, the owners, location)[4].

Cadastral maps support a significant data in land information systems. The cadastral map does not only show boundaries of parcels but also additional detail information of resources associated with them (owners, right) including physical structures on or beneath them (house, bunker), their geology, soils, vegetation and land use[5]. Cadastral maps which are based on large-scale maps can be adapted to general uses; besides as parcel map; such as utilities (pipeline, electricity and telecommunication), roads, canal and ports, land use and classifying land, disaster mitigation, administrative purposes (tax based area), analysis and interpretation of census data and spatial planning.

Level of modern mapping technologies developments varies in different countries. Most countries which have a history of formal land administration have already applied a computerized system or are in the process of the modern mapping technologies development. Countries which are building land administration system from the scratch -or almost- have to implement the possibility of optimal solution to deal with the very beginning development without any restrictions to use the existing system[6]. Therefore, the all components of modern mapping technologies have to be designed properly regarding to the legislation, time, cost and technology issues, including data collection management for cadastral maps.

Different countries applied different types of land registration system such as deed or title registration, fix or general boundary and systematic or sporadic. Those differences influenced on the type of cadastral maps as a component of cadastral system development. There is a classification of cadastral maps based on title registrations. Group of countries has their own standard for cadastral map: English Group uses the large scale topographic map, German/Swiss Group uses a parcel based cadastral map and Torrens Group uses an isolated survey plan. The fix boundary system requires higher accuracy of cadastral map rather than the general boundary system. The systematic system requires a larger coverage of cadastral map rather than the sporadic system. Therefore cadastral map is designed based on the different level of coverage area, level of accuracy and level of information. Cadastral map may serve as a high accuracy of cadastral map or as an index cadastral to identify the general location of parcel-but not its accuracy.

Cadastral maps serve broader purposes in their development such as for taxation, planning and disaster. Colombia and India are examples of countries implementing cadastral map for broader purposes, in addition to several other countries[7]. In Colombia, the cadastral maps also provide the base property of tax: building, usage and ownership; as cadastral belongs to the finance sector. In India, a particular cadastral map named a village cadastral map serves for a level-micro

planning (natural resources) and impact assessment (disaster mitigation).

Boundaries of parcel as a main element of parcel-based mapping are established using various data collection technology methods. Parcel boundaries survey and mapping system are now developing from a survey by a land surveyor (government, private or company) to participatory mapping by communities. Innovations of cadastral survey and mapping are being developed to generate cadastral maps in accordance with the desired information. As a result, cadastral maps can be represented in different digital formats (graphic, numeric, CAD, GIS) and different level of accuracy in accordance with its purposes

A modern cadastre is normally built based on digital maps and registers. Cadastral maps in digital format support a computerized modern mapping technologies. Several advantages of computerization of maps and registers to build a computerized modern mapping technologies are effective and efficient data analysis, reduce space of storage, avoid duplication of records and provide a backup data in case of disaster. As an example there is a project for computerization of cadastral map in Hungary as a key factor to modernize land registration. The existing paper-based maps are converted into digital cadastral maps to provide an accurate large-scale map in a national mapping base which can be rapidly maintained and updated.

The format and the level of accuracy of digital cadastral maps for developing a modern mapping technologies depends on the various data sources and technologies available in the country concerned. In Thailand as a developing country, the choices to use technologies or the method of modern mapping technologies development commonly based on personal interests, vendor promotions, demonstrations from some conferences/seminar or visited develop countries. The difference of format (GIS or CAD), data sources, accuracy and graphic quality of various maps led to confusions among the end users. The problem has been eliminated by composing “base map compatibility level” that distinguished the map scale with the application. They determined that the most suitable scale map for a base map of modern mapping technologies in the urban area is 1:1000; if the area has excellent hardcopy of cadastral maps overlaid on large scale rectified photomaps.

Scale map issues related to the purposes of cadastral map. Utilities of map presenting different purposes may be defined in large scale, medium scale and small scale. Each scale has advantages depending on the applications. Each nation may determine series of map according to their requirements. This issues affected in the accuracy level. Cadastral map is considered as a large scale map which has to show the various accuracy levels of parcel boundaries.

The requirements of geometric accuracy of parcel boundaries in some countries are very precise but in some other countries are far less demanding. High geometric position requirement is not often a compulsory but the possibility for applying low cost surveying and mapping methods should be always studied. Therefore, the definition of geometric positional accuracy is not only related to the centimetre or millimetre issues but is more regarding the purpose of cadastral map to serve reliable land information.

Positional accuracy is a great concern in the data quality of modern mapping technologies in addition to other accuracy issues such as temporal and attribute accuracy, lineage, completeness, and logical consistency. Information about accuracy issues in the metadata becomes consideration to determine the quality of modern mapping technologies desired. Positional accuracy in cadastral survey and mapping is corresponding with the errors.

The errors are originating from several sources such as the human, the instrument and the systematic errors. Skills of surveyor in survey and mapping affect the accuracy of observation. The survey instrument offers different level of accuracies depends on the technology and the method applied. Data processing such as adjustment method and mapping technique provide different result of accuracy. One source of error may lead to another error which is called error propagation. Cadastral survey and mapping contains the combination of errors and influence the quality of cadastral dataset. By recognizing the errors, the map can be used in accordance with the tolerable level of accuracy and type of requirement.

Cadastral data dynamically change due to population growth, land transaction, land use, conflict, environmental change and disaster. This condition should be coupled with the adequate ability to collect and update data, both the ability of the methods, tools and human resources. The National Research Council (NRC) of United States of America (USA) reported that the change of cadastral data occurs since there are numerous transactions that change the boundaries and its attributes. Cadastral map should be updated regularly due to change of cadastral data caused by a new subdivision, annexations, corrections and other routine modifications. The local government in USA maintains these updating to support the

local business processes that require current and accurate information.

The updating of the existing parcel registration is a subsystem of dynamic land registration model. There are two varieties of updating: first is transfer of right and second is subdivision or consolidation. The first variety deals with the change due to a transfer of right without change of property unit. The second variety deals with the changes of boundaries of the property unit and usually including the updating of cadastral map. The transfer of the right is the most common case of updating compared with subdivision or consolidation. However, the subdivision and consolidation is also an important process because it is accompanied by the formation of a new property with the change of spatial and attribute data attached on it.

In most cases, the new boundaries as results of subdivision have to be determined by geodetic survey, but in a rare exception cases, an (aerial) photograph can be used to do this in the office as long as the existing topographic features are visible. Take a sample in The Netherlands; the measurement and registration of cadastral boundaries has two aims: to enable splitting for creating and registering a new parcel, and to reconstruct boundaries between properties with sufficient accuracy. For the second aim, the reconstruction of a boundary in the field is not based on the cadastral map but based on the original survey boundary taken from terrestrial measurement. Therefore, photogrammetry measurement (ortho-image and oblique-image) is not suited for replacing terrestrial measurement but suitable enough for splitting and creating parcel formation in case of subdivision.

The changes of cadastral data have to be documented properly. Cadastral documents become representations that describing cadastral data. The cadastral document consists of three categories:

1. Legal changes which consist of 3 types: transfer of right, establishment of right and deletion of rights.

2. Changes of technical data, for example the change of number of areas after subdivision and the change of land use.

3. Changes of additional data, neither legal nor technical data, such as postal code.

After studing of the dynamic change of cadastral data we have found that they have a specific definition of spatial and attribute data change. They define the change of cadastral data into 2 categories:

Spatial Data Change; in a parcel-based modern mapping technologies means changes of parcel boundaries. The typical changes are:

Natural changes: land movement caused by nature (e.g. landslide, earthquake, volcanism)

Boundary relocation: moving of physical objects considered as boundaries such as for resolving legal conflict

Parcel evolution: subdivision and consolidation

Surveying observation: boundary changes affected by change of reference points.

Attribute Data Change; caused by legal and administrative actions such as transaction, public purposes and mortgage.

These changes imply the need for updating cadastral maps. According to their investigation, some requirements for a temporal parcel-based modern mapping technologies which deals with change of cadastral data are: automatic updating of cadastral maps, spatial data consistency checking, blunder detection and identification of spatial discrepancy.

Updating cadastral data in term of updating parcel boundaries related with the system to identify a parcel: graphic cadastre and numeric cadastre. In graphic cadastre, the updating has to be based on the original notes and sketch of original survey, and then it should be depicted in the cadastral map. In numeric cadastre, the updating is based on the set of coordinates from the boundary point represented a parcel.

Type of cadastral data and cadastral map affected to the updating process. The main purpose of updating is to inform the changes in the field into the database. The equipment and methodology of updating should be compatible with the existing cadastral map and the database. The updating process has to concern on how to provide streamlining and correct information of changes with a certain level of information to maintain the quality of information on the database.

A modern mapping technologies applies a modern information technology in data collection, storage, data analysis and dissemination of information. This has to be built using a computerized system that has digital databases to provide reliable and timely information for the user. In some countries such as USA, Netherlands, Canada and Australia have developed a modern mapping technologies to maintain their cadastral data. However, the common problems for building a modern mapping technologies in developing countries is the availability of digital data which are up to date in order to have an efficient modern mapping technologies.

Digital data format allows effective and efficient data management including data sharing and data access. Cadastral maps in digital format can be rapidly maintained and updated. Therefore, analogue format in the paper based (both spatial and textual) should be converted into digital format to meet with computerized system requirements. Analogue format has weaknesses such as large of storage space, lack of updating, difficulties in sharing, weak of security, vulnerable to fraud, possibility to disappear, and slow of access.

A step forward to obtain digital data in the field is linking between field data and office database. Automatic data collection has some advantages: reducing human errors occuring in writing and transcribing data, and facilitating the transfer of data to computer systems. Australia has introduced the digital data collection in 1990's. Digital surveying had been integrated in the DCDB project for updating the cadastral information directly to eliminate digitization or numeric input. New Zealand, for example, has applied automatic data collection through the Landonline program which has aims to automate the nation's survey and title system. Cadastral survey information can be validated and transferred electronically through the system for updating geodatabase.

Those different technologies are applicable for different nations but depend on their laws, traditions, infrastructures and factors influenced to the adaptation of the methods. The type of cadastral data and the purposes of the cadastral map also influences the technology used. Digitization and numeric input are common methods to convert paper-based maps into a digital format.

Paper maps are scanned and digitized using vectorization method, textual data may be converted by manual input using keyboard. Improvement of accuracy or the completions of the cadastral map are separate processes. Radar and LiDAR equipments are still considered costly. Recent technology of terrestrial survey to obtain a high spatial accuracy is time consuming and costly, therefore the use of photogrammetric methods is considered more rapid and cost effective. Photogrammetric methods have been used in several countries to accelerate the land registration process. Aerial photos or satellite images combined with other data collection technologies served as a base map are offering effective cadastral mapping processes.

An attempt to utilize satellite images combined with ordinary pens for recording cadastral data changes emerged in Indonesia. After the tsunami in 2004 in Aceh, the government had a responsibility to update all land records and cadastral maps which had been destroyed through adjudication. The main information sources about the post-disaster situation has been are mostly provided by communities. Combination of local spatial knowledge and geo spatial technology can be very useful re-builded land administration systems. The new approach used in Aceh is called Community Driven Adjudication (CDA) or also known as Community Base Mapping (CBM).

Before the adjudication, the community makes a "community agreement" regarding the boundaries of the parcels, the ownership and the sketching of all land parcels (basic map). Parties involved in this process are local community, government, donors and NGOs (Non-Governmental Organizations) as a facilitator. The agreement becomes the reference for the National Land Agency (NLA) on the adjudication activities. NLA provided the necessary materials such as administrative and legal forms as well as the basic map based on the satellite imaging. Quickbird panchromatic (0,61 m resolution) and Ikonos panchromatic (1 m resolution) have been used in the CDA. For the image processing, Ground Control Points (GCP's) have been obtained from GPS measurements; and the Digital ElevationModel (DEM) has been obtained from topographic maps scale 1:25000 combined with terrestrial surveying. The images were plotted in scale 1:2500 on A0-size inkjet glossy papers. Community aided by facilitator identified and demarcated village boundary and parcel boundaries on the top of base map using a pen. Parcel identifier and the owner were simply added inside the parcel or modern mapping technologiested on the backside of the map. The identification might took place in the "meunasah" (kind of mosque in Aceh) or in the adjudication base camp. The agreed base map together with other requirements for community agreement was submitted to NLA. Besides as a reference for the field survey, the base map was also used for work planning and work evaluation.

In Namibia, aerial photographs have been applied for updating cadastral maps digitized from handheld GPS for accelerating communal land registration. Based on the concept of the general boundary system, the accuracy to identify the location of boundaries is considered to be sufficient to avoid overlapping claims and to ensure that the right person is allocated to the right parcel. In Ethiopia, Quickbird satellite imagery has been tested as a base map for estabmodern mapping technologieshing a parcel index map. The test found that satellite images can support the data collection for land registration by participatory approach, producing field evidences from the field

and relatively easy to process. In Rwanda, satellite images and/or aerial photos have being used for demarcating parcel boundaries. The method was suitable when applied in the general boundary principle where boundaries incorporated as "social" rather than "technical" boundaries.

Conclusions and perspectives of future investigations. Modern mapping technologies and photogrammetric innovation offers various low-cost data sources, from a low-cost satellite image and Small Format Aerial Photo (SFAP) to free-cost geospatial information provided by Google Earth (Google), Bing Map (Microsoft) or World Wind (NASA- National Aeronautics and Space Administration). Google Map, for example, has covered a whole area in the world with satellite imagery including a high resolution satellite images from Digital Globe. Those data source might be combined with other free-data sources such as a free Digital Terrain Model (DTM) from NASA or from Shuttle Radar Topography Mission (SRTM) for geo-processing. A base map produced by photogrammetry might be combined with other data collection technologies to meet with the requirements. Cadastral data acquisition can be based on free available imageries. The geometric accuracy of boundary points can always be improved later. Cadastral maps based on the free imageries are mostly relevant to object identifications.

Issues considered the need of a high accuracy of photogrammetric products in cadastral maps is always rising. Nevertheless the possibility of photogrammetry to increase the image resolution and the innovation of the method combination provides significant contributions for standard-sized land parcel (spatial units) survey and mapping.

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